University of Salford MANCHESTER

14th INTERNATIONAL POSTGRADUATE RESEARCH CONFERENCE 2019: Contemporary and Future Directions in the Built Environment

CONFERENCE PROCEEDINGS

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SCHOOL OF SCIENCE, ENGINEERING & ENVIRONMENT

FOREWORD

I am proud to say that this was the 14th International Postgraduate Research Conference within the built environment sector that has been held by the University of Salford. We have held this conference in different venues and countries over the years, but we were pleased this time to be holding it once again on our campus.

These proceedings provide the various papers from the presentations that have been contributed to the conference by the postgraduate delegates, covering the areas of Business, Economics and Finance; Property and Project Management; ICT, Technology and Engineering; People, Skills and Education; Design and Urban Development, and Sustainability and Environmental Systems. It reflects the rich and varied research conducted in this subject area and I'm confident new insights and further discussions will result from this conference.

Our keynote speakers were Mr Mark Farmer of the real estate and construction consultancy Cast, author of the 2016 Farmer Review which examined the labour model within the UK construction industry, and Professor Jacqui Glass, Professor in Construction Management at the Bartlett School of Construction & Project Management, University College London.

I'm sure the conference will have provided much to think about and reflect on.

Professor Sheila Pankhurst
Dean, School of Science, Engineering and Environment

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O

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Professor Jacqueline Glass – University College, London

Professor Jacqueline Glass FCIOB FCABE SFHEA

Jacqui is Chair in Construction Management at The Bartlett School of Construction and Project Management, in University College London and Vice Dean Research for the Bartlett Faculty. She is Principal Investigator of the Transforming Construction Network Plus, funded by UK Research and Innovation (UKRI), an investment supported by the Industrial Strategy Challenge Fund (ISCF). Jacqui has published over 150 papers, managed c. £10m of funding (from research councils and industry) and supervised more than 20 doctoral students to completion. In so doing she has attended to research spanning strategy, procurement, standards, values, and accounting for sustainability. Her specialism is responsible and ethical sourcing, which relates to material and product supply chains, and in 2018 she was named in the Top 100 Corporate Modern Slavery Influencers. You can follow her updates on Twitter: @profjacquiglass

Mr Mark Farmer – Founding Director and CEO, Cast

Mr Mark Farmer

Mark has 30 years' experience in construction and real estate and is a recognised international commentator on a variety of industry and policy related issues. Mark is a member of the Mayor of London's Construction Skills Advisory Group, a board member for the Construction Scotland Innovation Centre, a co-chair of Constructing Excellence, a vice chair of the ULI UK Residential Council, a trustee of the MOBIE educational charity and is an honorary professor at The University of Salford's School of Science, Engineering and Environment.

Mark authored the Farmer Review, an influential 2016 independent government review of the UK's construction labour model entitled 'Modernise or Die'. He is a member of the Construction Innovation Hub Industry Board, the Construction Leadership Council Advisory Group and chairs the MHCLG joint industry working group tasked with enabling greater use of Modern Methods of Construction in the residential sector.

TABLE OF CONTENTS

Foreword 2

Conference Organisers 3

The Scientific Committee 5

Keynote Speakers 7

Table of Contents 9

BUSINESS, ECONOMICS AND FINANCE

RE-EVALUATING MEGAPROJECT COST OVERRUNS: PUTTING CHANGES INTO PERSPECTIVE 15

ESTABLISHING THE COST CONTRIBUTION OF SIGNIFICANT CASH FLOW FACTORS IMPACTING ON BUILDING PROJECTS PROFITABILITY 25

A REVIEW ON APPROPRIATE TOOL TO PREDICT PROFITABILITY OF BUILDING PROJECTS USING ESTABLISHED SIGNIFICANT CASH FLOW FACTORS 38

PROPERTY AND PROJECT MANAGEMENT

EXPLORING HOW PERSONALITY TRAITS IMPACT ON COUNTERPRODUCTIVE WORK BEHAVIOUR ON CONSTRUCTION SITES 50

A LITERATURE REVIEW EXPLORING THE CRITICAL SUCCESS FACTORS FOR THE EFFECTIVE IMPLEMENTATION OF THE ISO 9001 QUALITY MANAGEMENT SYSTEM IN CONSTRUCTION PROJECTS 61

THE ROLE OF VALUATION TASK COMPLEXITY IN COMPULSORY PURCHASE: A CONCEPTUALISATION 74

ASSESSING THE SAFETY PERFORMANCE IN KUWAIT'S OIL AND GAS SECTOR CONSTRUCTION PROJECTS 82

PERFORMANCE MANAGEMENT IN CONSTRUCTION SUPPLY CHAINS: A SYSTEMATIC LITERATURE REVIEW 95

APPRAISALS OF STUDENT PERSPECTIVES ON FIRE SAFETY PRECAUTIONS IN HALL OF RESIDENCE 108

A FRAMEWORK FOR POSITIVE CONSTRUCTION SAFETY CULTURE FOR IMPROVED SME CONTRACTOR PERFORMANCE IN GHANA 118

IDENTIFICATION OF THE CONTRACTOR SELECTION CRITERIA FOR PUBLIC PROJECTS IN TURKEY 128

EMBEDDING SUSTAINABILITY ETHOS ACROSS CONSTRUCTION PROJECT'S LIFECYCLE: A REVIEW OF PROJECT MANAGEMENT COMPETENCIES 141

CONCEPTUALISING A PROJECT MANAGEMENT FRAMEWORK FOR EMERGING CONTRACTORS IN THE FREE STATE 151

FACTORS AFFECTING MATERIALS MANAGEMENT ON LIBYAN CONSTRUCTION SITES 162

ICT, TECHNOLOGY AND ENGINEERING

INVESTIGATION ON COMPARATIVE ROLES OF MAJOR STAKEHOLDERS FOR BIM IMPLEMENTATION IN A TRADITIONAL CONSTRUCTION PROJECT ENVIRONMENT 175

A LEVEL 2 BIM MATURITY-KPI RELATIONSHIP ASSESSMENT 189

IMPROVING THE CONSTRUCTION INDUSTRY IN THE STATE OF KUWAIT 202

EXPLORING BEHAVIOURAL NEGATIVE FACTORS HINDERING THE PERFORMANCE OF STRATEGIC CONSTRUCTION ALLIANCES IN THE UK 213

GIG ECONOMY AS A TOOL FOR SUSTAINABLE LIVELIHOOD STRATEGY FOR CONSTRUCTION WORKERS IN SOUTH AFRICA 224

THE POTENTIAL OF INDUSTRY 4.0 TO ENHANCE CONSTRUCTION HEALTH AND SAFETY (H&S) PERFORMANCE 233

CONSULTATIVE APPROACH TO BIM IMPLEMENTATION 245

AN APPROACH TO "NATIONAL ANNEX TO ISO 19650-2" 254

DRIVERS FOR USING OFFSITE CONSTRUCTION IN IRAQ 263

PEOPLE, SKILLS AND EDUCATION

DEVELOPING PROFESSIONAL CAPACITY IN THE CONSTRUCTION INDUSTRY THROUGH THE SINO-AFRICAN RELATIONS: A LITERATURE REVIEW 275

INVESTIGATING REASONS FOR ENGINEERING SKILLS DEFICIENCY IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY 284

AN INVESTIGATION INTO THE IMPACTS OF THE TECHNICIANS' SKILLS GAP ON THE DEVELOPMENT OF THE NIGERIAN CONSTRUCTION INDUSTRY 294

DESIGN AND URBAN DEVELOPMENT

USING THE FEDUP GROUP SAVINGS SCHEME MODEL FOR THE PROVISION OF CONTEMPORARY SUSTAINABLE HUMAN SETTLEMENTS 307

TACKLING SPATIAL INEQUALITIES THROUGH MIXED INCOME HOUSING: A QUALITATIVE ANALYSIS OF STAKEHOLDER PERCEPTIONS 315

INVESTIGATION OF EMOTIONAL STATES IN DIFFERENT URBAN SOUNDSCAPES THROUGH LABORATORY REPRODUCTIONS OF 3D AUDIOVISUAL SAMPLES 327

THE GHANAIAN CONSTRUCTION INDUSTRY AND ROAD INFRASTRUCTURE DEVELOPMENT: A REVIEW 340

THE URBAN GOVERNANCE AND INFRASTRUCTURE NEXUS: DEVELOPING A CONCEPTUAL FRAMEWORK FOR URBAN NIGERIA 350

SUSTAINABILITY AND ENVIRONMENTAL SYSTEMS

EXPLORING UNCHARTERED TERRITORIES OF BUILDING ACCREDITATION RATINGS IN THE UK 361

ENERGY STORAGE FOR INCREASING SELF-CONSUMPTION OF WIND ENERGY AND MARKET VALUE ON A DISTRIBUTION NETWORK 372

INTEGRATING H&S REGULATIONS INTO GREEN BUILDING RATING TOOLS FOR MORE SUSTAINABLE OUTCOMES: THE CASE OF THE PEARL RATING SYSTEM (ESTIDAMA) ADOPTED IN ABU DHABI, UAE 384

SUSTAINABLE CONSTRUCTION AND SUSTAINABILITY EXPERTISE – UNDERLYING CONCEPTS: GETTING THE BALANCE RIGHT 397

SUSTAINABLE CONSTRUCTION IN WAR ZONES: PALESTINE AS A CASE STUDY 405

COMPRESSIVE STRENGTH ANALYSIS OF CONCRETE FLOOR USING A NON-DESTRUCTIVE TEST 418

PROPERTIES AND EFFECT OF DORMANT RIVER SAND USED FOR SANDCRETE BLOCK PRODUCTION IN NIGERIA 426

GEO-EXPERIMENTAL INVESTIGATION OF NSUKKA SANDY SAND: AN EVALUATION OF ITS ELECTROCHEMICAL PROPERTIES AND ANGLE OF REPOSE USING THE FIXED FUNNEL METHOD 436

NUMERICAL STUDY ON EFFECT OF FIRE ON STRENGTH OF BLAST WAVE AFTER STAND-ALONE HYDROGEN TANK RUPTURE 445

APPLYING THE RESOURCE-BASED VIEW (RBV) THEORY IN SUSTAINABLE PROCUREMENT PRACTICE IN THE AEC SECTOR 458

PHYSICAL RESILIENCE FACTORS TO ENHANCE COMMUNITY RESILIENCE TO PLUVIAL FLOODS IN THE UAE: THE CASE STUDY OF ABU DHABI CITY 468

A SERVITIZED BUSINESS MODEL FOR IMPROVED CIRCULAR ECONOMY PERFORMANCE IN CONSTRUCTION 479

DISMANTLING BARRIERS TO EFFECTIVE DISASTER MANAGEMENT IN NIGERIA 489

CRITICAL SUCCESS FACTORS THAT ENABLE THE UTILISATION OF AGRICULTURAL WASTE AS BUILDING MATERIAL 500

HOW TRAINING CAN SUPPORT LOW CARBON PRIORITISATION IN FLOOD AND COAST RISK MANAGEMENT CONSTRUCTION 513

A FRAMEWORK TOWARDS THE REDUCTION OF THE ECOLOGICAL AND CARBON FOOTPRINT OF CONSTRUCTION ACTIVITY IN GHANA 525

CONCEPTUAL PERSPECTIVE ON THE SUSTAINABILITY OF COMMUNITY-LED TOTAL SANITATION PROGRAMME IN GHANA 538

BARRIERS TO LOW CARBON TRANSITIONS AND ENERGY SYSTEM INNOVATIONS 548

OIL AND GAS INDUCED-DISPLACEMENT AND RESETTLEMENTS IN SOUTH-SOUTH NIGERIA 559

Business, Economics and Finance

RE-EVALUATING MEGAPROJECT COST OVERRUNS: PUTTING CHANGES INTO PERSPECTIVE

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Abstract: The vast sums of money involved in megaprojects, and the perceived lack of public benefit, create controversy. Flyvberg' s *iron law* asserts that megaprojects are *over budget, over time, under benefits, over and over again* (Flyvberg, 2018). More recent research suggests that this focus on cost overruns is based on highly misleading data (Love & Ahiaga-Dagbui, 2017). This research seeks to examine live megaprojects and examine Flyvberg's theories in practice, through an investigation of current megaprojects in the Middle East. The research provides three case studies for two recently completed and one on-going megaproject, to examine these claims further. The research questions whether the right comparisons are made between the initial offerings and final product, through consultation with professionals. Based on the findings, it is suggested that an increase of over 100% of the Contract price, may not constitute an over-budget megaproject. Professional Cost Consultants in the built environment can provide greater insight into the complexity that adds cost in the transitions from initial to final costs for megaprojects, although the validity of this insight may be reduced by a lack of distance from or overview of the megaproject. This paper investigates some of the familiar sources of megaproject cost overrun and considers the findings of Cost Consultants engaged in monitoring megaprojects in the state of Qatar. Time and Cost considerations are just two of the characteristics evident in megaprojects. This research suggests that reporting of time and cost overruns is frequently based on limited, misunderstood or misreported data, and that in order to provide higher fidelity, such 'headline claims' need to be careful considered in the context of the original project scope. This paper recognises that cost is just one element of a megaproject, and that megaprojects warrant more holistic considerations including acknowledgement of other significant characteristics such as their embodiment of large components of risk, political influences, organisational pressures and management complexities.

Keywords: Cost Overruns; Megaprojects; megaproject characteristics

1 INTRODUCTION

Headlines in the popular and trade press regularly draw attention to supposed extreme and regular time and cost overruns associated with megaprojects. Examples include the U.K. HS2 high-speed railway (Transcity Rail, 2019), Mexico's recently suspended new airport (Reuters, 2018), Ethiopia's delayed new dam. Megaprojects such as Dubai's International Airport, Hong Kong Airport or the Panama Canal contribute directly to a significant portion of the country's GDP (Flyvberg, 2017; McKinsey, 2015; Merrow, 1988) and so are essential to the local and global economy. This paper suggests that to arrive at a more accurate assessment of the issues in megaprojects, there is a need to consider all the project complexities and recommends a departure from the prioritisation of cost and time issues. While much of the research to date is dominated by EU related megaprojects (Flyvbjerg, Holm, & Buhl, 2002), this paper captures current Middle Eastern data. Large scale megaprojects are prominent in the Middle East, with the inclusion of projects such as the $500 billion NEOM megaproject in Saudi Arabia or the new $50 billion Lusail City in Qatar (GCR, 2018; Lusail, 2019). Current research considers cost overrun as the increase from the initial costs of a megaproject to its final costs (Flyvbjerg et al., 2002, p. 293). The author suggests that this logic is fundamentally flawed, as the initial product and final product are often quite different. This research examined three case studies involving "over-budget" megaprojects in the GCC. It provided a % comparison between the contract sum and the additional outturn costs, noting that the megaproject final costs reflected increases of between 17% to 113% of the contract sum. The paper investigates the factors which influenced these budget increases, to put these changes into perspective.

2 DEFINING MEGAPROJECTS & EXAMINING THEIR REPUTATION

Megaprojects are typically described as large-scale, complex ventures costing a billion dollars or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people (Davies, Dodgson, Gann, & Macaulay, 2017; Flyvberg, 2017; Mok, Shen, & Yang, 2015; Pollack, Biesenthal, Sankaran, & Clegg, 2018a; Turner, 2018). Megaprojects have been described as *wild beasts ……, hard to tame, known for their complexity, vast size, expensive cost, and long time frame* (Zidane, Johansen and

Ekambaram, 2013 p349). They were once considered *privileged particles of the development process* Hirschman (1995: vii, xi), but recent research indicates that they *are growing ever larger* and their *scale seems to be accelerating* (Flyvberg, 2017, p. 5). Megaprojects are inevitably accompanied by a perception of a lack of benefit to attract public scrutiny. Criticisms have recently been levied against the U.K.'s HS2 high-speed railways (Transcity Rail, 2019), Mexico's recently suspended new airport (Reuters, 2018) or Ethiopia's delayed new dam (GCR, 2018). It has also been identified that the high financial cost of megaprojects such as Dubai's International Airport, Hong Kong Airport or the Panama Canal contributes directly to a significant portion of the country's GDP (Flyvberg, 2017; McKinsey, 2015; Merrow, 1988). The vast sums of money involved in these ventures and the perceived lack of benefits to the public such as Mexico's airport or Ethiopia's Dam create controversy. There are also cases where megaprojects may be seen as financial failures, yet perceived by the public as a success, such as the UK- France Channel Tunnel or the Sydney Opera house (Flyvbjerg, 2018, Answer 99).

2.1 Overbudget, over time, under benefits, over and over again

In November 2018, the UK government expressed growing concern at the levels of financial exposure and the risks associated with UK megaprojects. To address these concerns, they requested Professor Flyvberg, in November 2018, to address the Public Administration and Constitutional Affairs Committee in the House of Commons and explain his *Iron Law of Megaprojects* (Flyvberg, 2018). In response, he suggested that megaprojects are *over budget, over time, under benefits, over and over again* (Question 89). He later clarified this statement to indicate that they were within budget once in every ten occasions (Answer 90). Research concerning cost overruns in megaprojects *Underestimating Costs in Public Works Contracts: Errors or Lie?* (Flyvbjerg et al., 2002) , is credited with a pendulum swing in directing criticisms of megaprojects away from technical explanations, to a focus on costs (Siemiatycki, 2018a, p. 364). It was suggested that megaproject budgets were derived using a false assumption that *Everything Goes According to Plan* Flyvbjerg et al., (2002, p. 289)**.**

Flyvbjergs widely quoted assertions have been criticised for failing to consider the broader impacts such as social, economic and political spectrum (Room, 2018, p. 368). His work has also been criticised for strategic misrepresentation associated with analysis of projects (the inclusion of non-megaprojects valued at 1.5 million), a lack of scrutiny of the data used to produce the quantitative statements and the lack of a universal standard or comparison for cost measurement (Love & Ahiaga-Dagbui, 2018, p. 5,11,15,19). He is accused of sensationalising financial data through 'cherry-picking results' (Love & Ahiaga-Dagbui, 2018) and using provocative and memorable titles to publicise his theories (Siemiatycki, 2018b)

Around the same timeframe of *Errors or Lie?*, a paper was published, which described megaprojects as an *Autonomy of Ambition* (Flyvbjerg, Bruzelius, & Rothengatter, 2003). This paper highlights the risk of cost overruns, but critically also acknowledged other challenges associated with megaprojects, such as large-scale decision making, performance shortfalls, and environmental impacts. A recent longitudinal study of the expansion of Heathrow Airport's T2 terminal, the Olympic Village and Cross rail suggested that megaproject underperformances are not cost-related, but instead due to inadequate organisational structural development (Perspective, Lundrigan, & Gil, 2015). Additional research has reinforced the complexities of organising megaprojects, recommending that they should be considered as *collaborative developments of one-off indivisible structures under pressure* (Perspective et al., 2015, p. 32).

This paper suggests that there is a significant danger that preoccupation with time and cost characteristics of megaprojects may distract from consideration of the other complexities associated with these extremely challenging ventures. Research has shown that other critical factors related to megaprojects such as public accountability, the complications in managing stakeholders, the volume of risk associated with their delivery, organisational and leadership challenges, the complexities of dealing with multi-cultural leadership or even the megaprojects impact on the nations GDP, can be as challenging as financial constraints (Li & Guo, 2011; Pollack et al., 2018a). The author suggests that a significant number of these issues, such as multi-cultural and leadership risks, do not receive sufficient consideration until it becomes too late to control their impacts. Researchers are now recommending the consideration of a more holistic approach towards the analysis of megaprojects characteristics, away from the traditional focus of time and cost characteristics (Eweje, Turner and Müller, (2012); Mišić and Radujković,(2015); Pollack, (2018); Garemo, Matzinger and Palter, (2015)). Initially, megaprojects were classified in terms of their initial cost, before research explored the multiple complexities associated with their execution. Cost has a significant role in the successful delivery of megaprojects, but megaprojects must be considered as more than a number.

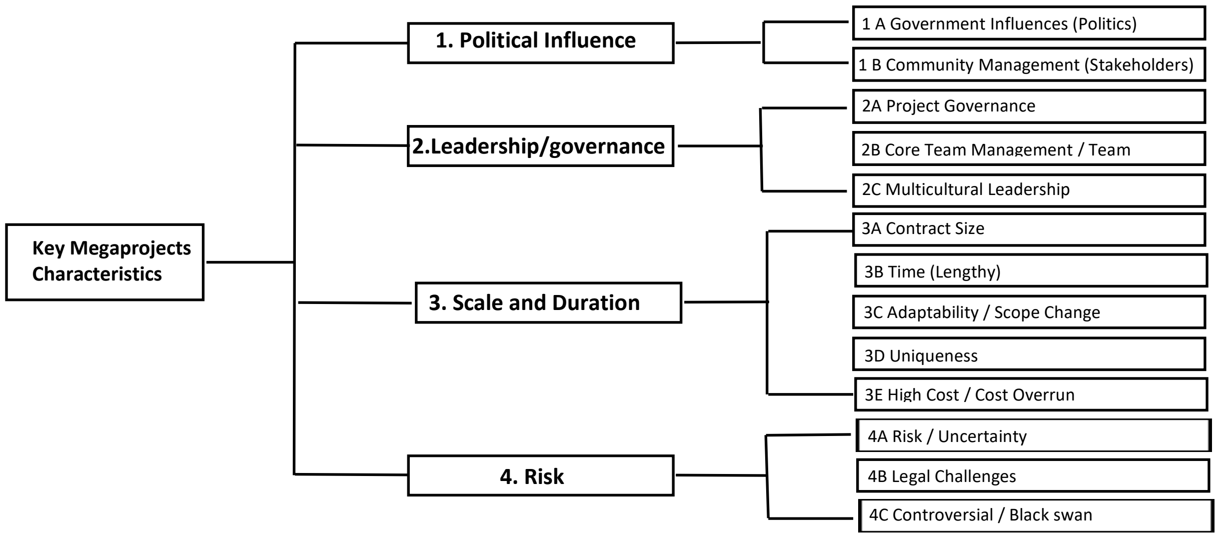
2.2 Megaprojects as a Number

The traditional linking of a megaproject as a project higher than *one billion* is linked to Capka (2004). He has been credited with establishing a megaproject benchmark value of one billion dollars for the new *different breed* of the project (megaproject) which was emerging in infrastructure projects for the United States Department of Transportation. Many countries have since followed suit, associating a monetary value of *one billion* units. These include Hong Kong one billion dollars (Mok et al., 2015); the UK one billion pounds (Flyvberg, 2017) and Europe considers projects of one billion euros (Pau, Langeland, & Njå, 2016). As costs are subject to inflationary pressures and continue to expand, researchers now consider augmented titles, such as the existence of *Giga* projects and *Tera* projects [Flyvbjerg & others] (2014). Researchers also refer to a new variety of enhanced or *complex* megaprojects Hillson (2018). It is evident that *one billion* of a local currency may have a significant impact on that countries GDP (Gross Domestic Product, yet the scale of some recent GCC projects, such as Saudi Arabia's $500 billion Neom city (GSR news, 2017) or Qatar's $46 billion Lusail City project (www.lusail.com) make *one billion* pounds appear an inappropriate measure. While critics may refer to budget overruns and time overruns (Flyvberg, 2017, 2018; Flyvbjerg, 2014b), it is worth noting that a megaproject's scope often grows and expands throughout its lifespan. It is misleading to relate initial costs to final costs when significant changes may be occurring during the megaproject's evolution. This paper suggests that when one compares the starting and final product, then labelling this increase as *overbudget* costs may not be accurate as we are comparing different scopes of works, the proverbial apples versus oranges scenario. A case study of three GCC megaprojects is used to examine the impact of changes on megaproject budgets.

3 THE SEARCH FOR A MORE HOLISTIC DEFINITION OF MEGAPROJECTS

Despite the often unique and temporary nature of megaprojects, research has shown that they often exhibit core characteristics. These may include short-term temporary collaborations for bespoke developments (Van Marrewijk, Veenswijk, & Clegg, 2014). Core megaproject characteristics need to be isolated to permit a more thorough examination of their nuances and interdependencies. After thematic analysis, repeated themes such as their complexity, size, and scale become evident. The *Oxford Handbook of Megaproject Management* Flyvbjerg, (2017b) collated views of 43 active megaproject researchers, seeking to understand the complexities of such ventures. The identification of common characteristics is difficult due to the unique nature of many of these projects and the knowledge that they are often considered as *temporary endeavours* (Brookes, Sage, Dainty, Locatelli, & Whyte, 2017). They also exhibit temporal characteristics such as *task complexity, singularity and innovativeness* (Sydow, 2017). Recent research (van Marrewijk, Ybema, Smits, Clegg, & Pitsis, 2016, p. 1750) emphasises the *culture of temporariness* within megaprojects makes collaboration *critical, challenging and laborious, frequently resulting in underperformance or failure* of the megaproject. This analysis also enables a review of how factors such as organisational, national or professional culture may influence megaproject governance. Such analysis helps outline the high levels of risks associated with megaprojects. The phenomenon of managing megaprojects is the subject of a European study seeking to *understand how megaprojects can be designed and delivered more effectively to ensure their effective commissioning within the European Union* (Barbero & Redi, 2015). Further analysis of megaprojects identifies other factors such as cultural influences impacting their governance, their association with vast levels of risk and their reputation of being notoriously hard to manage, permitting a fuller understanding. Works by Eweje, Turner and Müller, (2012); Mišić and Radujković,(2015) researched and exposed many of the complex characteristics associated with megaprojects. Researchers, including Pollack, (2018); Garemo, Matzinger and Palter, (2015) and Flyvberg (2017), have highlighted critical characteristics which caused completed megaprojects to succeed or fail.

A thematic analysis of these characteristics includes:



3.1 Time & Cost Considerations

Based on the isolation of a megaproject's characteristics, it is evident that Time and Cost considerations are critical elements in the evaluation of megaprojects. A recent analysis of risks in megaprojects considered published findings, specifically related to risk management in megaprojects. This research found that time and costs risks were the most frequent megaproject risk, as evidenced by their dominance in over forty per cent of published literature reviewed (Irimia-Diéguez, Sanchez-Cazorla, & Alfalla-Luque, 2014). Flyberg remains a staunch critic of megaproject time and cost overruns and has suggested a systematic falsification of initial costs. He suggests that this represents a Hiding Hand principle(Flyvbjerg, 2014a). This principle suggests that these cost estimates are *systematically, and significantly deceptive,* and indicated that such distortions are directly related to politics, economic self-interest and the buildings of a monument as a legacy (Flyvbjerg et al., 2002, p. 290).

In Europe, the majority of megaprojects are either State-funded or shareholder funded. Both funders provide a degree of transparency for financial costs associated with the megaproject outturn costs. Not all data is available as there are significant difficulties in gathering cost data related to megaprojects. The Royal Institute of Chartered Surveyors through its members, provide construction costings on a global basis. They advise the complexities involved in assessing megaproject costs including a decline in the use of Bills of Quantities (the traditional method of pricing projects), proprietary designs and uniqueness and confidentiality as critical sources why accurate cost comparisons cannot be made on a global basis (Horner & Muse, 2018). Provision of reliable financial data is crucial to the analysis of budget costs, as it allows researchers to establish valid comparisons between the original and final expenses of megaprojects. To date, there is a lack of published cost data for megaprojects associated with the GCC. Due to such lack of data, existing research has concentrated principally on *large European projects*, (Flyvbjerg et al., 2002, p. 294)**.** Some general studies are available (Johnson & Babu, 2018a; Mahdi & Soliman, 2018), which qualitatively engaged with GCC practitioners and examined the reasons for cost and time overruns in GCC megaprojects. However, they appear to lack of credible substantiation. Despite challenges associated with obtaining megaproject financial data in the GCC, three case studies were undertaken with international Cost Consultants. They provided financial data for some critical GCC megaprojects. The Cost Consultants have disguised confidentially confidential data but retained the ratio of the percentage cost adjustments for the components which impacted the contract sum. Despite this concealment of commercially sensitive data, the causes and proportions of changes represent the actual changes during the lifespan of the megaproject and serve as a benchmark for cost increments (*overbudget* in Flyvberg' s view) of the megaproject.

3.2 Middle East Megaprojects

Before considering this case study, it is beneficial to review the contextual background of GCC megaprojects, to appreciate how typical GCC megaprojects may differ from those European megaprojects examined by other researchers, such as (Flyvbjerg et al., 2003; Pollack et al., 2018b; van Marrewijk, Smits, Clegg, Pitsis, & Veenswijk, 2008). The Middle East and in particular the Gulf Cooperative Council (GCC) states extensively use megaprojects to deliver new cities, infrastructure and oil and gas-related projects. Deloitte (2016) estimated that the GCC has a US$2 trillion pipeline of projects under construction or planned. In June 2018, there were 300 active megaprojects, either being tendered or under construction in the GCC (www.constructionweekonline.com/projects). GCC megaprojects engage large numbers of non-European expatriate workers to support the creation of their megaprojects with Individual GCC States' reliance on expatriates, ranges from thirty-two per cent in Saudi Arabia to eighty per cent in Qatar in 2018. There are further challenges due to the mix of workforce culture, the complexities of design, and unique challenges due to the existence of multiple cultures involved in managing the process (Johnson & Babu, 2018b). Statistics indicate that the GCC engages almost nine million personnel in its construction sector, nearly twice the 4.8 million staff employed throughout the European Union, (Statista, 2019). In monetary terms, the value of construction-related activities accounts for nineteen per cent of GDP in the GCC which represents twice the estimated nine per cent construction spend in Europe (European Building Confederation, (2019). Table 1 summarises critical considerations for GC megaprojects by combining data related to GDP (World bank data, 2019) and population data (data.worldbank.org). It applies Central Intelligence Agency data, which estimates the percentages of expatriate and considers construction AECOM, (2018).

Table 1 *– GCC Statistics (AECOM, 2018; Central Intelligence Agency, 2019; World bank data, 2019)* ***Expatriate Statistics*** *Qatar www.mdps.gov.qa; Oman www.ncsi.gov.om; Bahrain www.blmi.lmra.bh; UAE www.grc.net; Saudi Arabia ; Kuwait www.ceicdata.com/en/kuwait*

	GCC State	Total Population	Expatriate Population	Expatriates Residents	% Expats in Construction	GDP USD Billion	Value of Construction USD, Billion
1	Qatar	2,639,211	2,111,369	80 %	50%	167.605	46.4
2	KSA	32,938,213	10,500,000	32 %	36%	683.827	109
3	UAE	9,400,145	7,800,000	83 %	30%	382.575	87.7
4	Kuwait	4,136,528	2,895,570	70 %	17%	120.126	12.6
5	Oman	4,636,262	2,086,318	45 %	31%	72.643	15.2
6	Bahrain	1,492,584	666,000	45 %	22%	35.307	7.7
7	Totals	55,242,943	26,059,256	47 %	31%	1,462,083	279

As indicated in column six, construction personnel account for between seventeen and fifty per cent of all expatriates within a particular state. Construction-related activities currently account for nineteen per cent of the GCC's Gross Domestic Product (World Bank, 2019). The nine million expatriate construction staff employed on GCC mega-projects, make the workforce for these projects *multicultural* (Dulaimi & Hariz, 2011), with the management *often comprising an extensive gathering of culturally diverse hired in expert consultants* (Archibald et al.,1991) assembled *from a pool of highly qualified resources around the world* (El-sabek, 2017).

4 RESEARCH DESIGN AND APPROACH

Case studies are considered a suitable method to examine complex projects within the built environment, such as megaprojects. Case Studies permit the *investigator to retain the holistic and meaningful characteristics of real-life events*, together with providing an ability *to capture rich and complex data* Barrett & Sutrisna, (2009). The author was working in the Middle East state of Qatar at the time of the research and had access to several firms of Cost Consultants in Qatar. There were eight live megaprojects at the time of the study (Summer 2019), and the Cost Consultants involved in these megaprojects were requested to participate in this research. Six western consultants were involved in the eight live megaprojects. Three agreed to join within the stipulated time frame (three months), while others refused citing time constraints, workload or confidentiality reasons for their non-participation. Two of the three cost consultants feature in the top ten cost consultancy practices (Building Magazine, 2019), and the third practice is based in Lebanon, which has multiple offices in the Middle East.

4.1 Quantitative or Qualitative approaches

There is a debate between the quantitative approach taken by Flyvberg in his review of 258 Infrastructure projects sample (Flyvbjerg et al., 2002, p. 293) and the earlier qualitative research by Hirschman (Lepenies, 2018, p. 361). Flyvberg suggested that Hirschman overstated his concepts based on a limited number of observations and biased data, while Lepine's contends that Hirschman's data provided half a century ago remains sound in principle (Lepenies, 2018, p. 262,264). One of Hirschman's suggestions is that some megaprojects succeeded by creatively responding to their context and succeeded through a form of luck or chance. Flyvberg suggests the this reflects a hiding hand principle as a *fallacy of beneficial ignorance* (Flyvbjerg, 2016) In his paper he argues that construction Estimators provide unrealistically optimistic outlooks -

overestimating benefits and potential success, yet substantially underestimate costs. A review of 161 World Bank-funded projects found evidence of the presence of influences including problem-solving, opportunity costs and luck (Ika, 2018).

Quantitative data may be taken from the figures provided by public accounts or shareholders year-end financial numbers may indeed offer an opening and closing balance for costs associated with a Megaproject. It is the authors view that expert construction knowledge and qualitative interpretation is required to understand why prices have increased and if they are the result of initial *deceptive* underestimations or the result of changing requirements. This research seeks to capture the experience of directors within such expert western Cost Consultancies. There was also a time constraint associated with a quantitative or qualitative choice in methodology. Flyvbjergs data was assembled over desk research for four years (Flyvbjerg et al., 2002, p. 293), while the contributors to this research typically have between 15 and 20 years of field exposure and were able to make use of this extensive practical experience. As the subject of interest, requires extensive feedback from the practising participants, semi-structured interviews were arranged around core themes and included the opportunity for the respondent to provide unstructured observation and analysis of the subject problem. Interviews were conducted on face to face basis. The initial meeting recorded the original scope and financial details of the project, confirming opening and closing account balances. A series of follow-up interviews took place (three per case study) during which significant changes, both positive and negative, were analysed. This information provided the delta between the original and final price cost overrun (Flyvberg's *overbudget*). This data was analysed and presented in annual increments, spanning the megaprojects lifespan except for one on-going megaproject. Once significant variations were identified, the reasons for these changes were explored. Following the completion of this review and the interpretation of the data, the data was summarised, tabulated and returned to the provider to review its authenticity. To retain confidentiality, the parties adjusted the figures (keeping accurate to the ratio of the variations) and endorsed its use in this case study.

5 INTERROGATION OF THREE GCC CASE STUDIES TO INVESTIGATE THE IMPACT OF CHANGES

Experienced construction professional consultants expect changes. In international contracts, provisions are made to anticipate and govern changes to the original scope. An extensively used form of contract - FIDIC – an acronym for the International Federation of Consulting Engineer - controls such changes using specific conditions of the agreement, Clauses 8 and 13 (FIDIC, 1999). These changes have time, and cost implications and the Contract Price gets adjusted accordingly in a process labelled as *variations*. The initially agreed price is known as the ***contract sum***. At the end of the project, a **final account** is prepared based on the original contract price and the adjustment of all variations issued on the project. This concludes the contract and provides a final sum for the megaproject (Clause 14). The methodology used by researchers, including Flyvberg is to measure the *difference between actual and estimated costs* (Flyvbjerg et al., 2002, p. 293). This equates to comparing the original *contract sum* with the agreed *final account.* A diverse set of megaprojects was selected for this research including an Airport, a Financial Hub and a new City. GCC megaprojects are generally large projects with a construction duration of up to ten years, such as the examples in the case studies considered within this research. While it may seem appropriate for Airports to engage the most advanced technology available, such as advancements in specialist radar systems, these technological advancements often come at a cost. Similarly, in the case of the new city, may seek to cater for updated infrastructure systems, such as a free-flow traffic movement and smart city requirements. These updates also attract a cost. The city's retail and recreational needs were also updated to incorporate demographics trends. The size of its commercial units, square footage of its tenant and public transport availability influenced variations to the original concept of the City. The Financial District responded to the revised office needs of relocating companies. Current research models fail to consider these natural progressions and may be classified as *overbudget*. The necessity to make changes and this impact on the financial outcome of three megaprojects are explored in the following Case Studies.

5.1 Case Study A – Financial District - Project Details

A new Financial District was developed for West Bay containing 700,000 m² of built-up area. The development comprises of 9 high-rise office towers, each up to 52 storeys in height, a five-star hotel, 15 podiums, state-of-the-art elevated car parking for 5,000 cars, primary substations and an energy centre. The Financial District is was designed to serve the global, regional and local financial sector. The project commenced in 2008 and construction was completed in early 2016. This was significantly later than its planned duration of five years, and the budget increased by seventeen per cent. The financial details are available on request.

Changes during the construction of the megaproject

Initially, the project suffered delays as the Employer restructured his organisation. This revision changed the planned occupation and fit-out for one full 52 storey tower. For the first five years of the project, 2008 – 2012, the project budget was reduced. On investigation, the Cost Consultant explained these reductions were the result of both value engineering and the omission of previously planned works. One definition of value engineering describes it as a process wherein the designers are requested to retain the same function at a lower price (Janani, 2019). The changes included a lowering in the thermal rating for glazing to the tower façade and accounted for a 2% reduction in the overall project costs, which represented a saving of around £120 million. Other minor cost variations occurred, and a significant budget increase was encountered in 2014 – 2015. As the overall size of the development appeared unchanged, the Cost Consultant was asked to explain the increment. His responded that a new tenant had purchased the development in its entirety. The rapidly declining price of commodities during 2014 and 2015, resulted in the client reducing his spending budget and deferring works to suit his adjusted cash-flow, in addition to reconsidering his office requirements, directing his advisers to alter parking and office space requirements. This resulted in a reduction in open areas, revised sizing of offices, increased car parking provisions and associated mechanical and electrical re-work. These were the significant changes with further details provided in Appendices 1. Overall the Cost Consultant confirmed that the project might have resulted in saving due to the optimisation of finishes, had the change of use not been applied. The 17% cost overrun, and the three-year delay period was accepted as attributable to changes in scope. Significantly the Cost Consultants viewed the project as a financial success.

5.2 Case Study B – Airport Extension - Project Details

The project involved the extension to an International Airport including departure and arrival lounges, with a built-up area of 134,000m2 including the full fit-out of lounges and food and beverage facilities. The construction contract was awarded in two phases. Phase 1included the main body of the Airport, and Phase 2 the nodes or extensions to the main body. This Phase 2 megaproject was awarded in 2009, and the building shell was structurally complete in 2014. The internal fit-outs and lobbies were undertaking a fit-out which was finished by late 2016.

Changes during the construction of the megaproject

The costs associated with this project increased by 113% of the original contract sum. The Cost Consultants figures were analysed. Following analysis of these figures, it became apparent that substantial additional works were incorporated to cater for an addition fit-out for lounges in the airport. These extra works were awarded in 2012 and 2014 for business class lounges, economy lounges, and a large number of restaurants and retail fit-outs. As these works did not form part of the original scope of works, they are categorised as variations. By removing these additional works from the contract scope, the suggested overrun reduced further from 113% to 55%. Further investigations examined a significant budget rise between 2015 and 2016. These investigations revealed that the massive spike in costs was associated with the award of the fit-out for a 5-star transit hotel. This luxurious hotel, incorporating a spa and fit-out accounted for over 25% of the initial budget increase. Following reduction of the additional lounges fit-out (58% of the overrun) and the hotel fit-out costs (25% of the overrun) the project costs had increased by 17 %. Cost Consultants then categorised these figures into different elements. Some 8% were allocated to Airport security and technological enhancements and the balance 9% had various uses, e.g. a specific aesthetic enhancement. The Contractors had also submitted claims for additional costs and management fees throughout the additional works. These were dealt with as overheads associated with the fit-out packages and the final accounts closed. Overall the Cost Consultant confirmed that the project was considered financially justifiable and that value for money was achieved. Despite the headline budget increase of 113% and three-year delays, this project is not viewed as overbudget.

5.3 Case Study C – New City - Project Details

This New City comprises of thirty-five square kilometres of land and water. The total land area is approximately twenty square kilometres. The City provides residential housing for about 195,000 residents, with mixed-use of retail, commercial, hotels, community facilities and recreational areas. It has an anticipated work and residential population of 450,000. The project commenced in 2012 and is continuing with an expected completion of 2021. This is significantly longer than its planned duration of five years, and the budget has increased by twenty-four per cent to date.

Changes during the construction of the megaproject

This twenty-four per cent cost increase would equate to £1.5 billion. The city was developed through various masterplans which emerged as the city evolved. There was a total of 17 masterplans reflected a significant progression with changes in land use within the city. Additional infrastructure works were done including other bridges to cater for newly created islands. The mix of retail and residential evolved as investors purchased plots, and the city met updated standards from the Statutory Authorities governing road and utility standards throughout the state. These included changes to the Traffic Control systems, a nationwide initiative to make key roads intersecting the Country as Freeflow (no traffic lights). The road authorities removed roundabouts from current construction projects and generally upgraded the specifications for road surfacing and lighting. The revised mix of tenants also gave rise to a significant change in the utility distribution network and associated facilities (substations and transformer capacities).

Based on a reduced income from commodities from 2014 to 2016, there was a Statewide initiative to reduce the costs of infrastructure projects, including the postponement or cancellation of services considered as non-essential. This resulted in reductions to the number of staff engaged in the management of the construction process and the reduction in rates and salaries to all parties. Deferment of non-essential landscaping, removal of provisions for Artwork and ornate lighting proposals were considered to reduce the budget. The project is still progressing using reduced rates for consultants. The scale and scope of works have increased to cater for timely completion of the works before the 2022 World Cup as the intended venue for the closing ceremony. Overall the Cost Consultant believes that value for money was achieved. The cost budgets have been increased, and despite the forecast, six-year overrun, the revised and improve city shall be seen as a financial success.

5.4 Overall Findings

Individually each of the three megaprojects experienced multiple changes through their evaluation. At first view, these megaprojects were over budget by 17 %, 113% and 24% equating to a cost increase of almost two billion pounds. They were each impacted by a global downturn in oil prices and incurred substantial variations and time delays throughout their lifespan. Despite each megaproject being *over budget*, each of the Cost Consultants considered the project as a financial success. This is based on their experiences with construction costs and the knowledge that variations cost money. They do not find that the megaproject was *overbudget,* as they have appropriately adjusted the initial budget progressively to match the Employers updated requirements.

6 CONCLUSIONS AND WAY FORWARD

This research recommends that cost overruns in megaprojects should be evaluated by capturing the detailed contextual knowledge of the project construction cost consultant and avoid the simplistic approach of deducting the initial and final costs and labelling all differences as 'overbudget'. While time and cost risk make up a reported 40 plus per cent of documented risk and is prey to sensational headlines, this author recommends that megaprojects should be considered at a more holistic level. When gauging the success or failure of megaprojects, it is essential to examine all complexities and characteristics associated with megaprojects, such as the consideration of risk and culture (Garemo et al., 2015; Pollack et al., 2018a; Söderlund et al., 2017). It is well known to professional construction consultants that the cost increases in such megaprojects are often explained by changes to the project scope. It urges caution in the use of distorted figures and allegations of financial mismanagement, without a fuller examination of the facts. Three megaproject case studies in the Middle East were carried out, and all found evidence from the cost consultants that increases of up to two billion pounds were explained and justified and the project cannot, therefore, be accurately described as 'over budget'.

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ESTABLISHING THE COST CONTRIBUTION OF SIGNIFICANT CASH FLOW FACTORS IMPACTING ON BUILDING PROJECTS PROFITABILITY

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Abstract: The competitive construction industry is vital to a nation's economy. Low mark-ups are introduced by contractors in job biddings to afford chance of job acquisition. This results in cash flow challenges and profitability that lead to company failing. This paper tries to determine the cost contribution of established significant cash flow factors on building contracts to aid in the effective cash flow and profit management. Purposive and census sampling techniques were employed which resulted in 39 D1 contractors and a response rate of 87.18% was obtained. It was established that wages of labour and staff and replacement of defective work accounts for 26.75% and 3.53% respectively of contract sums. It was therefore established that projects are mostly financed with short-term loans from banks and contractors' own financing due to late payment. Late payment issue motivates contractors to seek for various funding options and it was established that this contributes 20.44% average loss of projected profit and that affect quality delivery. Consequently, this results in defective works which was established to accounts for 3.53% of the contracts sum. The onus therefore rests on management to effectively manage these factors through application of suitable techniques to enhance profit through effective cost minimization.

Keywords: Cost, profitability, cash flow, construction industry

1. INTRODUCTION

Lee (2009) proffers that construction is a high-risk industry however an important sector of any national economy. Liquidity is the utmost significant resource for every construction firm is, with cash flow forecasting seeking to evaluate the distribution of expenditure and revenues of projects. Considerable profitability for any firm's growth is vital but contractors experience challenges in meeting targeted profit (Akintoye and Skitmore, 1991). This is ascribed to the tremendously competitive atmosphere in which the industry runs, and contractors cannot survive without effective management (Liu *et al.*, 2009). Consequently, contractors are influenced to present low profit margins in bids to compete within the industry (Mohamid, 2012) and this affects company liquidity. Studies have identified lack of liquidity and represents a major challenge towards the failure of construction projects and bankruptcy of construction companies (El-Kholy, 2014; Singh and Lakanathan (1992). The enhancement of profit has been shown by contractors through cost control measures to reduce cost and increase revenue (Chen and Chen., 2005). Construction managers has similarly been reported by Lee (2009) of paying limited attention to profit but rather contract sums relating to site and fixed costs which explain why only a third of medium-to-large companies make profits but are low on turnover and capital. The risks in cost of production underestimating makes contractors liable to the risk of failure though this may lead to the realisation profit in the long term. Several construction firms in the US fail as a result of impractical profit earned on projects executed (Halim, 2014). Profit margin reduction is informed to have an impact on the quality of delivery which later influences the industry's contribution to the economy (Gundecha, 2013). Predictive models have been established on forecasting, planning and management in studies in the construction and other industries. Given that contractor cash flow shortages remain general and entrenched within the Ghanaian construction industry, this research aims to develop a model(s) of cash flow factors that predicts profit. In realizing this aim, the research objectives seek to: i) establish the cost contribution of identified significant quantifiable cash flow factors. An accompanying objective is to safeguard that such research contributes to conserving the invaluable contribution that the construction industry makes towards a nation's economic prosperity

2. CASH FLOW AND LIQUIDITY IN THECONSTRUCTION INDUSTRY

The construction industry is reported to be key to a nation's economic health and contributes closely 7-10 percent of gross domestic product (GDP) value (Yong and Mustaffa, 2012). Approximately 7%, 8% and 5.5% within Europe, the United States and Turkey respectively of all workers are employed in the construction sector (Kazaz *et al.,* 2008). Several studies globally have been undertaken to address the performance enhancement challenge through effective cash flow management. Nguyen *et al.,* (2004) investigated the difficulties confronted by Vietnam's construction sector and establish that the capital loss ratio accounts for 30% of total construction capital as a result of ineffective management. The upsurge of competition for jobs and level of corporate failures in the industry have led to weakening in output and orders (Kehinde and Mosaku, 2006). These competitive pressures contribute to the diversion of surplus resources into other areas of business investment termed as 'cash farming' (Kehinde and Mosaku, 2006). Banks and lenders become unwilling in approving loans to contracting firms under such circumstance, as there may be insufficient security to secure the loan (Asante, 2014; Shubita and Alsawalhah,2012; Gambo and Said; 2014).

Industrial sickness has also been acknowledged to be a very piercing problem which unpleasantly affects the industrial health and the economy at large (Navulla and Sunitha. 2016). This happens when a company at the end of any financial year, accumulates losses equivalent to or exceeding its entire net worth and has suffered cash losses in such financial year and the financial year immediately preceding such financial year. Empirical studies further reveal that a connecting relationship is apparent between ineffective management of working capital and 'industrial sickness' (Arshad and Gondal, 2013). This supports the assertion of Sambasivan and Soon (2007) revelation that, 17.3% of Malaysian government contracts in 2005 suffered industrial sickness that led to delay or abandonment of projects. Likewise, Arditi *et al.,* (2000) reported on project failure in the US construction industry that was caused by macroeconomic and budgetary issues. Statistics specify that at least 80% of these failures (*ibid*) were contributed by 27% of insufficient profit, 23% weakness in the industry, 18% heavy operating expenses, 8% inadequate capital and 6% burdensome institutional debt. This steady manifestation causes failures in the industry and further contributing to redundancy, none availability of good and services and prices spiraling up (Singh,2011).

The Ghanaian construction industry is one of the highly regulated industries (Anaman and Osei-Amponsah, 2007) and contributes approximately 8.5% to the overall Gross Domestic Product (Akomah and Jackson, 2016). It is ranked third behind agriculture and surpassing the manufacturing industry (Donkor *et al.,* 2014). Couple to these, the industry is placed ninth to offer employment among the seventeen industries within its economy with an employment rate of merely 2.3% (Akomah and Jackson, 2016). Within Ghana, the sector is manifest by poor performance (Akomah and Jackson, 2016), hitherto the domestic construction sector is one of the fastest growing sectors with a remarkable average growth rate of 7%-8% (Osei, 2013). Little attention has been directed to the industry compared to agriculture, tourism, information and technology communication sectors and sports sectors as the main economic growth drivers (Anaman and Osei-Amponsah, 2007). Studies have unraveled the dominance by small–scales building contractors constituting over 90% of the job market (Amoah *et al.,* 2011) and many directors of the larger Ghanaian owned firms have little or no knowledge about the industry (Akomah and Jackson, 2016). This consequently contributes to non-application of basic management techniques in solving project problems and failure to meet performance target (Ofori-Kuragu, 2013). Akomah and Jackson (2016) reported that, a decline in growth is observed as a result of lack of knowledge and leads to disorganized use of resource. This is also characterised with problems such as underestimating and the use of incorrect data in rates building resulting in profit losses. Working capital plays a substantial role in improving firms' profitability (Makori and Jagongo, 2013) and the prevailing high inflationary rate makes the industry unstable. This reduces contractors' capital hence makes it difficult in managing firms (Dansoh, 2005) and prevent local contractors to compete with foreign and large firms.

Ofori (2012) proffers that a prevailing lack of measurable targets exist for enhancing the industry's general meagre performance in developing countries. This poorly impacts the financial profitability of firms and employee motivation (Ng *et al.,* 2004). Contractors lose skilled personnel under such circumstances and therefore reduce output and profit generation. Statistics gathered between 1995 to 2005 from the South Africa construction industry for example, indicate that 5907 construction firms were properly liquidated (Amoako, 2011; Thwala and Mofokeng, 2012) thus further underlining the need to address the challenges confronting the industry through adequate cash flow management.

3. CONTEXTS AND PERSPECTIVES ON PROFITABILITY

Profitability is defined as the earning of a firm or consistency of cash inflows of a firm (Kouser *et al.*, 2012). Vieira (2010) similarly defined profitability as the final measure of economic success achieved by a firm in relation to the capital invested. This refers to income less expenses before taxes, or net operating income. Vieira (2010) reported that, success is established by the magnitude of the net accounting profit. Profitability can also be relayed to the variation in output due to either cost minimization or increase in demand. The minimization cost comes with the investment in more productive capital equipment whiles demand increase motivates expansion on the part of firm. An indispensable indicator of a firm's competitiveness as well as a major indicator of the quality of management of firms is its profitability. It gives a reflection of the financial performance in the narrow sense with regards to the capability of a firm to produce a return on investment as well efficient management of assets. Profitability can be expressed as a percentage of profit over turnover or return on capital invested. Clutts (2010) further defined the profit for private companies as the additional gained income above an investment. It has been approved with research traditions that, firm's profitability is among the most relevant dimensions of multidimensional concept of performance (Pattitoni *et al.*, 2014).

Maes *et al.* (2003) reported that, source of financing is achieved when enough profitability is retained on which earnings are generated. This henceforth protects contractors from outsourcing finances. Pattitoni *et al.*, (2014) also stated that, higher opportunity cost of capital reduces firms' accessible set of profitable investments and this will have a negative relationship with profitability realised. Pattitoni *et al.* (2014) also stated that, firm's profitability is influenced by the commitment level of majority shareholders. This is as a result of requirement of compensation by majority shareholders due to the exposure to distinctive risk. This, hence, suggests a constructive relation between commitment level and profitability. Shareholders therefore choose higher commitment level when the firms' opportunity cost of capital is low. The opportunity cost of capital and majority shareholder commitment level at this instance is fundamentally related to each other and indirectly affecting firm profitability. More so, keeping a large share of current assets may be detrimental for a company profitability (Bolek and Wilinski, 2012) and this happens when the excess cash relating to expected costs does not play a role in the earnings and profit generation. It only serves as security for unexpected event such as sudden increase in demand or problems with supplies.

The engagement of resources in current assets introduces some benefits and losses and, in the event, when the losses exceed the gains, it gives an indication of a further growth in current assets. This increases the financial security but may cause a decline in profitability (Bolek and Wilinski, 2012). More so, profitability enhancement is reported when the cash conversion cycle is reduced and Napompech (2012) stated that, an increase in the cash conversion cycle by a day contributes to a decline in the gross operating profit of 0.60%. Napompech (2012) further reported that, the ability of financial managers to successfully manage receivables, inventories and payables has a major impact on the success of the business. Napompech (2012) also cited Erasmus (2010) and Nazir (2009) that, firm investing with an insufficient capital in cash, trade receivables or inventories, will experience difficulty in executing the daily tasks and this may result in diminishing revenue and profit.

3.1 Profitability in The Construction Industry

The construction industry is a competitive environment and exposed to risk hence, it is essential to achieve an appreciable profitability for the growth of any company. Contractors usually experience challenges in meeting targeted profit (Akintoye and Skitmore (1991) and this influences the use of low mark-ups in bidding for jobs to provide high chance of job acquisition. Notwithstanding the conditions of the industry, contractors strive to perform to survive in business. The understanding and implementation of efficient management process is key to be able to perform and survive in the industry. Countless researches have been undertaken to address challenges confronting contractors in their business sustenance. Akintoye and Skitmore (1991) reported that, contractors reduce profit intentionally for short term by buying work to survive or acquire additional works from same clients. With this action, contractors become liable to the risk of failure due to the dangers in the underestimating production cost though this approach could lead to long term profit realisation. According Halim (2014), the realisation of unrealistic profit from projects executed contributes to the failure of many US construction firms. Halim (20014) and Mohamid (2011) further reported findings that, insufficient profit caused about 27% of construction firms in the United States to fail. Aside these failures, 4.7% margin of profit is reported to be generated by the United Kingdom construction firms (Halim, 2014). This is conflicting to the generation of an average of 47% and 18% from firms that concentrate on infrastructure and real estate respectively which are considered as non-construction works.

Businesses in the industry are not to be making profit all the time on every won tender but rather realise a reasonable profit on aggregate business activities. Hong Kong construction firms is reportedly suffering from decline in business and profitability and this can be related to the dominance of low levels of profitability in the short term with the expectation of maximisation in the long term. Halim (2014) further reported that, Hong Kong construction industry experienced an average of 18% net loss between 1993 to 2000 and this gives an indication of the extent to which the revelation impact on the profitability during the period. Hence, this contributes in some firms struggling to preserve their financial performance. Therefore, contractors have shown profit enhancement through cost control measures to reduce cost and increase revenue (Chen and Chen., 2005). The unfamiliarity of the menace involved in bidding and strong competition in the industry contributes to the low profitability levels in the industry. Firms have been identified to be more profitable than what statistics establishes (Akintola and Skirtmore. 1991). This variation may be intentional to reduce tax or engage in other construction business related to generate further profit to support the low earn profit in construction. This action is deliberately engaged to offset tax alongside other business. Ling and Liu (2005) also stated that a project that generates a profit of margin above 5% in Singapore is deemed profitable. Therefore, it can be deduced that, when a contractor is able to win more contract and realise this threshold, the company is likely to be making more profit. This can be acknowledged with Ling and Liu (2005) statement that, contractors who win a project in every five bid are classified successful.

The uncertainties contractors encounter in estimating can be ascribed to the inaccuracy in resource forecasting and this contributes to declining profitability. Large companies at this instance perform better and are more profitable in this sense since they are more efficient and well controlled than smaller companies. This is because there are varying management strategies and potentially better off in low profitability situation. Moreover, large firms are likely to have well defined pricing policies and objectives that will influence bids and therefore the possibility of being more profitable than small firms (Ling and Liu, 2005). Akintoye and Skitmore (1991) also stated that large firms are more consistent and comparable to each other than smaller firms in estimating, pricing and production. The experience of large construction companies to competition or market awareness influence the low margins of profit that restricts the potential for viable alternatives. Above all, large firms possess a higher base of investment which spots them at a higher investment level than in other activities and this explains why large firms generate higher profitability than small firm in the industry.

4. METHODOLOGY

Adjei et. al. (2018) established the significant quantifiable cash flow toward the attainment of the aim of this study. Twenty-five (25) quantifiable cash flow factors were identified and with the use of one-sample test and principal component analysis (PCA), four factors were unraveled namely: wages of labour and staff; progress payment duration; bank interest rate; and replacement of defective works. The study was undertaken on contractors with D1 classification, registered with the Association of Building and Civil Engineering Contractors-Ghana and in good standing. D1 class of contractors are the highest classified firms and are presumed to be large with the financial muscle to execute large volume of works which is accompanied with the use of huge sums, large equipment and personnel. This therefore positions D1 contractors to develop policies and strategies to manage these funds. Purposive sampling was employed in Adjei et. al. (2018) and respondents were required to express their willingness to participate in the second-round of survey to establish the cost contribution of the unraveled significant factors. A total 39 respondents were obtained round from the first-round survey and this formed the basis for the sample size for the second-round survey. Consequently, the identified significant factors were developed into questionnaires towards the establishment of the cost contribution of the identified factors. This tool of data collection was employed to facilitate the use the results of this study in the development of a profit predicting model. A census survey was employed in administering the questionnaires. According to Kothari and Garg (2014), census survey is employed when the objective of a study is serious in nature and require information on every sampling unit. Couple to these, if population is not large and money is not important factor, census survey affords better results than any sample survey on condition that, trained and efficient staff are employed. Data was subsequently gathered from retrieved questionnaires and analysed.

4.1 Data Analysis

The measure of central tendency (mean) which refers to arithmetic mean or average was employed. It is of special importance in statistics as it describes the centre of the probability distribution (Walpole et. al (2007). Furthermore, it is useful in determining the overall trend of data set or offering a rapid snapshot of data in addition to its being very easy and quick to calculate (Begum and Ahmed (2015). Mean value is highly sensitive and not resistant measure as it is influenced by extremely high or low data values (Brase and Brase, 2007). It is computed by summing the observation and divided by the number of observations (Begum and Ahmed, 2015). The expression for the mean is show in equation 1:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$ Equation 1 (Curwin et. al., 2013; Brase and Brase, 2007)

Where:

$\bar{x}$ = mean
x_i = respondents
n = total number of respondents

Dispersion or standard deviation was also employed in analyzing data. This tool provides a measure of distribution or spread of data around an expected value or mean (Begum and Ahmed (2015). Statistically, it is the most significant measure, directly related to mean and widely used to measure dispersion (Curwin et. al., 2013). In selecting the mean as the most appropriate measure of central location, the standard deviation therefore become the natural choice for measuring dispersion. A large value of standard deviation depicts a that more data widely spread from the mean while lower value gives an indication data aligning with the mean (Begum and Ahmed, 2015). In research, standard deviation is suitable in defining the variation or spread in responses. Standard deviation is of the same unit as the mean and any change in unit will correspondently change the value.

$$s = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}$$ Equation 2 (Curwin et. al., 2013; Brase and Brase, 2007)

Where:

$\bar{x}$ = mean
x_i = respondents
n = total number of respondents

5 RESULTS AND DISCUSSION

A total of 34 responsive questionnaires were received representing 87.18% response rate. The variables under interrogation were wages of labour and staff, progress payment duration, bank interest rate and replacement of defective works.

5.1.1 Wages of Labour and Staff

It was revealed that a minimum and maximum of 12% and 55% respectively constitute the cost of labour on any project. It was also identified that, 21 of the respondents employed between 20% and 30% as the labour component. Couple to these, 7 respondents employed above 30% of contract and this resulted in an average and standard deviation of 26.75% and 9.22% respectively. This affirms studies that established that labour accounts for close to for a third of the total direct capital cost of construction projects (Hafez et. al. 2014, 2002; Ng et al, 2004). The range and dispersion observed can be ascribed to the specialized works usually undertaken comprising less cost of materials and high cost of specialized labour. Figure 1 shows the distribution of labour cost components employed in pricing works.

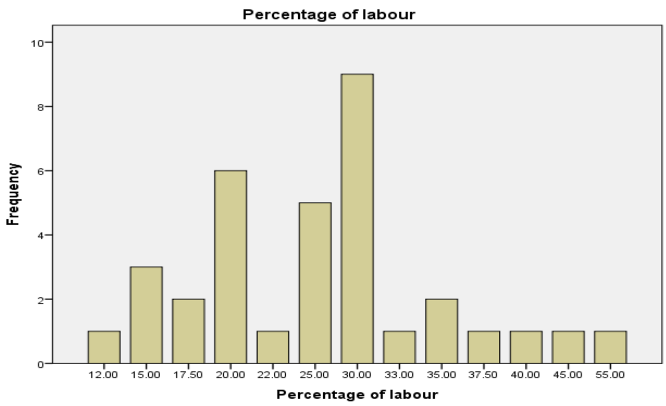

Figure 1: Distribution of Labour Cost Components

5.1.2 Progress Payment Duration

Liquidity plays a key role in the successful project delivery and its timely and periodical payment is very critical in maintaining a planned cash flow on project delivery. A total of 26 revealed that, payment schedules agreed in contract are not followed. This situation contributed to respondents' admission to the influence payment schedules have on cash flow and its impact on the project delivery. Figure 2 shows conformity of payment schedule on construction projects.

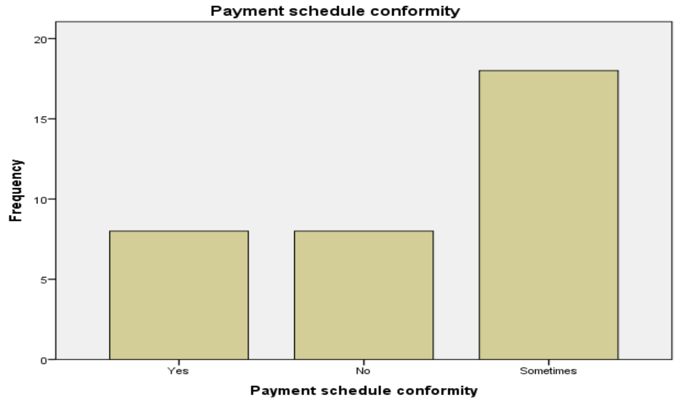

Figure 2: Conformity of Payment Schedule

It can be identified in Figure 3 that, 29 respondents indicated that, the periods with which payments are effected do always and sometimes influence project cash flows.

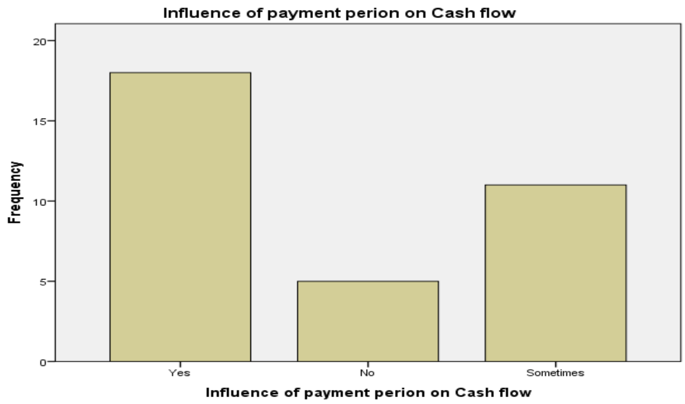

Figure 3: Influence of payment on cash flow

The conditions of contract have been silent on certificate preparation duration for payment. An investigation to discover the duration taken to prepare payment certificate unraveled a minimum of one week and maximum of sixty weeks and this is dependent on the client. This resulted in an average of 14.12 weeks with a standard deviation of 13.72 weeks. The dispersion can be attributed to the type and size of project as well as the client involved. An average minimum and maximum 8.56 weeks and 51.56 weeks respectively were established to be late payment duration. These results fall within Master Builders Association of Malaysia (MBAM, 2005) study in Malaysia as cited in Badroldin et. al. (2016) in which delay payment ranges between 91 days (18 weeks) and 12 months (52 weeks). Contrary in Badroldin et. al. (2016) whereas the agreed contractual term is between 25-35days (5-7 weeks), payment is effected or honoured between 15-25 days (3-5weeks). Only 5 respondents indicated interest on delay payments have always been honoured whiles 10 indicated non-regular payment of interest as shown in Figure 4. This clear establish that interest payments are not often honoured. These instances contributed to the establishment of an average loss of profit of 20.44% with standard deviation of 20.08%. The large deviation can be attributed to the range of 100% obtained from the study.

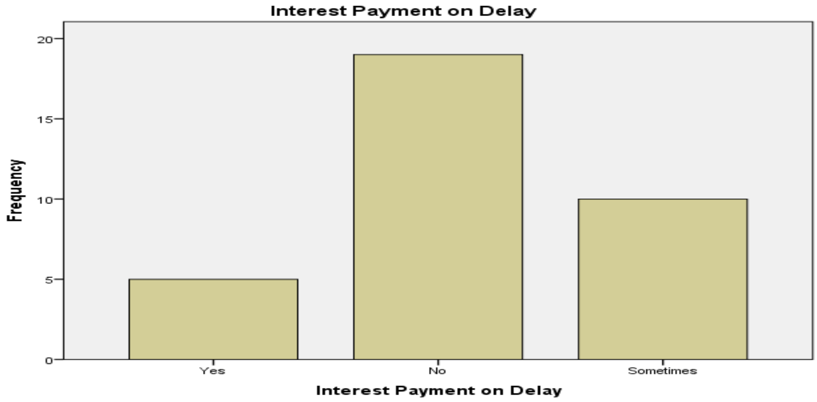

Figure 4: Interest on Delay Payment

5.1.3 Bank Interest Rate

Liquidity is essential as the industry is capital intensive and operate in a highly competitive environment accompanied with associate risk. It was established in this study that, labour is very significant in attaining a targeted profit and this constitute approximately 26.75% of the total cost of project. In the bid to execute the project timeously, funds are expended on labour and other related cost as well as cost in rectifying defects. However, payments are not effected on time as specified in contracts and this goes to compound the risk confronting contractors in the delivery which eventually impact greatly on cash flow and targeted profit. Regardless of this challenging risk and as a result of the contractors' reluctance in seeking for redress in payment related issues, external funds are sought to finance projects. The study further investigated into the source and duration funds employed and the interest rates charged on the respective source of funding. From Table 1, it can be identified that 40.08% and 29.97% of the cost of project is being financed through contractor own fund and loan respectively. Associated rates of 13.24% and 32.03 within an average period of 6.44 months and 5.62 months respectively were established. More so, it was recognised that, 15.44% and 19.29% of the cost of the project is being funded from overdraft and credit at a rate of 29.94% and 7.94% respectively. Additionally, these sources of funding were employed within 2.78 months and 1.87 months correspondently. A further interrogation on the financing combination option was also sought and revealed the results presented in Table 2.

Table 1: Source of Funding of Project by Contractors

Source of fund	**Average Composition (%)**	**Average Rate p.a.**	**Average Duration (months)**
Contractor	40.08	13.24	6.44
Loan	29.97	32.03	5.62
Overdraft	15.44	29.94	2.78
Credit	19.29	7.94	1.87

Table 2: Financing combination options of project financing

Options of project financing	Frequency	Percentage	Valid	Cumulative
Contractor financing	2	5.88	5.88	5.88
Loan	6	17.65	17.65	23.53
Contractor financing and Loan	7	20.59	20.59	44.12
Contractor financing and Credit	3	8.82	8.82	52.94
Overdraft and Credit	2	5.88	5.88	58.82
Contractor financing, Loan and Overdraft	2	5.88	5.88	64.70
Contractor financing, Loan and Credit	4	11.76	11.76	76.46
Contractor financing, overdraft and credit	5	14.71	14.71	91.17
Contractor financing, loan, overdraft and	3	8.82	8.82	100.0

5.1.4 Replacement of Defective Works

Good workmanship is essential to avoid correcting errors or defect and this can be achieved through adherence to specification and good workmanship. It was unraveled that 9 and 25 of respondents do always and sometime encounter replacement of defective works as shown in Figure 5. This clearly indicated that construction works cannot be executed successfully without defects being encountered and replaced. It was also observed that an amount ranging between 0.10% - 10% of the contract sum is usually earmarked for defective works however this amount can be well managed with the engagement of qualified personnel and to specification. The range might be attributed to the value of some specialized works which are usually executed by D1 contractors and are accompanied by high cost. Therefore, a lower percentage of such value will realize an appreciable value to get the defect remedied. More so, replacement of defective works was found out not to be predetermine. A dispersion of 2.90% and a corresponding average of 3.53% were established as the maximum to cover the cost of defective works. It will be appreciated that all defect is rectified not only after practical completion but prior to take-over as well. This also affirms Josephson (1998) study which stated that the cost of defects replacement amounts to 4.4% of production cost and takes almost 7% of the total time to have replacement effected. Mills et. al (2009) established cost of defect rectification 4% of the construction contract value also goes to support the established results relating to this significant factor.

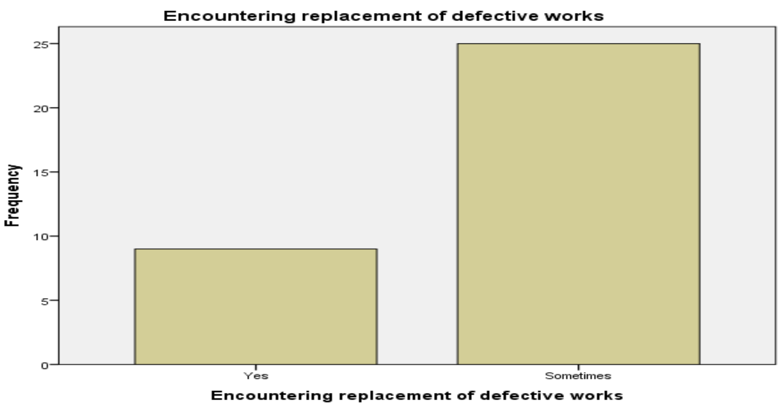

Figure 5: Encountering replacement of defective works

5.1.5 Profit Margin

The profitability predictive model development cannot be accomplished without the establishment of the margin of profit. The competitive working environment prevailing within the construction industry influence contractors to introduce low profit margin with the aim of winning bids. An employer awards contract to the lowest evaluated responsive bidder, however, reserves the right to accept or reject any bid at any time prior to award of contract. With these conditions being worked with, it was revealed that profit margin usually used in bids range between 4.00% and 35.00% with an average of 16.46% and a dispersion of 7.68% A maximum deviation from projected was also revealed to be 40.00% with an average of 7.62%.

Studies on the Australian Construction Industry established an average 10.0% as the profit margin of contractors in the industry with an annual exit and entry rates of 15.0% and 14.3% respectively (Bankwest, 2017). The Deloitte (2016) report on Victoria Builders Association also revealed a thin margin between 0.3% and 0.4% between 2013 and 2015. However, the report further indicated that, the range of profit margin between 1.3% and 3.5% before tax existed nationally for largest Australian non-residential construction firms.

Hastak (2015) revealed that, the estimated and actual profit margin on a case study was also established to 18.7% and 14.65% respectively with a deviation of -4.05%. PWC (2013) reported on South Africa construction industry that, the profit margin realized ranged between 5% and 6% prior to 2010 FIFA World Cup as a result of the global economic boom. Nevertheless, this was eroded between 2% and 3% due to the pertaining competition over the long term. In a study conducted on the Ghanaian construction industry, Laryea and Hughes (2009) reported that, a margin between 15% and 35% were applied by bigger contractors to absorb any unforeseen works (ibid). Due to the risk associated with construction, contractors do not meet projected profit, and this can be associated to the higher exit rate comparable to entry rate. Therefore, it was established that, Ghanaian contractors usually include a margin between 5% - 7.5% to the profit as risk allowance (Laryea and Hughes, 2009). An effective management of the cost related to the identified significant factors will have a corresponding risk minimization that will translate into reducing deviation from profit.

6 CONCLUSION

As a result of the construction being demanding and capital intensive, there is the need for contractors to manage resource to improve cash flow and further contribute to profit. The purpose of this survey was to establish the cost contribution of identified significant cash flow factors to the project cost however, 34 responses were received representing 87.17% response rate. It was subsequently established that wages of labour and staff accounts for 26.75% of the total cost of a project. The study recognized the influence of progress payment duration on contractors' cash flow and revealed that, payment for certified works are effected between 2-12 months. This delay subsequently impacts negatively on the projected profit by 20.44%. However, contractors are reluctant in pursuing for interest on late payment for fear of being blacklisted and subsequently take them out of business. As a result of the delay in progress payment contractors are confronted to seek for funds to finance projects. It was therefore unraveled that 40.08% and 29.97% of the project cost are usually financed through contractors' own funds and loan respectively at a corresponding rate of 13.24% and 32.03% as and when appropriate and available. Couple to these, 15.44% and 19.29% of the project cost was also established to be funded through overdraft and credit at a rate of 29.94% and 7.94% respectively. The study further revealed that, contractors sought for various funding options depending on availability and eligibility of the fund. It was subsequently revealed that, 20.56% of respondents employed contractor own funds and loan to finance projects while 17.65% employed only loans. Additionally, 14.71% employed contractor own funds with overdraft and credit whiles 11.8% also use contractor own funds with loan and credit to finance projects. It can therefore conclude that, the risk contractors encounter might have influenced these results. It is therefore the duty of managers to effectively manage factors through cost minimization that will translate into profit enhancement.

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A REVIEW ON APPROPRIATE TOOL TO PREDICT PROFITABILITY OF BUILDING PROJECTS USING ESTABLISHED SIGNIFICANT CASH FLOW FACTORS

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Abstract: The construction industry is a competitive environment which influences contractors in using low mark-ups in bidding for jobs to afford great chance of job acquisition. This makes contractors experience challenges of profitability management due to the risk associated with construction activities resulting in construction failures. The risk noted with construction, therefore requires effective management of cash flow and profit with the use of an appropriate tools. The purpose of this paper is to establish an appropriate tool to predict profit and aid in its effective management. Searches of predictive models undertaken unraveled numerous models and reviewed abstracts and conclusion to screen to relevant once. Critical examination of these models established three techniques namely: regression; optimization and hybrid. An evaluation of these techniques identified hybrid and optimization techniques possessing high predictive powers and accuracies. However, hybrid techniques are used to enhance performance of either the regression or optimization techniques. Since a novel model is being proposed with respect to variables and yet to establish the performance, the optimization technique is best suited for the model. Besides support vector regression demonstrated high predictive powers and accuracy than other optimization tools therefore, recognized to be the appropriate tool to predict profit.

Keywords: Cash flow, construction industry, model, predictive, profitability.

1. INTRODUCTION

Lee (2009) proffers that construction is a high-risk industry but one of the most important sectors of any economy. Additionally, the most important resource for every construction firm is liquidity, with cash flow forecasting seeking to evaluate the distribution of expenditure and revenues of projects. An appreciable profitability for any firm's growth is vital but contractors experience challenges in meeting targeted profit (Akintoye and Skitmore, 1991). This is accredited to the extremely competitive atmosphere in which the industry operates, and contractors cannot survive without effective management (Liu *et al.,* 2009). Contractors are hence motivated to present low profit margins in tender bids to compete within the industry (Mohamid, 2012) and this affects company liquidity. Lack of liquidity has been identified from studies and represents a major problem to construction projects failure and construction companies' bankruptcy (El-Kholy, 2014; Singh and Lakanathan (1992). Chen and Chen. (2005) indicated that, profit enhancement has also been shown by contractors, through cost control measures to reduce cost and increase revenue. Lee (2009) also indicated that construction managers pay less attention to profit but rather contract sums relating to site and fixed costs which explain why only a third of medium-to-large companies make profits but are low on turnover and capital. The dangers in underestimating cost of production make contractors liable to the risk of failure though this may lead to profit realisation in the long term. Many United States' construction firms fail as a result of unrealistic profit earned on projects executed (Halim, 2014). Reduction in profit margin is reported to have an impact on the quality of delivery which subsequently influences the industry's contribution to the economy (Gundecha, 2013). Predictive models have been established on forecasting, planning and management in studies in the construction and other industries. Given that contractor cash flow shortages remain general and entrenched within the Ghanaian construction industry, this research aims to develop a model(s) of cash flow factors that predicts profit. In realizing this aim, the research objectives seek to: i) review literature on predictive models; and ii) suggest an appropriate tool to predict profitability.

2. **PROFITABILITY IN THE CONSTRUCTION INDUSTRY**

The construction industry is a competitive environment and exposed to risk hence, it is essential to achieve an appreciable profitability for the growth of any company. Akintoye and Skitmore (1991) stated that, contractors generally experience challenges in meeting targeted profit. This influence using low mark-ups in jobs bidding to provide high chance of job acquisition. Aside the conditions of the industry, contractors strive to perform to survive in business. The understanding and implementation of efficient management process is required to be able to accomplish and survive in the industry. Studies have been undertaken to address challenges meeting contractors in the sustenance of business. Akintoye and Skitmore (1991) reported that, contractors reduce profit deliberately for short term by buying work to survive or acquire additional works from same clients. The dangers in underestimating production cost makes contractors liable to the risk of failure though this could lead to long term profit realisation. Halim (2014) also reported that, several United Ststes' construction firms fail due to the realisation of unrealistic profit from works executed. Halim (20014) and Mohamid (2011) further reported that, inadequate profit caused about 27% of construction firms in the United States to fail. Nevertheless, the United Kingdom construction firms are also reported of generating a 4.7% margin of profit (Halim, 2014). This is contrary to the generation of an average of 47% and 18% from firms that concentrate on infrastructure and real estate respectively which are considered as non-construction works.

Businesses in the industry are not to be making profit all the time on all tenders won, rather realise a reasonable profit on aggregate business activities. Hong Kong construction firms have been suffering from reduction in business and profitability. The domination of low levels of short-term profitability with the expectancy of long-term maximisation can be associated to this state. Halim (2014) also reported that, an average of 18% net loss between 1993 to 2000 was experienced by Hong Kong construction industry. This gives an indication of the extent to which the revelation impact on the profitability during that period. Hence, this motivates some firms in struggling to preserve their financial performance. Contractors, hence, have shown profit enhancement through cost control measures to reduce cost and increase revenue (Chen and Chen., 2005). The strangeness of the risk involved in bidding and keen competition in the industry contributes to the low profit level in the industry. Firms are more profitable than what statistics establishes (Akintola and Skirtmore, 1991) and this discrepancy may be deliberate on the part of firms to reduce tax or engage in other construction business related to generate further profit to support the low profit earn in construction. This action is intentionally employed to offset tax alongside other business. A project that generates profit of margin above 5% in Singapore is deemed profitable (Ling and Liu, 2005). It can therefore be construed that, when contractors are able to win contracts and realise the threshold, the company is likely to make more profit hence profitable. This can be acknowledged with Ling and Liu (2005) statement that, contractors who win a project in every five bids are classified successful.

The involvement of contractors in design further contributes to the profitability on project and Ling and Liu (2005) reported that, the margin of profit is enhanced by 3.5% when contractors are involved in design-build project than construct only. The inaccuracy in forecasting resources is one of the reasons of reduction in profitability generation and can be attributed to the uncertainty contractors meet in estimating. Large companies at this instance perform better and are more profitable in this sense since they are more efficient and well controlled than smaller companies. This can be ascribed to the varying management strategies and potentially better off in low profitability situation. Moreover, large firms are likely to have well defined pricing policies and objectives that will influence bids and therefore the flexibility of being more profitable than small firms (Ling and Liu, 2005). Large firms are also more consistent and comparable to each other than smaller firms in estimating, pricing and production (Akintoye and Skitmore, 1991). The exposure of large construction companies to competition or market awareness influence the low margins of profit that restricts the potential for viable alternatives. Above all, large firms possess a higher base of investment which positions them at an investment level higher than in other activities. This explains why large firms generate higher profitability than small firm in the industry hence, the need to propose a technique to predict profit that will aid its effective management.

3. METHODOLOGY

An extensive literature search was conducted systematically and purposefully to identify relevant articles. This was accomplished through searching literature with key words and phrases ‘profitability models’, ‘cash flow models’, ‘construction predictive models’ and ‘predictive models’. These searches were done in the database of Journal of Financial Management of Property and Construction, Construction Management and Economics, Journal of Civil Engineering and Management and Engineering Optimization. In addition, search was conducted in Automation in Construction, International Journal of Engineering Research and Application, Journal of Public Transportation, Journal of Geochemical Exploration, International Journal of Construction Management and Computer Aided Civil and Infrastructure Engineering. Couple to already mentioned databases were Pakistan Journal of Commerce and Social Science, Journal of Statistics and Management System, International Journal of Construction Engineering and Management, Engineering, Construction and Architectural Management, Applied Financial Economics and Journal of Business Cases and Application. More so, a further search on google with the same keywords resulted in unpublished thesis and other conference publication relevant to the subject matter. A meta-analysis which refers to the analysis of analyses was employed, and this involved the casual and narrative discussion of research studies that characterize attempts to make sense of expanding literature (Ismail, 2011). Couple to this a qualitative meta-analysis which refers to the systematic review of literature without having any mathematical synthesis was adopted. The returned number of articles and thesis were screened by reading the abstract, conclusion and in some cases the contents of abstract to reduce the articles to relevant once. However, in view of arriving at the appropriate models, the scope was not limited to only profitability or cash flow but other areas and these were categorized under various techniques.

4. PREDICTIVE MODELS

Countless studies have been undertaken in forecasting, planning and management with respect in the construction and other industries. Khosrowshahi and Kaka, (2007) revealed that mathematical models possess greater advantages of being practical, simple, fast and not requiring extensive information about projects. Various comparative studies have been conducted between the traditional or conventional techniques. An assessment on the various model established the techniques into two categories namely: Regression and Optimization techniques.

4.1 Regression Techniques

Regression techniques fall in a broad category of regression analysis. It is employed to predict a continuous dependent variable from several independent or input variables and divided into linear and nonlinear regression. Studies have been undertaken with these techniques among which is the structural model by Maes and Sel (2003) developed to investigate the direct and indirect effects of owner-manager human capital characteristics. Liu *et al*. (2009) also integrated analytic hierarchy process (AHP) to develop a stochastic model that studied the effect of cash flow factors on contractors' cash performance and forecasted cash flow more realistically by incorporating the identified factors. Chen *et al*. (2011) also developed a cost-payment model for project cost flow forecasting. One of the objectives of this study was to develop a coordination mechanism capable of resolving and / or alleviating problems of cost schedule integration model. It also focused on enhancing the accuracy and reliability of forecasts of future cost flows produced by cost scheduling models and established the capability of eliminating deviation between cost flow and historical payment flow. Besides, the model accounts for differential payment lags and payment frequency in addition to absorbing the combined effect of payment irregularity and uniform distribution of cost over time.

Ng *et al*. (2011) also employed vector errors correction (VEC) and regression to address the stationarity of data used with cointegration procedures and differenced regression. The study however focused on macro-economic (cointegrated) variables and the results of VEC exhibited high performance over regression in prediction accuracy and reliability. Odeyinke *et al*. (2012) likewise established a regression model of the risk impact on cost of construction. Eleven (11) risk factors were employed however, yielded an unsatisfactory predictive power. Owing to the limitation to case studies, it was not worthy to segregate data into different procurement methods and type. Makori and Jagongo (2013) more so implemented least square regression to establish the impact of identified risk factors on cost flow forecast on future projects. However, the study was limited to only ten (10) manufacturing and construction companies listed on the stock exchange between 2003-2013. Additionally, Zayed and Liu (2014) automated tool to forecast cash flow integrated analytic hierarchy process and simulation and is to serve as an advance warning flag to project managers. Ahmadu *et al.* (2015) correspondingly developed a multivariate model to determine construction duration and established a high accuracy in prediction with the incorporation of qualitative factors. Mensah *et al.* (2016*a*) predictive working model on the duration of bridge construction also produced high accurate results in prediction and validation. This therefore affirmed the model's suitability in determining duration in the presences of some limitation.

4.2 Optimization Techniques

Optimization techniques are use in discovering the optimum solution or unconstrained maxima or minima of continuous and differentiable functions. Countless optimization researches have been conducted in construction and other fields. Kashenas and Haber (1990) optimizing approach focused on minimizing total project cost, however it cannot be easily adopted on large project. Kaka (1996) also identified five factors lacking in current models and incorporated into cash flow forecasting which demonstrated high sensitivity and more accurate than the traditional models. Li (1996) on the other hand employed neural network in mark-up estimation to investigate its effectiveness in relation to regression and resulted in a flexible and dynamic promising model that performs better than regression. Similarly, Boussabaine and Kaka (1998) tried to minimize and addressed the limitation of neural network resulting in little difference between actual and forecasted. A consistency in results was likewise attained by Barbosa and Pimentel (2001) in addressing the problem associated with cash flow management using linear programming model. This demonstrated financial gains, simple structure and the equation allowed for more insight into relationship with external inputs and variables. In the bid to maximize net present value before tax and maximize / minimize qualitative factors, Lam *et al*. (2001) developed a multi-project cash flow optimization model. A stable model that was globally convergent to exact non-inferior solutions of multi objective linear programming in contract with other optimization neural networks was achieved.

An accurate early design phases cost of complex products was estimated by Huang (2007) using support vector regression (SVR). The results from this demonstrated good performance and strong predictable capabilities over other cost modeling techniques such as parametric method, case-based reasoning and neural networking under most conditions. Cattell *et al*. (2008) simplified unbalanced bidding model besides, focused on maximizing the top-line revenue rather than bottom-line profit. The model however encountered difficulties in accomplishment but did not demand benefit from added complexity. Alternatively, a two-stage optimization model by Liu and Wang (2009) for linear scheduling problems considered cash flow using constraint programming. The study was aimed at maximizing profit and minimizing total interruption time for maximizing work continuity. A resulting model to help contractors agree on the amount and timing of borrowing was hence attained. Couple to this, an optimum project schedule formation with appropriate crew formation was also identified. Wichan et. al. (2009) more so developed a model to predict final budget and duration of highway construction projects using ANN. The objectives of the study were to forecast final budget and final time required to finish the highway construction project during construction stage. A more accurate result relative to that obtained from the current method adapted from the earned value technique was achieved. The results furthermore exhibited very stable for both project final budget and project duration forecasting that can provide construction manager with accurate information according to budget and time needed to complete the project.

A support vector regression on the other hand was employed by Listiani (2009) to find a good regression model to explain vehicle residual price. This model revealed a good predicting capabilities and accuracy with the right kernel and hyperparameters setting than the standard multiple regressions. Cui *et al*. (2010) also developed a system dynamics model to maximize project cash flow using overbilling and under billing strategies. These strategies resulted in 11.4% reduction in overdraft and an effective trade credit also reduced overdraft by 19%. Nevertheless, the study was limited to system dynamic software. To be able to maximize final cash balance and minimizing total cost of money, Jiang *et al*. (2011) developed Pareto Optimality Efficiency Network to maximize final cash balance and minimize total cost of money. Though a convincing result was attained, the study was limited to meet the real and complex situation such as client delay payment and penalty on delay payment. Furthermore, a multi period dynamic optimization model by Jiang (2012) provides possible alternatives and scenarios in decisions to achieve project and sound cash balances. It is useful at the contract negotiation stage as it gives a perfect insight in choice of scenario and allows users to define the predicted cash flow planning horizon and maximize the cash balance. Odeyinke *et al*. (2013) alternatively used neural network to develop a model which established a potential in predicting any change in cost flow profile due to the presence of risk. Results established its potential usefulness in helping contractors to predict any change in cost flow due to risk occurring. El-Kholy (2014) on the other hand modified Jiang (2011) study with the aim of maximizing final cash balance as well as minimizing cost of money and initial cash balance. It was however recommended that, any number of objectives with the addition of only one constraint and be employed

Contrary to cash, Hattab *et al*. (2013) developed a model to predict the chromium concentrate in dwarf leaves using neural network which outperformed multiple linear regression modeling. ANNs possess number of significant benefits that make it a powerful, rapid and practical tool for solving many soil engineering problems. Gurmu and Fan (2014) besides developed an ANN model which provided accurate prediction of bus travel times. Though a promising was attained to implement an advance public transport system, it recommended the incorporation of an additional independent variable to improve the model prediction. A synthetic cash flow model with singularity functions for unbalanced bidding scenarios was also established by Su and Lucko (2015). This prepare an artificial cash flow model with retainage to first examine balanced bidding and express the varying markup in unbalanced bidding by way of singularity functions. This model function fits into more complicated situations of the construction management domain but failed to state its predicting capabilities. In addition, was expanding the model toward diverse scenarios of unbalanced bidding. Chen *et al*. (2015) likewise developed a generalized network flow model for the multi-mode resource-constrained project scheduling problem with discounted cash flows (MRCPSPDCF). It was aimed to maximize NPV of all cash flows and this efficiently and optimally solve the MRCPSPDCF although difficulties were encountered. This, therefore affirmed its reliability over the previous heuristic approaches from the optimization perspective. Mensah *et al.* (2016*b*) alternatively developed a model to predict duration of rural bituminous surfaced road projects that demonstrated its appropriateness in duration estimation. However, the predictive power was influence by the small sample size and was limited to executed work items in the BOQ as well as limited to six regions. On the other hand, Wu and Li (2017) nonlinear model aimed at introducing several theories and methods of non-linear models to maximize contribution margins and profit. It demands the use of accurate and sophisticated non-linear models to aid in planning business operations to make more accurate business decisions. An understanding and being able to expertly apply computer technology, such as excel regression and solver toolboxes, can greatly improve business profits

4.3 **Hybrid Techniques**

Hybrid techniques are combination of more than one technique. Every technique demonstrates some strengths and weaknesses characteristically hence, the adoption of hybrid techniques tends to reduce the negative effect of one or more as well as the performance of the other (Bodenhofer, 2004 and Gaba, 2013). An evolutionary fuzzy decision model for cash flow prediction using time-dependent support vector machines developed by Cheng and Roy (2010) infused the advantages of several current artificial intelligences (AI) to overcome the difficulties inherent in cash flow problems. It possessed the potential as a predictive tool for cash flow management to control projects performance. The hybrid intelligence approach based on LS-SVM and Differential Evolution, by Cheng *et al*. (2013) also, aimed to develop an innovative model to predict construction cost index in Tawian. Higher prediction accuracy was demonstrated over other methods, establishing enhanced performance comparable to the other methods. Cheng and Cao (2014) also developed and tested the evolutionary multivariate adaptive regression splines (EMARS) that demonstrated significantly better predictive capabilities in both accuracy appraisal and operation efficiency. Couple to these, Chen *et al*. (2015) established an adaptive time-dependent least squares support vector machine inference model aimed to obtain an optimal model capable of predicting best performance on new data. The evaluation of result and performance demonstrated a robust potential of the new inference model. Cheng *et al*. (2015) also predicted productivity loss using evolutionary fuzzy support vector machine inference. The objectives of this study were to predict productivity loss as a result of change orders and evaluate the feasibility and capability of the model. A high prediction capabilities and accuracy were demonstrated over ESIM, ANN and SVM, however, it requires more computational time.

5. CONCLUSION

Construction profitability is essential to maintain steady work process and contractors' survival in business. It is therefore prudent to make accurate prediction and manage effectively. The purpose of this review is to establish an appropriate technique to predict profitability using the established significant cash flow factors namely: wages of labour and staff; progress payment duration; bank interest rate and replacement of defective works. These variables were unraveled in an earlier paper using principal component analysis (PCA). It can be acknowledged that, all the predictive models come with benefits however possess some limitation(s). This limitation(s) somehow defeats the predictive capabilities, accuracy and reliability of a model. It can be inferred from the review that; optimization and hybrid techniques best perform than regression techniques. In addition, hybrid techniques are recognized of reducing the effect of one and enhance the performances of the other. However, since the established factors are to be employed in a novel model, the strengths and weaknesses of the model are not yet discovered to facilitate the use of a hybrid technique. In view of that, optimization techniques best fit the propose model development. It can also be deduced from the review that models developed with support vector machine (SVM) and support vector regression (SVR) demonstrated high predictive and accuracy performance comparable to other techniques including neural network (NN). This, therefore, exhibits confidence as the best tool for modeling. This is as a result of reviewed models with SVM making comparison with other tools. However, there are two forms of SVM namely: SVM for classification and SVM for regression. Whereas SVM for classification performs classification, predicting discrete categorical labels, SVR performs regression, predicting continuous ordered variables. In view of this, it can be inferred and concluded that the most appropriate tool in profitability prediction is SVR in relation to the dataset available.

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Property and Project Management

EXPLORING HOW PERSONALITY TRAITS IMPACT ON COUNTERPRODUCTIVE WORK BEHAVIOUR ON CONSTRUCTION SITES

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Abstract: The causes of construction accidents have been linked to different factors, one of which is the human factor, which is a by-product of personalities that determine how people react in a work environment. The reported research explores the effects of counterproductive work behaviour (CWB) of construction workers. The study of personalities in the work environment has been explored to, inter alia, predict future CWB among workers in high-risk work environments. An attitudinal scale and CWB checklist were used to categorise workers into personalities as described by the Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (OCEAN) personality trait model, which was followed by a questionnaire survey and interviews with workers. Non-participant observation was also used to identify general CWB on construction sites around Summerstrand, Port Elizabeth, South Africa. The analysed data revealed that workers do not conform to the general definition of CWB in their work environments, although a strong relationship between some personality traits exist. The findings led to the conclusion that CWB on construction sites should be further researched to establish what it means on a project site. This will enable site management to focus on methods that are most beneficial to enable the attainment of set project objectives.

Keywords: Accidents, construction, human-factor, personality traits, safe-work.

1. INTRODUCTION

The growth of an economy is measured by its ability to realise infrastructure development. Zin and Ismail (2012) suggest that construction accidents linked to human factors inhibit the effort of any economy from meeting its infrastructural goals, and suggest that construction managers must make it a duty to ensure such accidents are minimised. This corroborates with earlier work by Choudhry and Fang (2008), who state that people contribute to the occurrence of accidents, and management has the ability to address such occurrence by preventing unsafe acts and conditions. According to Shin, Lee, Park, Moon and Han (2014), 88% of accidents are caused by unsafe acts and 10% by unsafe conditions, and that unsafe acts are more difficult to identify and prevent than unsafe conditions. Unfortunately, the focus of attention when an accident or near miss occurs is on the site conditions, because physical evidence can be easily collected as causes, and subsequent changes can be made to prevent a reoccurrence.

Unsafe acts in turn could be classified as CWB, which is also known as workplace deviance. Worthy of note is not CWB itself, but the impact that these sets of behaviours pose in work environments. Discussion among scholars revealed that this concept has the potential to negate the intent of progress efforts in a workplace if not properly managed. Researchers have defined this concept, and all definitions seem to agree that CWB is a voluntary act engaged by an employee that has the potential to cause harm and deter the organisation from meeting its set goals and objectives (Lau et al., 2012). The consequences of these actions by employees has the capacity to not only cause an organisation an increase in the cost of production, time delays, and quality issues, but also cause employee dissatisfaction, demotivation, and team conflict (Roxana, 2013).

Considerable research resources have been invested by scholars in the field of organisational behaviour and this has yielded commensurate research outputs proffering solutions to management with respect to how to effectively manage CWB among workers. Scholarly articles investigating CWB in the workplace have often been concentrated in workplaces such as production and manufacturing, health services, the public service, and hospitality. This has provided a blanket cover for the assumption that the same approach to CWB can be adopted across all workplaces. Therefore, research with respect to what constitutes CWB among construction workers needs to be undertaken.

The primary objective of this research is to explore the interaction between personality and CWB, to establish if the general construct of CWB applies to construction workers, or not. Organisational behaviour-related research which focusses on CWB has often subtly generalised the outcomes to apply to all work environments, despite a range of research findings having reiterated that the construction workplace is unique in its construct. For example, Hinze and Teizer (2011) mention that the causes of accidents in the construction industry may be related to the constantly changing environment. This implies that certain assumptions, and / or recommendations by researchers meant to apply to all work environments may or may not apply to the construction industry. It is therefore imperative that construction researchers investigate selected issues to either confirm or proffer recommendations, which are appropriate for the construction workplace (Zin and Ismail, 2012).

2. LITERATURE REVIEW

Kozako, Safin and Rahim (2014) mention that organisations have witnessed an increase in CWB and that an individual's personality to a great extent influences their chances to engage in CWB. Beus, Dhanani and McCord (2015) emphasise that personality has proven very useful in the prediction of safety violations among individual workers. Parks and Guay (2009) define personality as a human character with the capacity to produce repeated patterns after interaction with an environment and further state that it is linked to the human physiological process. It is unrealistic to attempt to discuss issues relating to accidents in construction without acknowledging the role of human errors emanating directly from the workers. Toppazzini and Wiener (2017) discuss the role of human factors in workplace accident causation, insisting that factors which influence human behaviours must be adequately investigated by individual organisations in order to enhance workers' performance and reduce human errors, which are likely to lead to workplace accidents.

Hassabis et al. (2014) state that the use of personality models can be quite accurate in the prediction of human behaviour based on the logical assumption that the human personality is a product of repeated patterns of behaviour. Therefore, the prediction is possible through a mental simulation of events which are yet to manifest. The study of human personalities has evolved over the years, which has resulted in a sea of personality models, which researchers in the field of personality psychology have exhaustively expounded. One of the widely accepted models in personality psychology research is the OCEAN personality trait model also known as the big five factor (BFF) model. The OCEAN model comprises of an accepted taxonomy in the field of personality study, which offers personality researchers the benefits of reliability in measurement, and yields results that can be compared across several fields of study.

The OCEAN personality trait model describes an individual with a high score in the Openness trait as an intellectual, creative, inquisitive, flexible, and non-judgmental person. A high Conscientiousness score individual will be one who reaches out for competence, and a sense of accomplishment. Such an individual is methodical, dependable, calculative, and self-disciplined. Extraversion in the model is described as one who enjoys the company of others, is active, loquacious, confident, and seeking stimulation. Agreeableness refers to people who are well-mannered, pleasant, supportive, easy-going, and empathetic rather than unfriendly. A score high in Neuroticism is seen as one who experiences unpleasant and undesirable feelings, such as anxiety, worry, cynicism, sadness, and self-doubt (Levine and Raynor, 2009). The literature also mentions that the extraversion personality trait has been linked to a set of preventive and risky behaviour such as increased and impulsive alcohol consumption, cigarette smoking, risky driving behaviour, and risky sexual behaviour. All these negative traits have been reported among construction workers (Emuze and Smallwood, 2012; Oswald, Sherratt and Smith, 2013). Neuroticism has been linked to all the aforementioned except for risky driving and sexual behaviour, but decreased sleep quality, and efficiency. This however has not been replicated in other traits such as conscientiousness. High scores in agreeableness did predict decreased alcohol use disorders, and sub-components of agreeableness, straightforwardness, and tendermindedness were inversely related to alcohol use, and alcohol disorders.

According to Ferreira and Nascimento (2016), literature linking personality traits to CWB exists, and they mention that the OCEAN trait model is the most widely used by researchers attempting to establish relationships between the two in the work environment. Schermer, Vernon, Maio and Jang (2011) also state that though personality is largely influenced by genes, it is also shaped by other factors such as the environment. This may imply that all factors which are part of the environmental build-up such as culture, religion, ethics, and so on, will have a role to play in an individual’s personality, therefore, empirical findings from other environments such as South Africa may contribute to existing generalisations.

3. RESEARCH METHOD

This research adopted the pragmatic world view, which emphasises the need to use all approaches possible to understand a problem, thereby availing the researcher a freedom of choice regarding a suitable research design (Ceswell, 2014). A mixed method was further employed for the purpose of data collection and analysis, which entails the use of both quantitative and qualitative data. As explained by Saunders, and Lewis (2016), a mixed method approach which collects quantitative and qualitative data in more than one phase of data collection is known as a sequential mixed method. This study uses a single strand of quantitative data to explain its interaction with the qualitative data, this is known as the sequential exploratory mixed method. Quantitative data was collected using the personality questionnaire followed by a set of close-ended questions on safe work behaviour. Data extracted from the personality questionnaire was used to group participants by their personalities and the safe work behaviour questions allowed respondents to score factors which affect their safe work behaviours relative to a five-point Likert type. The second phase of data collection involved face to face interviews, and non-participant observation of how workers interact among themselves in relation to the study, which constituted the qualitative component of the study.

Traditionally, measuring CWB and human personality have often entailed the use questionnaires that include five-point Likert scale type questions, and the computation of a measure of central tendency in the form of mean scores to determine the respondents' personalities or CWB in the workplace (Berry, Carpenter and Barratt, 2012; John and Srivastava, 1999). The adopted CWB questionnaire was designed using a 45-item scale, and the OCEAN trait personality questionnaire using a 44-item scale. The target participants were construction workers, and it is important to note that the workers were mostly illiterate, so their ability to comprehend was limited. As a result of this, the questionnaire option did not prove very effective among the target participants without translations, and the use of interpreters. An option was to get someone else who was literate enough to respond on the worker's behalf, however, this approach also poses a limitation because of how sensitive some of the questions were and how individuals do not want to portray themselves in a 'bad-light', especially knowing that their anonymity was compromised. The second method used to solicit information from the construction workers was the semi-structured interviews. This method proved to be very effective, as construction workers are often willing to discuss issues that relate to their work depending on the interviewer's mode of approach. The third method was the non-participant observation, which involved the researcher noting the interaction among workers and any activity, which coincides with the subject matter.

Figure 1 below illustrates the methodology adopted for the research and data collection.

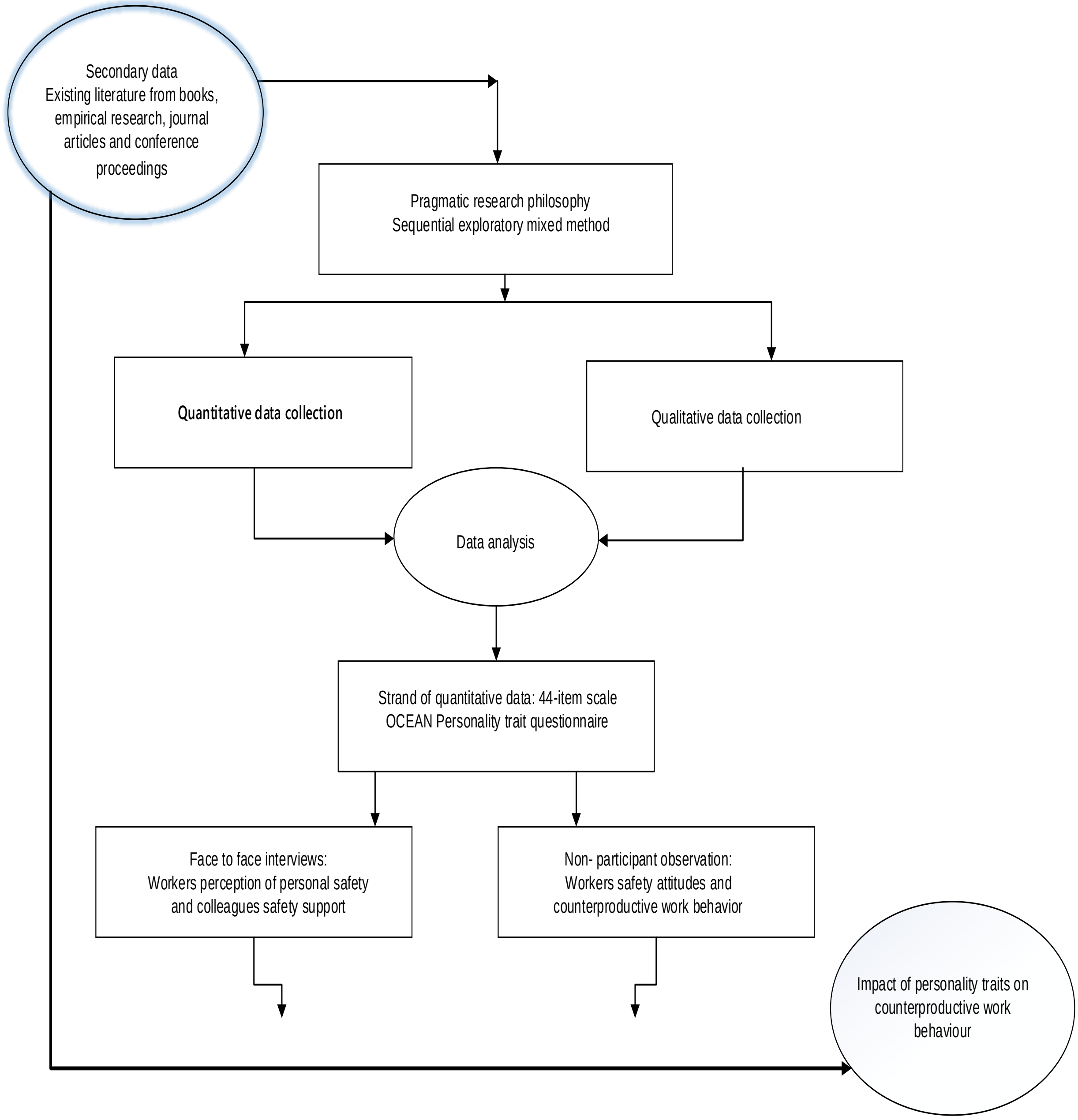

Figure 1: Research methodology (Source: Researcher's own)

4. RESEARCH FINDINGS

Research method and sample stratum

Quantitative and qualitative data was retrieved from a total of 21 participants using the personality questionnaire, face to face interviews, and non-participant observation. Participants were recruited voluntarily after seeking consent from their supervisors and ensuring that no ethical requirements were breached. 15 Participants responded to the personality questionnaire, and participated in interviews, while the remaining 6 were only interviewed. For the purpose of analysing the personality categories, only scores above 30 were considered significant, as individuals may exhibit more than one personality trait (Dailey, 2016).

Demographics of respondents

62% of participants recruited for the study fall within the 21-30 age range, 76% were male, and their construction work experience ranged between 1-10 years. The nature of their employment was either contract, casual, or permanent / full-time.

Findings

Table 1 below depicts respondents' opinion to the safe work behaviour questions. Constructs such as if they perceive that their colleague will ensure they are safe, their attitude to meeting deadlines, their personal safety knowledge, the priority they attach to their safety, their adherence to their personal safety regulations and if they will personally ensure a colleague was safe were asked. The personality questionnaire and the safety behaviour questions were asked on the same questionnaire to enable the researcher to identify the response by personality type. The co-relationship between the variables and personality traits was calculated using the statistical package for social science (SPSS) and a highly significant (0.690**) relationship was observed between the openness trait and their willingness to support another colleague's safety. Again, a highly significant negative relationship was found to exist between the neuroticism trait and the personal safety adherence construct.

Table 1: Personality and Safety construct among construction workers

Personality trait	**Perception of colleague's support to their personal safety**	**Attitude towards meeting deadlines**	**Personal safety know-ledge on the job**	**Personal safety priority**	**Personal safety adherence**	**Support for colleague safety**
Openness	,237	,365	.567*	,267	,352	.695**
Conscientious	,103	,076	-,177	,241	,183	-,203
Extraversion	-,063	,096	,188	,051	,140	,272
Agreeableness	.593*	,451	,505	,469	,084	,256
Neuroticism	-,506	-.541*	-,427	-.605*	-.787**	-,430
Total	15	15	15	15	15	15

The Openness to experience trait claim to be aware of the hazards they are exposed to and accidents they are likely to encounter in the course of executing their jobs and have not experienced any accident in the past. They further mentioned that they will do everything within their personal means to ensure that they are safe on the job. They all stated that they will do whatever it takes to meet deadlines set by their supervisor and do anything to ensure that a fellow worker is safe.

Conscientiousness: this category of respondents reveal that they have experienced an accident or injury in the discharge of their duty in the past - accidents mentioned include shock, and falls, and injuries include broken bones. They however did not hesitate to mention that they will not necessarily do anything to meet a deadline nor go out of their way to ensure that a fellow worker is safe but will do anything within their means to ensure that they remain safe.

Extraversion: high score responses relative to this personality trait were few, and behaviours similar. They all indicated that they will go out of their way to meet deadlines set by supervisors, will do anything to ensure they are safe, and will go out of their way to see that a fellow worker is also safe. They admit to being aware of the hazards they are exposed to, their response further shows they have not experienced any accidents in the past.

Agreeableness: workers with high scores relative to this personality trait show that they are aware of the hazards they are exposed to in the course of their duties on site and take adequate measures to ensure that they are safe. They all agreed that they will do anything within their means to meet deadlines set by their supervisors and will not necessarily go out of their way to ensure a fellow worker is safe;

Neuroticism: one respondent scored a very high score relative to the neurotic personality trait. The respondent indicated that they will do anything to be safe and had never been involved in an accident in the course of their work. They claimed that they will not push themselves too hard to meet deadlines set by their supervisor, that their supervisor does not motivate them to be safe, and neither will they go out of their way to ensure that the safety of another worker is guaranteed.

The results from the interviews reveal that workers are not aware of what they need to do to ensure that they remain safe on the job, they also admitted that they do not adhere to all safety regulations. However, when asked, all the respondents admitted they will do anything to ensure that another worker is safe. Non-participant observations revealed that workers seem to share a very friendly bond among themselves. The researcher also observed that some sites do not provide their workers with the required personal protective equipment (PPE), and on sites where the majority of the workers had PPE provided, some workers still refuse to wear theirs, for example, handling glass without wearing protective gloves. Workers were also seen to be somewhat careless while working on upper floors and were often distracted by what was going on around them.

Table 2 below is an adaptation from Gruys and Sackett (2003) description of CWB and its applicability to the construction industry. Following non-participant observations, the definitions have been modified to reflect its meaning and implication to a typical construction site. An individual may engage in some form of CWB irrespective of their personality and it is important that the construction manager ensures that appropriate measures to curtail its occurrence are implemented.

Table 2: Categories of Counterproductive Work Behaviours (CWB)

S/No	CWB	Likelihood on construction site
1	Attendance	Construction workers employed on a full-time basis have a clocking system which indicates the time they commence work, casually recruited workers cannot afford to come to work late because once the supervisor gets the required hands for the day, then they are not likely to work on that day
2	Work violations	The possibility of this happening in construction work is very high, as workers are willing to push themselves to any length to meet deadlines set by a supervisor. Another possibility is a poor working relationship between the supervisor and the workers, and if supervision is very poor
3	Alcohol and substance use	This involves either consumption prior to work, or during work. While this was not evident on selected sites, it cannot be ruled out
4	Misuse of information	Construction work is done in such a way that each worker only has information relating to their job description. An experienced worker is not likely to engage in this CWB
5	Unsafe behaviour	This could be errors or violations of health and safety standards, which may be a common occurrence in the construction workplace
6	Inappropriate verbal and physical action	This is common on construction sites when there is a breakdown in workplace relationships, this may result in fights and/or heated arguments
7	Theft	Construction sites with very poor supervision and control over material use are likely to suffer from this type of CWB
8	Destruction of property	The likelihood of this occurring in construction is limited
9	Misuse of time and resources	Construction workers have this tendency where there is poor supervision and control - where there is strict adherence to work schedules, it is almost impracticable for workers to engage

Adopted and modified from Gruys and Sackett (2003)

5. DISCUSSION

The results reveal some form of contradiction between what the participants opined in the questionnaire, and what they maintained during the interviews. For example, the friendly bond observed among workers corroborates their perception as revealed from the one-one interview that their colleagues will go out of their way to ensure that they are safe, but the contrary was observed in their response to the same question on the questionnaire. While the externally observed friendliness among workers may seem like a good practice in terms of workplace relations, the question arises as to what may happen if any fall outs occur among the same workers. Disagreements in the workplace may occur due to any reason, and this may quickly result in harmful conflicts. Workers indicated in the interviews that they will do anything to meet deadlines set by their supervisor, which could be interpreted to mean that they will engage in deliberate violations, which aligns with the findings of Emuze (2018). Supervisors appear to allow workers to get away with certain behaviours such as not wearing their PPE and playing around on very high floors, which again can be linked to supervisors not having strong supervisory capacities towards workers (Berry, Carpenter & Barratt, 2012). Some workers opine that they do not know what they need to do to ensure their personal safety, these workers are a not just a threat to themselves, but to their colleagues, the organisation, and the project. Furthermore, they may be classified as 'human hazards' a category evolved by Emuze (2018). Any worker behaviour contrary to the organisation's interest may be termed CWB. Gruys and Sackett (2003) investigated the multi-dimensionality of CWB and resolved that CWB may be intentional or accidental and may be targeted at either the individual or the organisation or both, which often results in negative consequences. According to Wu and Lebreton (2011), Openness to Experience, is regarded as the most argued trait of the five personality traits, which is comprised of other aspects such as openness and intellect. Conscientiousness has a minimum of six sub-categories such as self-control, attention seeking, achievement motivation, orderliness, responsibility, and conventionality. Extraversion consists of at least four other aspects such as social inhibition, sociability, dominance, and energy. The Agreeableness trait includes antagonism, prosocial tendencies, and cynicism, while Neuroticism, one of the most widely studied traits in the field of psychology, includes both anxious distress and irritable distress.

6. CONCLUSIONS

This research explored the influence of personality trait on CWB on construction sites. The findings indicate that a fair percentage of construction workers are not fully aware of the hazards that they are exposed to in their line of duty. This may imply that construction workers do not consider their personal H&S as their responsibility, which may further suggest the value they place on their personal H&S vis-a-vis meeting deadlines, is influenced by supervisors. An individual who conforms to this is a hazard to themselves and others around them. Supervisors saddled with the responsibility of ensuring that workers remain healthy and safe while at work are seen to approach this task with limited enthusiasm and focus on meeting deadlines. Workers' personalities will naturally push them to desire being viewed in a good light by their supervisors, and therefore will do anything to satisfy this desire.

7. RECOMMENDATIONS

While individuals, irrespective of their personality may engage in CWB, it is important to state that CWB among construction workers does not conform in its entirety to the general construct according to organisational behaviour researchers. Therefore, it is recommended that:

- Construction H&S researchers focus on CWB among construction workers and clearly define what it means for the construction industry;
- An appropriate CWB measurement method be developed for the construction industry;
- Supervisors identify which categories of CWB apply to the project at hand, to enable and trigger interventions to mitigate such CWB, and
- Supervisors approach unsafe acts or CWB with the same vigour directed to meeting deadlines and address the poor H&S culture and climate.

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A LITERATURE REVIEW EXPLORING THE CRITICAL SUCCESS FACTORS FOR THE EFFECTIVE IMPLEMENTATION OF THE ISO 9001 QUALITY MANAGEMENT SYSTEM IN CONSTRUCTION PROJECTS

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Abstract: Interest in quality began during the Second World War, where companies in various industries incorporated quality systems and established independent rules for their suppliers' compliance. This situation continued for decades, creating barriers to the exchange of goods and services due to inconsistencies in the characteristics and standards of quality. Therefore, it became necessary to introduce common standards to simplify the task of meeting the client's requirements, as achieved by the International Organization for Standardization (ISO) since 1947. The initial ISO 9001 version was launched in 1987 to enhance client satisfaction and increase quality in the manufacturing sector. It has been accepted worldwide and expanded to other domains, including the construction industry. However, research has found that project managers often tend to view quality management systems (QMSs) as being primarily beneficial in terms of marketing, while issues exist regarding their implementation and awareness of the short- and long-term value potential to the project and client. Therefore, this research identifies critical success factors (CSFs) for the ISO 9001 QMS's effective implementation in UK construction projects, to enable the construction industry to develop a strong motivation to improve project performance and ensure quality in delivering construction projects. The research summarises 10 CSFs and 82 factor components that must be effectively carried out for the project to succeed. The analysis of these CSFs provides a strong assessment and factors for strategic planners in the construction field, highlighting vital areas to address in order to ensure that the construction project succeeds.

Keywords: critical success factor, construction, ISO 9001, project management, quality management system.

1. INTRODUCTION

With the global competitive environment increasing, today's construction projects encounter a range of complex issues, due to the challenges of considering all the different activities, sequences and potential approaches to a construction project, each involving specific risks (Ellingham and Fawcett, 2007; Ning et al., 2011). The construction industry is project-based in nature, whereby myriad parties must cooperate in order to ensure the final product meets the required quality (Vrijhoef and Koskela, 2005). Key to the project's overall cost and completion is quality, which significantly impacts the outcome (Heras et al., 2011), with ISO 9001 representing the most important quality management instrument (Criado and Calvo-Mora, 2009).

The majority of construction projects encounter a range of challenges in terms of completing their projects that include 'manufacturing defects', delays, and cost overruns (Neyestani and Juanzon, 2016). The key competitiveness component of construction projects is quality, and thus the management of quality is a vital role of project management. With project management representing a more contemporary field, it has developed into an important facet of the construction domain, becoming a horizontal approach featuring multiple disciplines, while it engages in a broader operational function that enhances control, improves client relationships and offers increased profit (Barron and Burke, 2007; Medić et al., 2013). Nevertheless, regardless of the project manager's competency and training, a number of challenges exist in the context of managing construction projects that may cause the project to fail, be delayed, run over budget or be of poor quality (Schwalbe, 2015), which must be evaluated in terms of their importance and addressed accordingly (Jato-Espino et al., 2014; Książek et al., 2015). To overcome these challenges or reduce their negative impacts, the commitment of management to ongoing quality improvement and the promotion of high process quality by management leadership are critical (Arditi and Gunaydin, 1998).

This paper focuses on ISO 9001, the best-known standard for management systems with broad use worldwide, and its successful implementation through the application of critical success factors (CSFs). Although the application of ISO 9001 is not mandatory, there is a growing interest in its implementation (ISO, 2016).

2. PROJECT MANAGEMENT AND QUALITY MANAGEMENT

2.1 Project Management

The construction industry is often characterised by a lack of standards, poor productivity, and unsatisfactory quality compared with manufacturing industries (Aziz and Hafez, 2013). Meanwhile, the construction project has been described as a temporary activity established to produce a final outcome, with a unique and temporary aim that is achieved through gradual progress, while a client is required and stakeholders are always included (Schwalbe, 2015). The purpose of the project is developed through the stakeholders' needs and values. The notion of project management suggests engaging with knowledge, methods, practice, skills, and tools in order to fulfil the project's requirements, where project managers must not only strive to achieve the respective goals of cost, scope, quality and time, but they also need to ensure progress, which means responding to the client's expectations and needs (Schwalbe, 2015). Project management is vital to ensure that deadlines are met with lower costs while efficiently and effectively meeting the required objectives (Martin and Tate, 2002). Organisations' use of project management has steadily increased over recent decades, and despite some evidence that projects are becoming more successful, Allen et al. (2014) cautioned that a substantial number of projects still do not meet the stated goals or expectations. In terms of measuring construction project success, Davis (2016) found that the satisfaction of stakeholders has seen increased popularity that complements cost, quality and time. According to Hadavi and Krizek (1994), the construction industry is unique due to i) labour being mobile; ii) construction projects' diverse forms, shapes, and types; iii) the broad geographical distribution; iv) the contractual relationships; v) vulnerability to climatic conditions; and vi) virtually every project being unique.

2.2. Construction Project Management Challenges

A study conducted by Rostami et al. (2015) that included 153 construction companies concluded that for such companies, especially those small and medium-sized, the main challenge is scaling the resource management process so their requirements can be met. Singh et al. (2018) postulated that the failure of some construction projects is due to issues such as poor engagement of the project stakeholders, as well as absent or weak practices of project management, which can lead to undesirable consequences that include the overrun of costs, considerable delays, and in the worse-case scenario the premature conclusion of the project. According to Pasian et al. (2012), a key challenge for construction project management is vague or unspecified goals, since the stakeholders may be unclear of their exact aim(s), while Ahsan and Gunawan (2010) underscored the importance of the project manager's ability to communicate concerns in order to assess and inform the stakeholders of changes. Meanwhile, Chiocchio et al. (2011) discussed the need for accountability, with the project manager being responsible for ensuring that all goals are allocated to the correct individual or team, while assuring that all the involved parties are accountable for their tasks.

Risk management represents an important challenge in construction project management, due to the elevated threats and considerably increased expenses that may then arise (Loosemore et al., 2012), while lack of communication can be fatal to a project (Gündüz et al., 2012). Furthermore, unrealistic expectations can damage morale and productivity (Lines et al., 2015), while stakeholder indifference to the site activity may lead to delays and the need for rework (Mirza, 2010). The most important means of reducing challenges that manifest in construction project management is through the implementation of some form of quality management system (QMS), since construction projects are typically described as lacking standards (Bawane, 2017), and inherently operate in an environment that is not closely monitored (Landin, 2000).

2.3 The ISO QMS

In 1947 in Geneva, the International Organization for Standardization (ISO) was developed to enable the technical specifications for internationally traded products to be standardised, and in 1987 the ISO created the first family of standards (Searcy, 2011). The ISO is populated by members from a range of national standards' bodies, and is responsible for international standards. Aized (2012) reported that the ISO QMS is a systematic approach, documentation, direction and review that is applicable to each process of organisational management extending from the start of the activity to the final stages of completion. Five quality standards were created by the ISO organisation in 1978, namely the ISO 9000 family: ISO 9000 and ISO 9004 that represent guidelines pertaining to quality systems being developed by the organisation; while ISO 9001, ISO 9002 and ISO 9003 comprise standards for conformance in terms of systems for quality assurance applicable to the client–supplier relationship.

ISO 9001 certification often appears as a contractual requirement at companies that have a certificated QMS and impose it on their suppliers. Since 1987 and its first appearance, the ISO 9001 standards have been widely accepted, with the number of ISO 9001-certified organisations having grown exponentially, and a recent survey finding over one million certifications by the close of 2016 (ISO, 2017). In ISO 9001:2015, seven principles of quality management were developed: i) client focus; ii) leadership; iii) ensuring participation; iv) the process approach; v) improvement; vi) making decisions based on evidence; and vii) managing relationships.

2.3.1 The Benefits of Implementing the ISO 9001 QMS in Construction Projects

In a study by Manders and de Vries (2012), the key findings of forty-two research papers revealed that applying the ISO 9001 QMS standard enhances performance. Nichols (2013) reported that ISO certification can also improve internal communication, processes, and the supplier–client relationship, while providing financial benefits for stakeholders. Therefore, becoming certified has the potential to offer a plan that allows quality to be defined and the strategic plan to be continually improved. Studies such as Wu and Chen (2011) and Kafetzopoulos et al. (2013) found that ISO 9001 results in a positive influence on the success, development and innovation of organisations and their products. However, Aravind and Christmann (2011) indicated that almost all researchers focus on the effect of being ISO 9001 certified, as opposed to the impact of ISO 9001 implementation.

The project benefits achieved by ISO 9001 QMS-certified construction companies can be categorised into internal benefits, including organisational gains that are useful for the staff and internal operations such as enhanced company communication, efficiency and productivity, employee morale, documentation, the quality of completed work, and working techniques, as well as reduced wastage of materials (Willar, 2012); meanwhile, the external benefits indicate those that can be perceived as enhancing the company's corporate image, increasing profitability, elevating sales with existing clients, enhancing supplier relations, increasing the number of new local clients, reducing problems in terms of the defect liability period, more projects completed on time, and more agreements or contracts in the construction market, among others (Keng and Kamil, 2016). Therefore, ISO 9001 can be utilised to enhance construction projects' internal/ external performance to ensure performance benefits from a financial and quality perspective (Nolan, 2016).

2.3.2 The Challenges of Implementing the ISO 9001 QMS in Construction Projects

While there are a range of advantages offered by ISO 9001, a company being awarded certification does not necessarily ensure that all the possible beneficial outcomes will be realised, with George (2015) reporting weak awareness and training of the benefits of the ISO 9001 QMS, and Magd (2008) cautioning of the implementation challenges that manifest when the project team fails in terms of the understanding and application of the QMS. The unique nature of the construction industry, which tends to hamper the effective implementation of QMSs in this sector, leads to challenges in terms of introducing a QMS. In contrast to the manufacturing industry's fixed processes, the construction industry's processes tend to be bespoke (Bawane, 2017). According to Boiral (2011), many project managers hold the belief that the QMS is merely beneficial in terms of employing the certification as a marketing mechanism. Consequently, managers frequently place their focus on the certification itself as the key objective, as opposed to the value of the projects, where this approach can cause process inefficiencies due to the lack of any effective QMS. Khattak and Arshad (2015) demonstrated that the greatest challenge to the implementation of QMSs in construction projects is poor senior management support, while Rybski et al. (2017) cautioned that the paucity of evidence on the QMS's actual impact on project performance and practices, such as inadequate QMS awareness and training, is a major challenge for construction project owners and project managers in the context of effective QMS implementation. Some construction companies believe that the implementation of ISO 9001 merely represents wasted time and money for the consultancy, training, internal and external audits, and certification fee, without any tangible benefits other than covering the requirements of the clients and competitiveness in the market (Neyestani and Juanzon, 2017).

Subrahmanya Bhat and Rajashekhar (2009) identified a range of challenges facing construction projects in attempting the effective implementation of ISO 9001 standards, such as the limited financial/ human resources, poor technical awareness of quality management, and the weak understanding of formal systems. As each construction project and its processes are unique (Loushine et al., 2006), implementing a single system as a comprehensive solution for all projects is challenging (Anttila and Jussila, 2017), as seen in more standardised contexts where solutions can be developed and then repeatedly applied during the project's lifetime (Gibb and Isack, 2001; Perumal and Bakar, 2011; Ramaji and Memari, 2015).

2.3.3 CSFs for the ISO 9001 QMS's effective implementation in construction projects

This paper proposes ten CSFs that are pertinent to the effective implementation of the ISO 9001 QMS in construction projects:

i) Change management

Neyestani and Juanzon (2017) reported the need to both determine and monitor the needs and expectations of stakeholders, with value to be found in planning for change (Nolan, 2016), as well as the promotion of continual improvement (Adetunji et al., 2003).

ii) Evidence-based decision making

Decisions grounded in the evaluation and analysis of data or information will have a greater likelihood of leading to the required outcomes, whereby the analysis of process data can be utilised to inform decisions (Anttila and Jussila, 2017), provided that it is analysed through appropriate methods (Medić et al., 2016). It is necessary to evaluate the effectiveness of the actions adopted to deal with risks (Neyestani and Juanzon, 2017), as well as to address opportunities (Fonseca and Domingues, 2017). Meanwhile, performance should be monitored (Willar et al., 2015), measured (Mansour et al., 2019) and analysed (Neyestani and Juanzon, 2017). It is vital that individual performance is evaluated (Hoyle, 2017), while regular internal audits should be conducted (Anttila and Jussila, 2017). Medić et al. (2016) cautioned on the need to strike a balance between practical experience and the analysis of data, while decision making should be grounded in evidence, with the organisation assuring that the data or information are sufficiently accurate and reliable (Fonseca and Domingues, 2017).

iii) Client focus

Quality management is primarily focused upon striving to exceed the client's expectations wherever possible (Willar et al., 2015), with Luburić (2015) asserting the importance of understanding both current and future clients' requirements. Top management should communicate the clients' expectations and needs organisation-wide, while the satisfaction of clients should be measured and the findings acted upon (Fonseca and Domingues, 2017). The organisation/ project should ensure that client satisfaction is assessed (Hoyle, 2017), and place the focus on the intangible advantages to increased client satisfaction (Shaari et al., 2015).

iv) Non-standardisation

With a survey underscoring the paucity of quality system documentation for most of the contractor participants (Bubshait and Al-Atiq, 1999), quality system documentation should be both developed and enhanced (Neyestani and Juanzon, 2017), since the efficiency of all processes can be improved through documentation (Ramaji and Memari, 2015) in order to reduce the impact of non-standardisation during the construction project lifecycle.

v) Engagement

An engaged employee's working relationships are considerably increased in terms of quality due to more effective communication, whereby an open forum can develop for the discussion of issues (Fonseca and Domingues, 2017) and barriers (Mansour et al., 2019). The organisation/ project team must ensure that all employees have the required competency and deliver value through empowerment and engagement, with quality issues promoted through efficient teamwork (Willar et al., 2015). The motivation of employees must be maximised (Mansour et al., 2019), since engaged personnel are focused on the goals and values of their organisation/ project. Ultimately, it is vital that employees feel that their abilities are valued and utilised in order to enhance employee satisfaction (Juuso Röyttä, 2016).

vi) Leadership

The leaders at all tiers generate direction and purpose, while establishing an environment whereby individuals are focused on realising the quality objectives through creating high-quality processes (Fonseca and Domingues, 2017). It is the leadership's responsibility to create both a vision and a pathway for the project (Medić et al., 2013). Neyestani and Juanzon (2017) asserted the importance of equipping and empowering employees with the skills and resources necessary to carry out their role, with Fonseca and Domingues (2017) underscoring the value of creating a trusting environment. Leadership implies realising exemplary behaviours that are compatible with and can deliver the organisation/ project's values, while identifying challenging targets (Sickinger-Nagorni and Schwanke, 2016). A clear organisational vision should be established by the leadership while ensuring commitment to both policy (Jabnoun and Sedrani, 2005) and the role (Mansour et al., 2019). The use of resources should be efficient (Jabnoun and Sedrani, 2005), with the project's environmental impact reduced insofar as is feasibly possible (Sadikoglu and Zehir, 2010), and responsibility to the project partners ensured at all times (Sitnikov, 2015).

vii) Process approach

The results in the context of consistency and predictability can be more efficiently and effectively realised when tasks are comprehended and perceived as connected processes behaving as a system that is coherent (Wilson and Campbell, 2016); therefore, activities should be managed as processes, with a reduction in those activities identified as adding no value (Sickinger-Nagorni and Schwanke, 2016). The feasibility of activities should be determined (Aized, 2012), as well as the links that exist between them (Chiarini, 2017). All processes should be audited, and those processes identified as adding no value should be reduced (Mansour et al., 2019). Meanwhile, Jabnoun and Sedrani (2005) reported the need to establish the knowledge necessary for processes to operate, where this understanding must be maintained (Sickinger-Nagorni and Schwanke, 2016). Action should be taken to address risk (Aized, 2012), as well as to exploit opportunities that may present (Mansour et al., 2019).

viii) Relationship management

To achieve sustainable success, organisation/ project teams should effectively establish (Aized, 2012) and manage their relationships with the stakeholders, that is, any group or individual concerned with the success or performance of the organisation/ project (Manders et al., 2016). The organisation/ project team should form short- and long-term relationships (Mansour et al., 2019). The relation management of stakeholders involves the dissemination of goals, knowledge, values, and understanding, while suppliers are not viewed as hostile entities (Sickinger-Nagorni and Schwanke, 2016). Therefore, it is important to share plans (Hoyle, 2017), resources (Chiarini, 2017) and expertise (Anttila and Jussila, 2017) with the stakeholders, while cooperation in the development of activities is vital (Hola, 2015).

ix) Skills and training

Skills and training are an important component, with Willar et al. (2015) highlighting the need to enable learning through personnel trained in terms of quality. The quality aims and characteristics should be delivered to the personnel through training seminars (Adetunji et al., 2003) and then shared throughout the organisation (Chiarini, 2017). To achieve the optimum levels of quality, communication must be managed (Chua et al., 1999) and improved (Shaari et al., 2015), with knowledge disseminated (Chua et al., 1999).

x) Continuous improvement

Successful organisations should identify the requirements necessary to promote improvement (Hoyle, 2017), while conducting operational planning (Mansour et al., 2019) as well as operational control (Chiarini, 2017). To ensure continuous improvement, resources should be provided (Hoyle, 2017) and managed (Hola, 2015), with documentation provided to allow corrective action (Anttila and Jussila, 2017). Mansour et al. (2019) underscored the importance of enabling the project team to participate in improvement, and Shaari et al. (2015) the need to consistently measure improvement. Meanwhile, performance should be analysed (Willar et al., 2015) and improvement celebrated (Anttila and Jussila, 2017), with a reward system developed and introduced to increase motivation (Chiarini, 2017).

Table 1 presents the 10 CSFs and 82 factor components that must be effectively carried out for construction projects to succeed through the ISO 9001 QMS's effective implementation

Table 1. Summary of the CSFs and factor components for the effective implementation of the ISO 9001 QMS in construction projects

CSFs	Factor Components	References
Change management	Determine the needs and expectations of stakeholders	Neyestani and Juanzon (2017)
	Monitor the needs and expectations of stakeholders	Neyestani and Juanzon (2017)
	Promote continual improvement	Adetunji et al. (2003)
	Plan for change	Nolan (2016)
Evidence-based decision making	Analyse data through appropriate methods	Medić et al. (2016)
	Use the analysis of processes data to inform decisions	Anttila and Jussila (2017)
	Evaluate the effectiveness of actions taken to address risks	Neyestani and Juanzon (2017)
	Evaluate effectiveness of actions taken to address opportunities	Fonseca and Domingues (2017)

	Monitor performance	Willar et al. (2015)
	Measure performance	Mansour et al. (2019)
	Analyse performance	Neyestani and Juanzon (2017)
	Conduct internal audits	Anttila and Jussila (2017)
	Evaluate individual performance	Hoyle (2017)
	Ensure access to exact and reliable data	Fonseca and Domingues (2017)
	Strike a balance between practical experience and data analysis	Medić et al. (2016)
Client focus	Understand the current clients' requirements	Luburić (2015)
	Understand future clients' requirements	Luburić (2015)
	Measure client satisfaction	Hoyle (2017)
	Exceed client expectations	Willar et al. (2015)
	Focus on intangible advantages to increased client satisfaction	Shaari et al. (2015)
	Ensure the project objectives match the client's requirements	Fonseca and Domingues (2017)
	Ensure the project objectives match the client's expectations	Fonseca and Domingues (2017)
Nonstandardisation	Develop quality system documentation	Neyestani and Juanzon (2017)
	Enhance quality system documentation	Neyestani and Juanzon (2017)
	Improve the efficiency of processes through documentation	Ramaji and Memari (2015)
Engag emen	Facilitate the open discussion of issues	Fonseca and Domingues (2017)

	Facilitate the open discussion of barriers	Mansour et al. (2019)
	Enhance the motivation of personnel	Mansour et al. (2019)
	Promote quality issues through efficient teamwork	Willar et al. (2015)
	Increase employee satisfaction	Juuso Röyttä (2016)
	Ensure that employees' abilities are utilised	Juuso Röyttä (2016)
	Ensure that employees' abilities are valued	Juuso Röyttä (2016)
Leadership	Establish a vision for the project	Medić et al. (2013)
	Establish a pathway for the project	Medić et al. (2013)
	Empower employees	Neyestani and Juanzon (2017)
	Equip employees	Neyestani and Juanzon (2017)
	Create trust with employees	Fonseca and Domingues (2017)
	Ensure commitment to the role	Mansour et al. (2019)
	Ensure commitment to policy	Jabnoun and Sedrani (2005)
	Ensure responsibility to project partners	Sitnikov (2015)
	Reduce the environmental impact	Sadikoglu and Zehir (2010)
	Identify challenging targets	Sickinger-Nagorni and Schwanke (2016)
	Promote high-quality processes	Fonseca and Domingues (2017)
	Ensure the efficient use of resources	Jabnoun and Sedrani (2005)
Process approach	Manage activities as processes	Sickinger-Nagorni and Schwanke (2016)
	Reduce activities that add no value	Sickinger-Nagorni and Schwanke (2016)

	Reduce processes that add no value	Mansour et al. (2019)
	Conduct audits of processes	Mansour et al. (2019)
	Improve processes to prevent nonconformities	Wilson and Campbell (2016)
	Determine knowledge necessary for the operation of processes	Jabnoun and Sedrani (2005)
	Maintain knowledge necessary for the operation of processes	Sickinger-Nagorni and Schwanke (2016)
	Take action to address risk	Aized (2012)
	Take action to exploit opportunity	Mansour et al. (2019)
	Gauge the feasibility of activities	Aized (2012)
	Determine links between activities	Chiarini (2017)
Relationship management	Share information with stakeholders	Sickinger-Nagorni and Schwanke (2016)
	Share plans with stakeholders	Hoyle (2017)
	Share resources with stakeholders	Chiarini (2017)
	Share expertise with stakeholders	Anttila and Jussila (2017)
	Cooperate in the development of activities	Hoła (2015)
	Establish effective intra-project-partner cooperation	Aized (2012)
	Manage effective intra-project-partner cooperation	Manders et al. (2016)
	Establish short-term relationships	Mansour et al. (2019)
	Establish long-term relationships	Mansour et al. (2019)
Skills and training	Train personnel in terms of quality	Willar et al. (2015)
	Share knowledge	Chua et al. (1999)
	Enable learning	Willar et al. (2015)

	Share the quality aims and characteristics	Chiarini (2017)
	Teach the quality aims and characteristics	Adetunji et al. (2003)
	Manage communication	Chua et al. (1999)
	Improve communication	Shaari et al. (2015)
Continuous improvement	Provide resources for continuous improvement	Hoyle (2017)
	Manage resources for continuous improvement	Hoła (2015)
	Provide documentation for corrective action	Anttila and Jussila (2017)
	Enable the project team to participate in improvement	Mansour et al. (2019)
	Conduct operational planning	Mansour et al. (2019)
	Conduct operational control	Chiarini (2017)
	Identify the requirements	Hoyle (2017)
	Measure improvement consistently	Shaari et al. (2015)
	Analyse performance	Willar et al. (2015)
	Celebrate improvement	Anttila and Jussila (2017)
	Develop a reward system	Chiarini (2017)

3. CONCLUSIONS

This study's primary aim was to identify the critical success factors that support the effective implementation of the ISO 9001 QMS in construction projects to improve the project's performance. The importance of this study is underscored by its emphasis on the impact of the ISO 9001's effective implementation on the success of organisations and those barriers that limit the potential for implementation. The literature review found performance in terms of the ISO 9001 standards to be reliant on a variety of critical success factors (10 factors and 82 factor components) that are vital to support effective implementation, that is, activities that must be undertaken effectively for the organisation/ project to succeed (Fryer et al., 2007). The critical success factor analysis provides a robust and practical assessment for strategic planners, highlighting vital areas where positive outcomes are required for the organisation/ project to succeed and excel in the field of competition (Neyestani and Juanzon, 2017). To take this research forward, the authors have conducted a survey of project managers in order to explore their perspectives on the findings of this paper regarding the critical success factors that are vital to support effective implementation of the ISO 9001 QMS in UK construction projects. The findings of this survey will be published in a future paper.

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THE ROLE OF VALUATION TASK COMPLEXITY IN COMPULSORY PURCHASE: A CONCEPTUALISATION

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Abstract: The purpose of this study was to conceptualise a complex task in property valuation for compulsory purchase using the theory of task complexity. Compulsory purchase is the power of government to acquire rights over an estate in land without the owner's consent in return for compensation. At the heart of the compulsory purchase system is the problem of valuation variation. Valuation variation is the difference between acquiring authorities and the property owners' valuations. A wide valuation variation makes negotiated agreement problematic and results in costly appeals at Valuation Tribunals. Valuation task complexity has been recognised as an important contributory factor of valuation variation. However, currently there is no consensus on the definition of task complexity. The methodology involved a review of several studies on task complexity based on structuralist, resource requirement and interaction models. Consistent with theory it is established that variation in valuations is more pronounced in comparatively more complex valuation tasks. These findings have several implications including the inability of valuers to agree market values for compulsory purchase and compensation purposes. Consequently, this results in costly litigations, delay in relocating property owners and limit their ability to purchase replacement properties in the locality.

Keywords: Compulsory purchase, open market value, task complexity, valuation accuracy, valuation variation.

1. INTRODUCTION

Compulsory purchase is the power of government to acquire rights over an estate in land without the owner's consent in return for compensation (Grover, 2014). At the heart of the compulsory purchase system is the problem of valuation variation. Valuation variation is the difference between acquiring authority and the property owner's valuation. However, Crosby (2000) defines valuation variation as the difference in opinion of value that two or more valuers assign to the same property at the same valuation date. A wide valuation variation in compulsory purchase makes negotiated agreement problematic and results in increased appeals to Valuation Tribunals. The issue of valuation variation in compulsory purchase has been a problem for some time and property owners have called on the government to reform the system. Furthermore, valuation variation has made the ability of valuers to make effective assessment of property values to be called to question by academia, the media and the courts (Bretten and Wyatt, 2000). According to Bretten and Wyatt (2000), the cause of valuation variation could be due to lack of coherent and consistent valuation methods employed by property professionals. However, Awuah and Gyamfi-Yeboah (2017) suggest that a contributory factor of valuation variation is the lack of research in the field as it has been neglected for so long in favour of valuation accuracy. As a consequence, an increase in research in the field will help resolve the problem of valuation variation.

There appear to be several conceptual problems with task complexity identified in the literature. First, defining task complexity is fraught with confusion leading to misuse of the construct (Liu and Li, 2012). Although task complexity has been recognised as an important factor in valuation variation, yet there is no consensus on the clear definition and understanding of the construct in the literature (Awuah and Gyamfi-Yeboah, 2017). The problem needs to be resolved to minimise the increase in appeals to Valuation Tribunals. This is due to wide variations among valuers and their inability to agree market values for compensation purposes when properties are acquired by a compulsory purchase order(CPO). According to Awuah and Gyamfi-Yeboah (2017) variations in property valuations appear to be influenced by complex valuation tasks. This is because consistent with theory it is established that variation in valuations is more pronounced in comparatively more complex valuation tasks.

Where the differences in valuations between acquiring authority and property owners' valuations are small it is easier for valuers to agree market values by splitting the difference. However, where the valuation gap is wide negotiations become problematic and the opposing valuers are unable to agree values resulting in appeals to the Upper Tribunal (Lands Chamber) where the market values are determined. Litigation is costly and also delays property owners from acquiring replacement properties in the locality. There have been numerous conceptualisations of task complexity and yet no consensus on its definition has been achieved (Liu and Li (2012). A conceptualisation of valuation task complexity will provide a clear and systematic definition of complex valuation tasks to enhance negotiated agreements of market values by property professionals instead of ending in Valuation Tribunals as appeals (see Table 1).

Table 1: Upper Tribunal Decision on Valuation Variation in 2019

DATE/ FILE NO	**Interest to value:**	**Property Type**	**Acquiring Authority & Proposed Valuation**	**Property Owner & Proposed Valuation**	**Upper Tribunal Determination**
02/08/19 LCA 51 2018, .	Long leasehold for a term of 125 years from 1995 subject to an Assignment to expire in 2013.	Re: Industrial Site, Smithyard Somerset, TA 23 0NA MLU	NNB Generation Co(HPC) Ltd Tenure: L/H Date: 02/08/19 OMV: £925,000	599 Developments Ltd Tenure: L/H Date: 02/08/19 MV £1,175,000	Mr Peter McCrea FRICS & Judge E. Cooke Tenure: L/H Date: 02/08/19 OMV: £925,000

Source: Upper Tribunal (Lands Chamber) Archival Data

2. REVIEW OF RELEVANT LITERATURE

In conceptualising valuation task complexity, various studies on task complexity were reviewed. According to Liu and Li (2012), conceptualisation of task complexity follows three viewpoints: structuralist, resource requirement, and interactionist. In the structuralist viewpoint, task complexity is defined from the structure of the task whilst in the resource requirement viewpoint, task complexity is defined as resource requirements imposed by a task. However, proponents of interaction viewpoints hold that task complexity is a product or creation in human-task interaction. Structuralists define task complexity as a function of a number of elements of which the task is composed of and the relationship between those elements. Structuralists are of the view that a complex task has many task elements, which interconnect with each other. Some notable structuralists are Wood (1986), Campbell (1988), Bonner (1994), Harvey (1997), Ruthrock (2005) and Awuah and Gyamfi-Yeboah (2017). Campbell (1988, p.43) integrative framework defines a complex task as one which is "*related directly to the task attributes that increase information load, diversity, or rate of change".* Consequently, Campbell (1988) identifies three criteria for defining a complex task namely: *information load, information diversity* and *the rate of information change* which all involve high cognitive demands placed on the task performer.

Furthermore, Campbell (1988) suggests that a complex task has one or more of the following characteristics: multiple paths, multiple outcomes, conflicting interdependence among paths, and uncertain or probabilistic linkages. Consequently, Campbell (1988) integrative framework holds that a task becomes more complex as and when its characteristics increase information load, information diversity or rate of information change. In the resource requirement viewpoint, task complexity is defined as resource requirements or other similar concepts in human information processing (HIP) such as cognitive demands, physical and mental demands, cognitive efforts, required HIP resources and short term memory requirements (Liu and Li 2012). Notable resource requirement theorists include Gingrich (1986), Kieras & Poison (1985) and Jacko et al., (1995). In resource requirement viewpoint the concept of resource represents the resources in HIP, such as visual, auditory, cognitive, and psychomotor resources, knowledge, skills, and time. Resource requirement theorists hold that complex tasks require task performers to invest more resources during task performance.

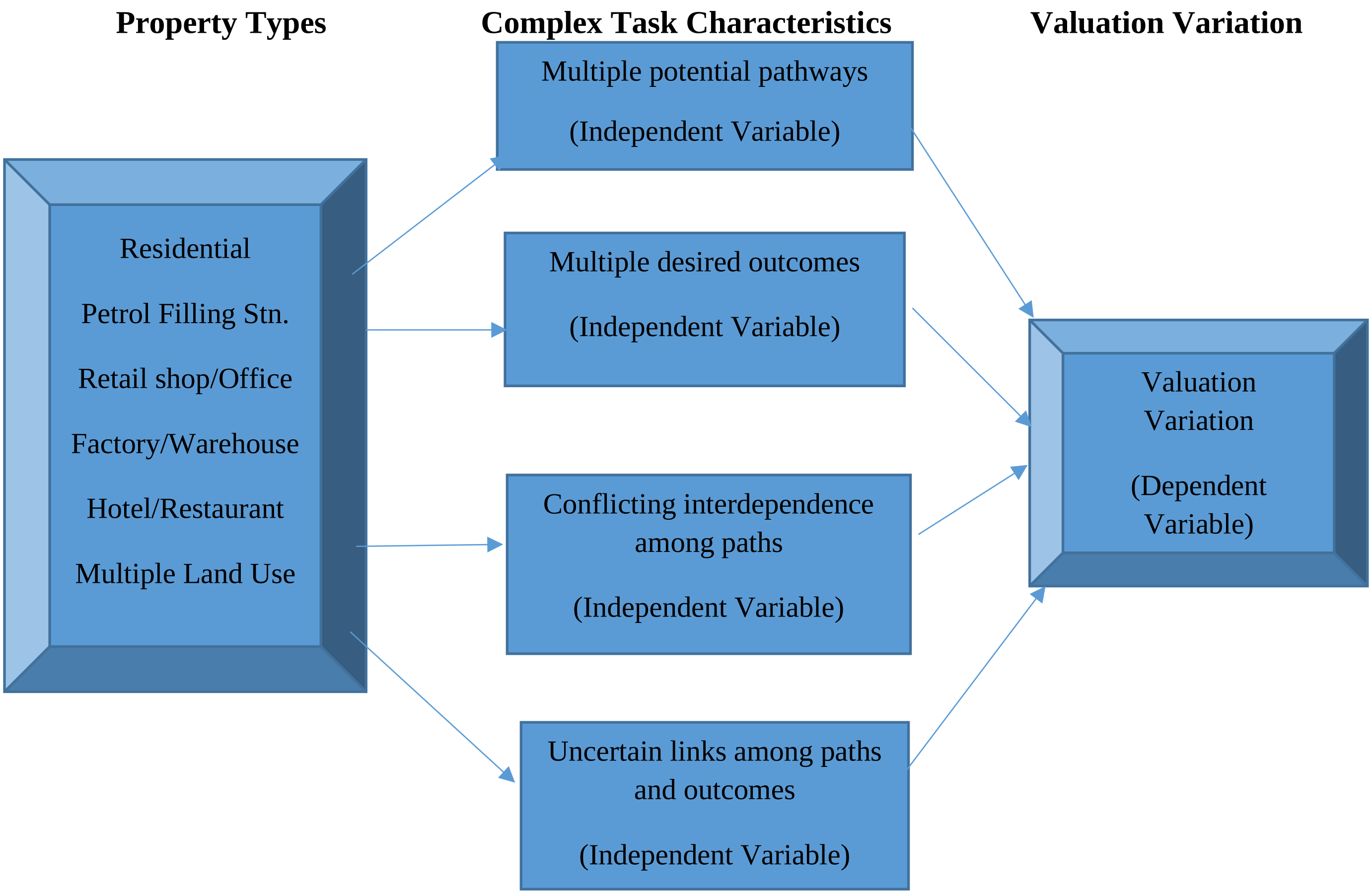
In the interaction viewpoints task complexity is viewed as a product of the interaction between task and task performer characteristics (e.g. idiosyncratic needs, prior knowledge and experience. Interactionists are concerned with subjective task complexity from task performers' standpoints (Liu and Li,2012). Notable interactionists include Hackman (1970), Hendy et al., (1997), Gonzalez et al., (2005) and Brown and Miller (2000). However, the conceptualisation of valuation task complexity in this paper hinges on insights of Campbell (1988) integrative framework. This was done to provide a clear and systematic definition of task complexity which has so far eluded researchers (Awuah and Gyamfi-Yeboah, 2017). According to Liu and Li (2012), tasks are activities that people conduct to move their work and life forward. Thus, property valuation is a task undertaken by surveyors and valuers when assessing compensation for compulsory purchase. In conceptualising valuation task complexity, the author firstly reviewed the literature on task complexity as discussed above to be conversant with the various models from structuralists, resource requirements and interactionists viewpoints.

3. METHODOLOGY

The methodology of conceptualising complex valuation task involved a review of several studies on task complexity as discussed above. In conceptualising valuation task complexity, the approach adopted was the examination of the Upper Tribunal (Lands Chamber) databases to see the valuation variations between the acquiring authority and property owners (see Table 1). Although some valuation tasks could satisfy all the complex task characteristics proposed by Campbell (1988), the majority of tasks may not meet all the characteristics (Awuah and Gyamfi-Yeboah (2017). Thus, in conceptualising a complex valuation task, the tasks were evaluated based on the complex task characteristics prescribed by the integrative framework similar to Awuah and Gyamfi-Yeboah (2017). This approach was adopted to determine the levels or degree of complexity of the valuation of the various property types. Thus, the evaluation of complexity of valuation tasks of different property types was based on the four task characteristics (Campbell, 1988). All the valuation tasks under consideration were undertaken for the purpose of compensation for compulsory purchase. The properties involved were of six main types namely: residential; petrol filling station; retail shop/office; factory/warehouse; hotel/restaurant and multiple land use (see Figure 1). Consequently, the property types were used as the valuation task types. Consequently, the complexity of the valuation tasks was determined by:

(a) the presence of multiple potential ways(paths) to arrive at desired end state,
(b) the presence of multiple desired outcomes (end states) to be attained,
(c) the presence of conflicting interdependence among paths to multiple outcomes and
(d) the presence of uncertain or probabilistic links among paths and outcomes.
Figure 1 shows that all the complexity characteristics were present in the valuation of all the property types and resulting in valuation variation.

Figure 1: Evaluation of complexity of valuation tasks of different property types



Source: Adapted from Campbell (1988) Integrative Framework

Furthermore, the complexity of valuation tasks was also determined by:

- the presence of complexity characteristics in the task;
- whether the complexity characteristics are high (1), low (2), or very low (3) if they are present in the task;

- the total number of the complexity characteristics present in the tasks and
- the valuation complexity types labelled as A-D (see Table 2).

Table 2: Measuring Instrument of Valuation Task Complexity

Valuation task type	Multiple Valuation methods or pathways (A)	Multiple desired outcomes (B)	Negatively related desired outcomes (C)	Uncertain linkage between pathway activities & desired outcomes (D)
Residential	2	3	3	3
Retail/Office	2	3	3	3
Factory/Warehouse	2	3	3	3
Hotel/Restaurant	1	3	3	1
Petrol Filling	1	3	3	1
Multiple Land Use(MLU) e.g. Pentecostal Church	1	3	3	1

Source: Adapted from Awuah & Gyamfi-Yeboah (2017).

Table 2 shows that all the complexity characteristics were present in all the valuation tasks although in different levels (see Figure 1). Furthermore, the table shows that multiple valuation methods or pathways could be used to address all the valuation tasks. However, while residential, retail shop/office and factory/warehouse valuation tasks are normally limited to the two traditional methods of valuation, namely: comparison and investment, the valuation task relating to petrol filling station and multiple land use such as a Pentecostal Church usually requires more than the two traditional methods: namely comparison, investment, profit, depreciated replacement cost and the contractors test. This explains why the valuation complexity characteristic 'A' was rated high for valuation relating to petrol filling station and Pentecostal Church whilst the ratings for the other three property types are low. Consequently, the valuation task complexity characteristics is high (1) for hotel/restaurant, petrol filling station and the Pentecostal Church and low (2) for residential, retail shop/office and factory/warehouse.

Similarly, all the valuation tasks were rated very low 3 for the valuation task complexity characteristic 'B' because only two outcomes were expected: (i) expeditious assessment of market value for compensation purpose; and (ii) detailed and high-quality valuations of subject properties for the Upper Tribunal (Lands Chamber). These outcomes were also negatively related and meant that valuation complexity characteristic 'C' was present in all the valuation tasks. Finally, hotels/restaurants, petrol filling stations and Pentecostal Church all exhibit a considerable level of heterogeneity albeit for economic rather than physical reasons (Awuah & Gyamfi-Yeboah, 2017). Thus, the economic characteristics of two hotels/restaurants, petrol filling stations and a Pentecostal Church can be very different and thus make comparisons difficult. However, residential, factory/warehouse and retail shop/office on the other hand are very similar in their physical attributes and also show minimal differences in the economic activities they support. Consequently, hotel/restaurant, petrol filling station and Pentecostal Church are ranked highest on task complexity characteristic (D), whereas, residential, retail shop/office, and factory/warehouse are ranked lowest as shown in Table 2.

4. DISCUSSION

In the conceptualisation process, explicit task models were adopted as in Awuah & Gyamfi-Yeboah (2017) and Campbell (1988). In both studies the task model consists of four essential complexity characteristics. The complexity factors also provide a base for operationalising and assessing task complexity in the operationalisation process. Furthermore, in conceptualising valuation task complexity, Awuah & Gyamfi-Yeboah (2017) suggest four complexity factors for complex tasks: multiple paths, multiple outcomes, conflicting interdependence among paths, and uncertain or probabilistic linkages (see Figure 1). This study was aimed at conceptualising valuation task complexity and thus the structuralist model was replicated similar to Campbell (1988) and Awuah & Gyamfi-Yeboah (2017). The effect of valuation tasks complexity was then illustrated in Table 2. Additionally, in the conceptualisation process, complexity factors were deductively identified through the combination of the task models (Liu and Li, 2012). They were then used to organise the valuation tasks to identify the complexity characteristics (see Table 2). Thus, the conceptualisation of valuation task complexity in compulsory purchase was illustrated using the integrative framework of Campbell (1988) similar to the method adopted in Awuah & Gyamfi-Yeboah (2017).

5. CONCLUSION

In conclusion, this study attempts to provide clear, systematic understanding of valuation task complexity in compulsory purchase. In the conceptualisation process, the review work provided a good base for conceptualising valuation task complexity. From the above discussion, it is proposed that task complexity should be considered seriously by property professionals to minimise wide variations and enhance negotiated settlement of compulsory purchase compensation to minimise litigations. Furthermore, the importance and necessity of understanding valuation task complexity conceptualisation was highlighted in Awuah & Gyamfi-Yeboah (2017). Academics and property professionals have all called for the development instruments to measure task complexity factors but this has not yet materialised. Thus, it is hoped that the conceptualisation process of valuation task complexity in this study will enhance negotiations in compulsory purchase valuations and minimise the risk of litigations at Valuation Tribunals.

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ASSESSING THE SAFETY PERFORMANCE IN KUWAIT'S OIL AND GAS SECTOR CONSTRUCTION PROJECTS

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Abstract: The safety outcome has been measured in various ways, and these measures have their pros and cons. In contrast to what one would typically expect, a firm's safety performance cannot be ascertained simply on the basis of its accident rates. This is because accident reporting may not be completely reliable, and because the restriction of variance can render statistical data imprecise. More focus should be on accident self-reporting as a trustworthy method to measure organisation safety outcomes in Kuwait's construction industry. Also, most Kuwaiti construction industries do not have recorded data, and even if they do so, such data are not released due to insurance complications and competition. The researcher used a personally administered, paper-based survey to assess safety outcomes, such as near-misses, days off rate and occupational injury type rate, during the past 12 months at Kuwaiti oil and gas construction projects; 508 responses were received and analysed. The results show that accident statistics among Kuwaiti construction firms are of concern. The most frequent accident type is 'falling from a height', the second accident type is 'transportation means', and the lowest type was 'electric shock'.

Keywords: Safety outcomes, safety performance, safety climate, safety indicator, oil and gas projects.

1. INTRODUCTION

The construction industry is multifaceted in that it involves various types of work, methods, and resources. However, the broad and precarious nature of the work activities within the industry generate a range of risks, with research indicating that the chance of construction workers dying on the job is five times more likely than in other industries (Kartam & Bouz, 1998). Construction workers are exposed to dangerous and life-threatening situations on a daily basis, with many fatalities or falling injuries occurring every year (Al-Humaidi & Tan, 2010). To address this, the governments and private agencies have implemented strategic approaches to health and safety. A key example is the UK government's implementation of legislation to improve health and safety procedures within construction companies. Some measures initiated include the replacement of the Construction Design and Management Regulations (CDM) 2007 with the CDM Regulations 2015, the Construction Skills Certification Schemes, and the 2007 Corporate Manslaughter and Corporate Homicide Act.

Nonetheless, the measures have thus far failed to lower the high injury and fatality rates associated with the industry, with statistics still revealing high figures and adverse impacts on the bottom lines of construction companies. Vasconcelos, Soeiro, and Junior (2011) pointed out that around 16.7% of industrial fatalities per year across the globe happen in the construction industry, which equates to approximately 60,000 deaths. In the United States, the Bureau of Labor Statistics (2018) revealed that 971 worker deaths had occurred in the construction industry, thus constituting 18.9% of all occupational fatalities. The construction industry itself is the third highest of all US industries in terms of non-fatal injury rates (NFIs), with figures standing at 149.6 NFIs per 100,000 full-time employees (Hallowell & Yugar-Arias, 2016). In

Britain, data from the last two decades evidences clear improvements to the frequency and types of NFIs and occupational fatalities. However, these reductions are still not enough, with fatal injury rate within the UK construction industry 1.64 per 100,000 workers at around four times the all industry rate (Health and Safety Executive [HSE], 2018). UK construction industry health and safety key facts presented in Figure 1.

Figure 1: UK construction industry health and safety key facts. (Source: HSE, 2018)

Although the situation in the developed world is problematic, it is even more so – and often ambiguously so – in the developing world. As a case in point, the rapidly developing Kuwaiti construction industry is constrained by relatively few health and safety regulations, and although it is certain that the frequency of NFIs and occupational fatalities is high, no credible data sets are available to evaluate the magnitude of the issue. This issue is worsened by the insufficient research within the Kuwaiti context over the last two decades. Any research that exists has reported that the industry is one of the most perilous in Kuwait (Al-Humaidi & Tan, 2010; Al-Tabtabai, 2002; N. Kartam, Flood, & Koushki, 2000; N. A. Kartam & Bouz, 1998). Robertson and Lamm (2008) have actually categorised Kuwait as being one of the world's most dangerous places to work.

The present paper is aimed to evaluate the current safety measures that could be implemented to predict and prevent major accidents in Kuwait's oil and gas sector construction projects. Kuwait's oil and gas sectors are crucial for meeting the country's energy and economic needs. It is thus crucial to be aware of the human and organisational conditions that may serve as early indicators of possible issues within the industry's safety system. Awareness of such conditions may aid company managers in implementing sufficient measures to prevent major incidents from occurring in Kuwait's oil and gas industry in the future. On the whole, the research is a valuable contribution to the improvement of the safety climate. The paper will be structured in the following way: safety performance will be discussed in the next section, followed by the research methodology in the third section, research results and analysis in the fourth section, and concluding remarks and directions for future research in the fifth section.

2. SAFETY PERFORMANCE

Atak and Kingma (2011) defined safety performance as the ability to work safely over a period of time. If there is an increased amount of accidents happening, this is regarded as poor safety. Safety can be comprised of multiple factors within a culture. It is represented in the conduct and attitudes of all concerned workers. A company's workers may not always file a report about a risky or dangerous incident that they have encountered, believing that they may lose incentives if they were to do so (Dejoy, Schaffer, Wilson, Vandenberg, & Butts, 2004; Probst & Brubaker, 2001). Moreover, researchers have demonstrated that a decline in the number of accidents ensures that there are effective safety measures in place within that culture. This is only possible if workers tell the truth to the company and honestly report incidents as they occur so that similar incidents can be prevented in the future. Moreover, this shows that the workforce are actively taking part in the company processes. According to Cheyne, Cox, Oliver, and Tomás (1998), the insufficient indicators comprise the reactive measures that are taken in response to a situation that are determinants of the safety performance.

Abdul-Hamid, Abd-Majid, and Singh (2008) defined an accident as an unfavourable, unanticipated, uncontrolled, and undesired occurrence that may either lead to injury, damage to materials and equipment, or both. However, accidents causing injuries typically receive the most attention (Hinze, 1997). Irrespective of the injuries, loss, or damage involved, it is important for all accidents to be taken seriously so that these instances can be learned from in order to predict and prevent similar incidents from occurring in the future (Abdul-Hamid et al., 2008).

When measuring incidences of accidents and injuries, statistics are often used rather than self-reporting (Griffin & Neal, 2000; Mearns, Whitaker, & Flin, 2003; Zohar, 2000). Clarke (2006) has suggested that a decrease in the number of incidents and accidents could signify the presence of positive safety measures. However, a number of sources, including Glendon (1995), have placed doubt on the reliability of accident data as an indicator of safety performance, as there are no reliable ways of assessing exposure, and such statistics are frequently not sensitive, given that incidents are rare (Glendon & Litherland, 2001). Recently, companies have focused more on implementing safety measures, for example, by raising the number of workers provided with safety training and the frequency of safety-enhancing events, and implementing more safety inspections and audits (Mayze & Bradley, 2008; Tremblay & Badri, 2018). Once all safety outcomes measures have been implemented, safety compliance and safety participation are brought together to be assessed using a theoretical framework applied at the worksite level of a construction project.

Near misses refer to unplanned incidents that are close to causing death, injury, illness, or property damage, but which are prevented out of pure luck or an unanticipated change of events. Jones, Kirchsteiger, and Bjerke (1999, cited in Thoroman, Goode, & Salmon, 2018) suggested that many companies analyse near misses and consider them to be significant factors indicating a company's safety performance. Moreover, Reason (1997) has pointed out that, given the more frequent occurrences of near misses, they should be used to assess certain aspects of safety management. The safety of a company may be improved if near misses are used to improve safety management (Winkler, Perlman, & Westreich, 2019), especially if the staff have the motivation to partake in identifying, evaluating, and understanding the near misses and their causes (Thoroman et al., 2018). The reporting of such incidences may cause negative outcomes, especially in cases where the main focus is on less important matters to the detriment of more serious difficulties (Kjellén, 2000). This may ultimately cause an overwhelming amount of information to be given, and may make it difficult for the manager to respond in the most effective manner. As a result, it is important to establish clear guidelines for the near-miss reporting processes, and such processes must point out the areas of most concern and the types of near misses that should be reported.

According to both Fogarty and Shaw (2010) and Atak and Kingma (2011), safety log entries are deemed to form the basis of safety performance. If there are numerous of logged safety incidences, this is an indicator of poor safety effectiveness. Morrow, Koves, and Barnes (2014) have pointed out that safety culture and various other factors can largely influence safety performance. For this reason, Öz, Özkan, and Lajunen (2013) stressed the importance of the influence that employees' willingness to adhere to safety measures can have on institutional safety effectiveness. Furthermore, Bellamy, Geyer, and Wilkinson (2008) asserted that companies within a given industry should count all of the safety incidents that they experience in order to establish the overall safety of the industry. Investing assets into the enhancement of safety logs may be required of a company that demonstrates a history of poor safety, as improved safety effectiveness is often thought to be impacted by factors such as human characteristics, management perspectives, and employees' proficiency (Fogarty & Shaw, 2010). Other factors that could impact safety effectiveness include legislative punishments, health-related experiences, and legal expenditures (Kontogiannis & Malakis, 2009). Gangolells, Casals, Forcada, Roca, and Fuertes (2010) stressed that business expenditures will undoubtedly rise for companies that have poor safety records and that are shown to have poor safety regulations throughout the production and service processes.

Various indicators of safety efficacy have been proposed by Hinze, Thurman, and Wehle (2013), including death rates, incident rates, and the total recordable injury frequency rate. Nonetheless, Guo and Yiu (2013) were critical of such indicators, stating that it is impossible to predict incidents, and their fundamentally reactive nature is not particularly helpful. This is due to the decrease in variables and hazardous conduct, which can cause incidents in the construction workplace. The measurement of safety efficacy must thus be a matter of urgency. Nonetheless, assessing safety efficacy has started to move towards implementing leading indicators. The safety of companies in the industry may be improved by strengthening safety measures, promoting safe work practices for the workforce, and supplying company performance data.

Safety efficacy estimators are often the most crucial safety performance leading indicators. Øien, Utne, and Herrera (2011) pointed out that the use of these indicators is crucial for achieving the desired safety results. Additionally, Hinze (2005) pointed out that a focus on safety management processes and direct links to planned projects are key features of leading indicators, whereas the safety performance of prior schemes are known as lagging indicators. Hinze, Thurman, and Wehle (2013) also added that, after recognising a shortcoming in safety measures, the leading indicators will show that amendments need to be made immediately. There may be both active and passive leading indicators when evaluating safety performance. Such leading indicators within the construction sector include training, safety familiarisation, housekeeping, Stop Work Authority, employee monitoring, and near-miss records.

Mearns et al. (2003) recommended self-reporting accidents as an effective model for evaluating safety outcomes (Mearns et al., 2003). The failure to record incidents, illnesses, and accidents is a key issue. According to Probst and Brubaker (2001), poor understanding of guidelines could be a key factor in a company's failure to report sustained injuries. Furthermore, changing employment conditions may render it difficult to monitor work-related illnesses. To combat this, Occupational Safety and Health Administration (OSHA) have assessed staff members' effective and ineffective workplace adherence to safe practices. This process is often used to assess effective safety behaviours. OSHA and Cheyne et al. (1998) both concurred that safety measures are inadequate in their responsive assessments of accidents.

2.1 Safety Performance and Safety Climate

Many techniques have been used to measure the safety outcome construct in a variety of safety climate studies. Some of these methods include:

- Self-reported safety behaviours in the work environment.
- Safety performance ratings provided by supervisors, regulators, and management.
- Statistics of accidents provided by companies to explore both high and low accident rates in factory-based workplaces.
- Self-reported accidents and incidents in the workplace.

There are advantages and disadvantages to all such methods. It is possible for workplace accident statistics within construction firms to be impacted by arbitrary actions, thus rendering the technique vulnerable to variations in reporting. There may also be under-reporting of accidents. Company-generated statistics may ultimately be unusable because of insurance issues, competition, and limited variance. However, it is also possible for self-reported measures to be unusable as a result of bias in reporting. Yule (2003) suggested that collecting such reports anonymously may be beneficial, as it may be more likely to demonstrate the true situation than company-generated statistics. Mearns et al. (2003) described the self-reporting of accidents to be a reliable means of assessing injuries and accidents within companies.

Contrary to popular belief, it is not possible to establish a company's safety performance according to its accident rates. This is because accident reporting may not be completely reliable, and because the restriction of variance can render statistical data (especially for rare occurrences) imprecise (Thompson, Hilton, & Witt, 1998). As well as establishing that some company accidents go unreported, Probst and Estrada (2010) found, when investigating accident under-reporting amongst 25 employees across five industries, that an average of 2.48 accidents go unreported. Van Der Schaaf and Kanse (2004) carried out multi-industry research which attempted to establish why a number of workers do not report accidents. They identified four key factors. The first of these is employee anxiety, a predominant result of companies' blame cultures and the fear of being subject to disciplinary processes. Second is perspective, which is often related to the macho culture in some industries in which occupational hazards are typical and inevitable. Third is employees do not see the point in reporting if they believe that the response will not be productive. Finally, there is a belief that the process of involving management and collecting data will be too complex and time-consuming.

More focus on the self-reporting of accidents in Kuwait's construction industry is needed. It is an industry subject to frequent, rapid changes that make it challenging to employ conventional assessment methods. Moreover, a majority of Kuwaiti construction companies have no recorded data, and even those that do have such data will not release it, as they fear insurance complications and competition (Al-Humaidi & Tan, 2010; Al-Tabtabai, 2002; Kartam & Bouz, 1998; Kartam et al., 2000).

3. METHODOLOGY

3.1 Sample and Procedures

The sampling framework for the present study is the populations within the Kuwait oil and gas sector. Therefore, the sample will be restricted to frontline construction workers (carpenters, bricklayers, steel benders, plasterers, and labourers) at Kuwait oil and gas construction project sites. In this study the approximate target population size is 150,000. De Vaus (2014, cited in Saunders et al. 2015) proposed the following steps for calculation of sample size:

Step 1: $n = \frac{z^2(p)(1-p)}{c^2}$ Step 2: $n' = \frac{n}{1+\frac{n}{N}}$

n = Minimum sample size z = confidence level (e.g. at 95% confidence level) =1.96

p = population proportion (the percentage belonging to the specified category) (0.5 is the maximum possible proportion).

c = confidence interval (e.g. ±5%) = 0.05 N = Target population = 150,000

n' = Adjusted minimum sample size =?

Substituting these values in the formulae to get 383;

Frequency index: this consists of a formulation utilised to order major accident types based on how regularly an accident occurs as recognised by the research participant.

Frequency Index (FI) (%) = $\sum a \left(\frac{n}{N}\right) * 100/5$

a is the constant expressing weighting given to each response.

n is the frequency of the responses. N is total number of responses.

3.2 The Research Instrument

The questionnaire was an integral part of the present study, and its key purpose was to collect suitable and accurate data (Sekaran & Bougie, 2017). The questionnaire was separated into two parts, and was developed according to previous survey instruments designed in previous studies exploring the same topic. It was considered important that only the most relevant items from existing questionnaires would be included; thus, the researcher chose to omit any features that overlapped or were deemed conceptually inconsistent with the current research topic. This omission of any conceptual overlapping aided in limiting confusion in terms of common-method variance. A five-point Likert scale, which is often used in questionnaires, was used to assess the items on the questionnaire. Any relevant items that had been included in previous questionnaires that did not use Likert scales were adapted to suit the Likert scale in the present research, which was crucial to ensuring consistency and convenience in controlling and analysing the data. Part A of the questionnaire focused on obtaining personal demographic information from participants, such as their age, gender, education level, and job type. Part B consisted of 14 questions relating to safety outcomes; for example, incidents of near misses, number of days off per week, and any occupational injuries experienced over the course of the last year. To measure the safety outcomes, a number of measurement variables were used from research by Lee and Harrison (2000), Probst and Brubaker (2001), Oliver, Cheyne, Tomás, and Cox (2002), Goldenhar et al. (2003), Siu, Phillips, and Leung (2003), and Jiang et al. (2010). These variables were then adapted to suit the Public Authority for Manpower (PAM) major accident type categorisations, taking the following format: falls from heights, injuries from falling objects, injuries from heavy lifting, tool-related incidents, materials, electric shocks, burns and explosions, accidents with transportation, and chemical-related injuries.

4. RESULTS AND DISCUSSION

4.1 General Statistical Analysis

The questionnaire the researcher used was administered personally. As Sekaran and Bougie (2017) pointed out, this method generates a high response rate, and has the added benefits of allowing the researcher to clarify any misunderstandings and the ability to motivate participants. The predicted population of the target group was 150,000, with a sample of 383 participants being used. Table 1 presents the data results from 546 collected questionnaires. As 700 questionnaires were originally handed out, the response rate was 78%. However, only 72.6% were fully completed. Of the 546 collected questionnaires, 508 were used, with 38 having to be discounted due to not being fully completed.

Table 1: Questionnaire response rate

Distributed Questionnaires	Collected	Response Rate	Completed	Response Rate
700	546	78%	508	72.6%

4.2 Reliability Test

Reliability refers to the consistency of the measurement tool. In most cases, Cronbach's alpha (α) is employed to assess the degree to which research findings can be considered reliable. Cronbach's alpha values will vary between 0 and 1, with values at the lower end of the scale indicating that the variables in question are heterogeneous and will not be very reliable in representing the measure under investigation (Pallant, 2016). Table 2 presents the Cronbach's alpha value for the present research. It is shown that the Cronbach's alpha coefficient is 0.904, which is clear evidence that the collected data is both consistent and reliable.

Table 2: Questionnaire Cronbach's alpha

Construct	Number of cases	Number of variables	Cronbach's alpha
Safety Outcome	508	14	0.904

4.3 Factor Analysis

4.3.1 Item-total Correlations

Lu, Lai, and Cheng (2007) defined the item-total correlation as a correlation of variables whereby the construct is built using the composite scores of all concerned variables. A value that falls significantly below 0.3 indicates that the variable is not measuring what the construct is supposed to be measuring; therefore, the variable may be omitted (Pallant, 2016). Subsequently, Pallant (2016) advised that all the variables with a low item total (below 0.3) be eliminated if the total Cronbach's alpha is calculated to be below 0.7. Table 3 evidently indicates that the variables of SO11 and SO14 have values below 0.3. Thus, after a subsequent analysis of the two constructs, all values were kept.

4.3.2 Exploratory Factor Analysis

Prior to carrying out any type of analysis, researchers have to ensure that there are sufficient correlations within the data to justify factor analysis. The word factorability relates to the reliability of the data needing to be factorised, particularly when there are inter-correlations between the variables. The Bartlett's test of Sphericity and the Kaiser-Meyer-Olkin (KMO) Test are the most suitable methods for determining this. The former can be used to identify any relationships between the variables; for example, if there are any specific p-values below 0.5, which would confirm the existence of a relationship and indicate the accuracy of factor analysis (Field, 2009). The KMO values, however, tend to fall between 0 and 1, and the calculated value must fall near to 1 to show that the sample is significant for the analysis (Pallant, 2016). Moreover, the KMO Test value for the safety outcomes construct is presented in Table 4 as being 0.939, thus signifying that each construct value exceeded the minimum acceptance level of 0.6 (Pallant, 2016). The Bartlett's test of Sphericity showed a significant relationship between safety outcomes variables for each construct, with values being particularly high at $p < 0.001$.

Table 3: Safety outcomes variables item-total correlation

Variables	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
SO1: Falling from a height accident	0.604	0.898
SO2: Falling objects accident	0.704	0.894
SO3: Heavy lifting accident	0.682	0.895
SO4: Tools accident	0.733	0.892
SO5: Materials accident	0.651	0.896
SO6: Electric Shock accident	0.675	0.895
SO7: Burns and explosion accident	0.757	0.891
SO8: Transportation Means accident	0.900	0.885
SO9: Chemicals and Gases accident	0.789	0.890
SO10: Injuries due to slips	0.821	0.889
SO11: Near misses and unsafe conditions	0.287	0.909
SO12: Accidents resulted in less than one day absence	0.323	0.909
SO13: Accidents resulted in 1-3 days absence	0.300	0.901
SO14: Accidents resulted in more than three days absence	0.219	0.911

Table 4: Safety Outcomes - KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.939
Bartlett's Test of Sphericity	Approx. Chi-Square	4292.594
	Df	91
	Sig.	.000

In terms of the construct of the safety outcomes, two key factors were identified: near misses and the number of days off (component 2) and types of occupational injuries (component 1). These items had 60.6% of total variance (Table 5).

Table 5: Exploratory factor analysis of safety outcomes.

Safety outcomes (SO) variables	Component 1	Component 2
SO1: Falling from a height accident	.734	-.016
SO2: Falling objects accident	.750	.180
SO3: Heavy lifting accident	.770	.084
SO4: Tools accident	.787	.169
SO5: Materials accident	.728	.108
SO6: Electric Shock accident	.755	.101
SO7: Burns and explosion accident	.829	.118
SO8: Transportation Means accident	.905	.245
SO9: Chemicals and Gases accident	.846	.159
SO10: Injuries due to slips	.883	.138
SO11: Near misses and unsafe conditions	.098	.694
SO12: Accidents resulted in less than one day absence	.147	.676
SO13: Accidents resulted in 1-3 days absence	.109	.714
SO14: Accidents resulted in more than three days absence	.060	.603

4.4 Safety Outcomes Analysis

Figures 2 and 3 present the frequency indices of the respondents' answers to the frequency of each type of accident. They also show the frequency of near misses and days off for those working on oil and gas construction projects in Kuwait. The frequency index (FI) for the identified accident types was determined by applying the formula discussed in section 3.1. The accident types, near misses, and number of days off were ranked according to the respective FI scores, which are presented in Tables 6 and 7. Falling from heights is shown to be the most common type of accident (FI = 68.50394) and electric shock to be the most infrequent type of accident (FI = 44.28291). However, only a very small difference is evident in the FI scores of the accident types in first and second place. Accidents with transportation is the second most common type of accident (FI = 68.0943), which the researcher suggests is due to the fact that a majority of Kuwait Oil Company construction projects occur in remote areas that require long travel times to reach.

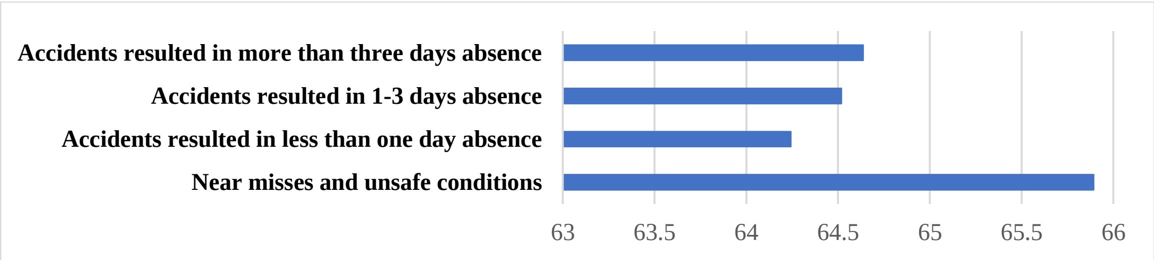

Figure 2: Near misses and day off rates rankings based on FI

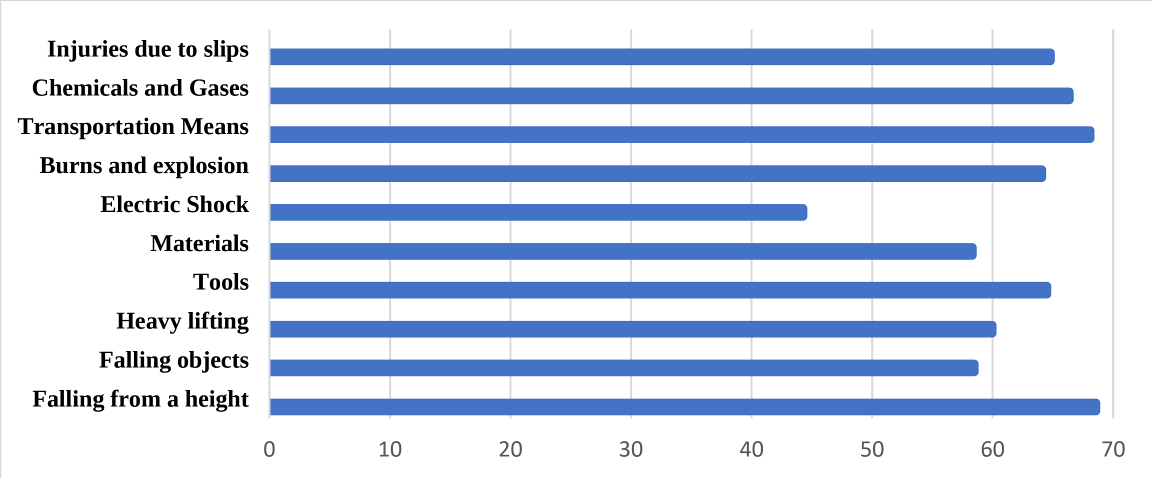

Figure 3: Ranking of Major accident types based on FI

It has been determined that falls from heights are one of the chief causes of fatalities on construction sites (Dong et al., 2017; Hamid et al., 2019; Nadhim, Hon, Xia, Stewart, & Fang, 2016). In the UK, 48% of fatal injuries in the construction industry caused by falling from height (HSE, 2018). Contractors attempt to minimise casualties by using safety belts, ropes, and cables; a minority also use safety nets. Nevertheless, a highly weighted frequency of fall injuries continues to occur, and this indicates either that most frontline construction workers do not have access to these safety measures, or that the site safety managers permit workers to ignore them. Additional research is called for to determine which of these interpretations is accurate. Another significant cause of accidents is transportation means, along with injuries caused by chemicals and gases on construction sites. Chemicals and gases leaks can cause serios accidents in the oil and gas construction industry (Kashwani & Nielsen, 2017).

5. CONCLUSION

Existing data pertaining to the topic indicate significant safety issues in the Kuwaiti construction sector. The most common accidents are falling from heights, transportation means, or injuries due to slips. Many accidents on construction sites throughout the country are caused by untrained workers; thus, it appears essential to improve on-site supervision and control. Safety management and planning will be necessary to improve the dangerous working conditions. Falls from heights are common, and many are the result of falling from ladders or losing balance while working by an opening. Workers ignore regulations, fail to wear the correct personal protective equipment (PPE), and miscalculate situations, as they believe they have the resources in place to carry out the work. The emphasis on site is productivity and meeting deadlines, and this prioritisation can cause accidents.

Neither management nor the workforce are willing to accept responsibility for accidents. Supervisors have a key role to play in connecting safety issues with performance, but safety plays a secondary role to productivity on construction projects, as they run on tight schedules, and, as a result, managers and supervisors tend to close their eyes to hazardous situations. There is no comprehensive and reliable system for reporting accidents, and workers who are hired for the length of a contract, or are paid by the day, have no job security, and this lack of long-term commitment also results in minor and major accidents occurring on site. Given the findings of the present study, it is highly recommended that construction companies ensure that their tools and equipment are well maintained and fit for purpose, and that the sites provide workers with safe working environments.

It would also be useful to create an accident database to contain and share all necessary information with the Kuwaiti authorities. There should also be a single central authority in charge of construction project safety. A detailed database of this type would help this authority to improve safety practices on construction sites and to lower the incidences of future accidents. It is also possible to enhance safety by imposing local legislation for on-site practices. Safety legislation and codes could be particularly improved by learning from examples of prior errors that have caused accidents.

This proposed legislation should focus more attention on re-establishing company safety priorities and creating a more supportive environment. Enhancing supervision practices by implementing effective working processes and changing facilities would also be beneficial actions. This should be applied in the areas of workers' updates, equipment maintenance, and management's commitment to safety. Research findings of the present work serve as a valuable contribution to research in the field, which researchers and industrial practitioners can reference to learn valuable lessons and identify what needs to be done to enhance the current safety performance within the Kuwaiti construction industry.

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PERFORMANCE MANAGEMENT IN CONSTRUCTION SUPPLY CHAINS: A SYSTEMATIC LITERATURE REVIEW

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Abstract: Supply chain performance measurement systems are "the central managerial mechanisms for achieving efficient and effective supply chain management" (Hald and Mouritsen, 2018, p. 256), yet only a few studies have been conducted within the construction sector. The purpose of the research presented in this paper was to discover if construction projects could be made to benefit from end-to-end analysis of the kind seen more generally in supply chain management. With this in mind, a methodology of systematic literature review was adopted, aimed at (1) assessing the current state of supply chain performance measurement in construction projects, and (2) identifying areas of inadequacy. The findings of this study reveal construction supply chain performance to be an ideal area for further research. Although the disciplines of supply chain and project management differ, they overlap in terms of how an organisation can manage performance within both upstream and downstream networks. Drawing upon the viewpoints of different disciplines, the study provides original insights for practitioners seeking to improve performance through the reconfiguration of metrics commonly used in project management. Furthermore, it identifies opportunities for academics to research a critical yet underrated aspect of the supply chain.

Keywords: Construction, project, supply chain performance.

1. INTRODUCTION

As Ren et al. (2004, p. 6036) observed, "you cannot manage what you cannot measure." Performance measurement is essential to supply chains of all kinds, yet Wickramatillake et al. (2007) revealed that "supply chain progress measurement" in a construction project is very difficult, or even impossible if there are no clear indicators (Choi, 2018).

Liu et al. (2018) found no universal definition of the construction supply chain, indicating that the topic is at this time still immature and research is limited in extent. A number of studies support this claim, including Thunberg and Persson (2014, p. 1065) who report that "most performance-oriented literature seems to focus more on customer-facing relationships, paying less attention to the internal facing and supplier relationships". While it is crucial to align performance with the demand side, omitting the other components (the internal value chain and the supply side) prevents organisations from optimising the supply chain. In a similar vein, Halman and Voordijk (2012) observed that while construction companies realised the importance of measuring supply chain performance, none of those studied had adopted a clear system for monitoring and improvement. These examples capture the viewpoints of both academic and practitioner perspectives, indicating deficiencies in existing approaches, particularly in evaluating the performance of the focal organisation itself, and the supply side.

Recommendations for good supply chain practices in construction were given by Latham (1994) and Egan (1998). Commissioned jointly by the Government and the industry, many researchers still make reference to these reports (e.g. Dainty et al., 2001; Smyth, 2005;

Eriksson, 2010; Halman and Voordijk, 2012; Thunberg and Persson, 2014). In particular, Egan (1998) found the supply chain is critical for innovation, incremental and sustained performance improvement. Similarly, Choi (2018, p. 88) argues that "a better understanding of construction supply chain performance is clearly necessary", while Arbulu et al. (2003) echoes the need to understand system-level performance as a way to drive improvements.

Kim and Nguyen (2018) argue that poor performance in construction projects is a common phenomenon, characterised by schedule delays, quality defects and cost overruns; Bahera et al. (2018) associate further problems with construction supply chains including low productivity, frequent change orders and inadequate design specifications. With these challenges in mind, two research questions were formulated:

- *What is the state of the current development of supply chain performance studies in the construction sector?*
- *What areas of research within the sphere of construction supply chain performance are fertile for development?*

2. METHODOLOGY

Among the many approaches that might be employed to address the knowledge gap described, a literature review was found to be appropriate to assess the current state of developments in the topic area. Within the realm of supply chains, scholars have been seen to conduct literature reviews in two distinct ways. Some use a framework to guide the review process (e.g. Beske-Janssen et al., 2015; González-Loureiro et al., 2015) whereas others have chosen an approach which does not rely upon a distinct framework (e.g. Shepherd and Günter, 2006; Mishra et al., 2018). All share some similarities in terms of setting the scope of the review, employing a search strategy to identify papers and reporting the findings. These stages are also found in this study, using a systematic approach – considered appropriate because it offers the methodological rigour of a replicable, transparent and auditable process. Utilising the framework proposed by Tranfield et al. (2003), the systematic literature review process involves planning, conducting and reporting stages, as discussed below.

Planning for the Review was conducted with the research questions presented in Section 1 in mind. These research questions provided the keywords for the study: 'Supply Chain Performance' and 'Construction'. Since Basu (2017) found construction to be a subset of project-based supply chains, 'Project' was included in the scope of the review, although project-based supply chains in other sectors (e.g. healthcare, manufacturing, agriculture or oil and gas) were excluded. These inclusion and exclusion criteria are important as construction supply chains have distinctive characteristics that delimit the subject area, as discussed in Sections 3.2.1 to 3.2.3. The resulting boundaries are consistent with the deficiencies in supply chain performance research that were presented in Section 1.

In conducting the review, indices of multiple databases including ABI/Inform Complete, Emerald Journals, ProQuest Central, ScienceDirect and Scopus were searched. Keywords were mapped against search criteria using Boolean connectors. The search criteria were 'All Fields', 'Title', 'Subject Terms', 'Abstract' and 'Full Text'. The results from this process are shown in Table 1. Two combinations were selected for use as they were deemed to be neither deficient nor overwhelming in terms of the quantity of literature. These used two search criteria, 'Title' and 'Abstract' with 'AND' as a Boolean connector, thus:

- Title:(supply chain performance) AND Abstract:(project) = 189 outputs

- Title:(supply chain performance) AND Abstract:(construction) = 96 outputs

Table 1: Results from the systematic literature search

Keywords		**Supply Chain Performance**				
Keywords	**Search Criteria**	All Fields	Title	Subject Terms	Abstract	Full Text
Project	All Fields	1,959,856	1,339	5,874	14,478	1,929,717
	Title	19,785	87	163	502	18,823
	Subject Terms	11,661	26	403	424	10,464
	Abstract	66,097	**189**	759	6,071	58,670
	Full Text	1,940,865	1,112	5,078	10,235	1,922,122
Construction	All Field	1,631,665	625	3,008	7,167	1,613,189
	Title	14,130	57	152	534	13,283
	Subject Terms	40,232	97	774	1,118	37,239
	Abstract	37,005	**96**	427	3,200	32,757
	Full Text	1,617,206	481	2,413	4,504	1,605,859

In combination, these yielded 285 papers. In each case, abstracts were studied in order to identify relevant papers for systematic review. In cases where the relevance of papers was ambiguous, the full text was examined. The qualification processes used the following set of protocols:

- Papers that did not meet the inclusion and exclusion criteria were not incorporated into the review. Projects with no relevance to construction were excluded at this point. Supply chain studies concerning materials used in construction projects (e.g. rebar or cement) were excluded due to their manufacturing focus.
- Only papers related to the topic area of supply chain performance studies in a construction sector were considered.
- Only published journals and conference proceedings were shortlisted, due to the purpose of this review. The indexes searched included a range of other sources such as ebooks, books, book chapters, preprint and theses.
- Duplicate papers were identified and consolidated.
- The selection process was repeated by another author to ensure consistency and robustness. Discrepancies were discussed, and arbitrated upon.

The end result was a set of 33 papers, selected for analysis in detail.

In terms of reporting, results from the literature review took two forms: a descriptive analysis capturing facts and figures from a quantitative perspective and a qualitative interpretation of the key themes emerging from the selected papers. This combined approach was deemed appropriate as it (a) provides a more comprehensive review process, demonstrating the robustness of the methodology, (b) addresses the research questions by revealing the current state of construction supply chain performance measurement and (c) yields recommended areas for further development.

3. FINDINGS AND DISCUSSION

The findings from the literature review process are discussed here, based upon two levels of analysis, these being descriptive (Section 3.1) and inferential (Section 3.2).

3.1 Descriptive Analysis

Within the sample of 33 papers that were selected for analysis, the majority (85%) were in peer-reviewed journals, the remainder being in conference proceedings. The journal papers had appeared in diverse range of publications, typically just a single one in each with the exception of four journals that featured two or more articles, as follows:

- *Supply Chain Management: An International Journal* – 3 papers;
- *International Journal of Construction Supply Chain Management* – 2 papers;
- *Procedia Engineering* – 2 papers;
- *Production Planning & Control* – 2 papers.

The wide range of publications shows the fragmented nature of the construction supply chain performance topic, as the studies do not fit neatly into a few specific journals. This is not surprising, given the interdisciplinary nature of a topic that encompasses supply chain, construction, project management and civil engineering – and which requires interfacing between these functions for its practical application. Also noted was a considerable degree of commonality with concepts and practices from other sectors including the lean supply chain and Total Quality Management.

The literature review process identified papers from 2001 to 2018. It is apparent that many relevant papers were published in the years 2010 (6 papers) and 2018 (7 papers). A growth trend can be seen (Figure 1).

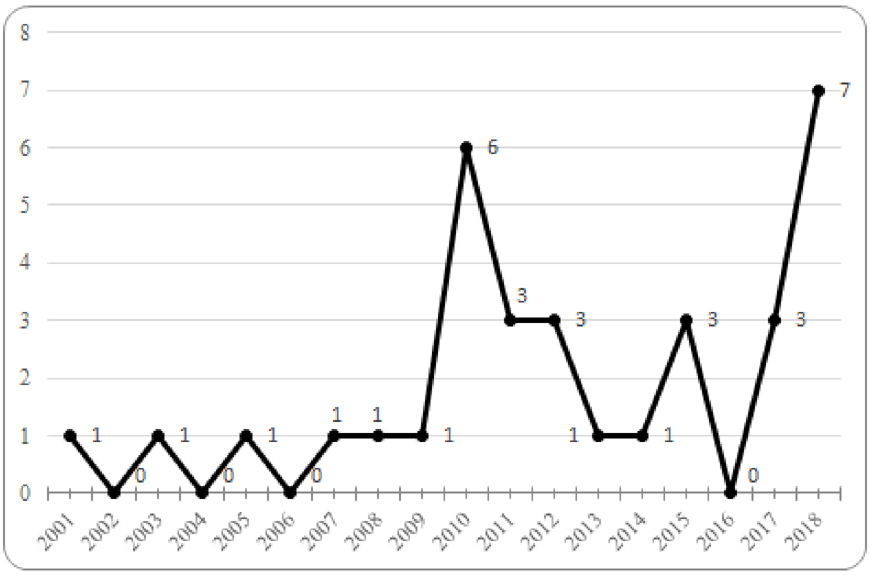
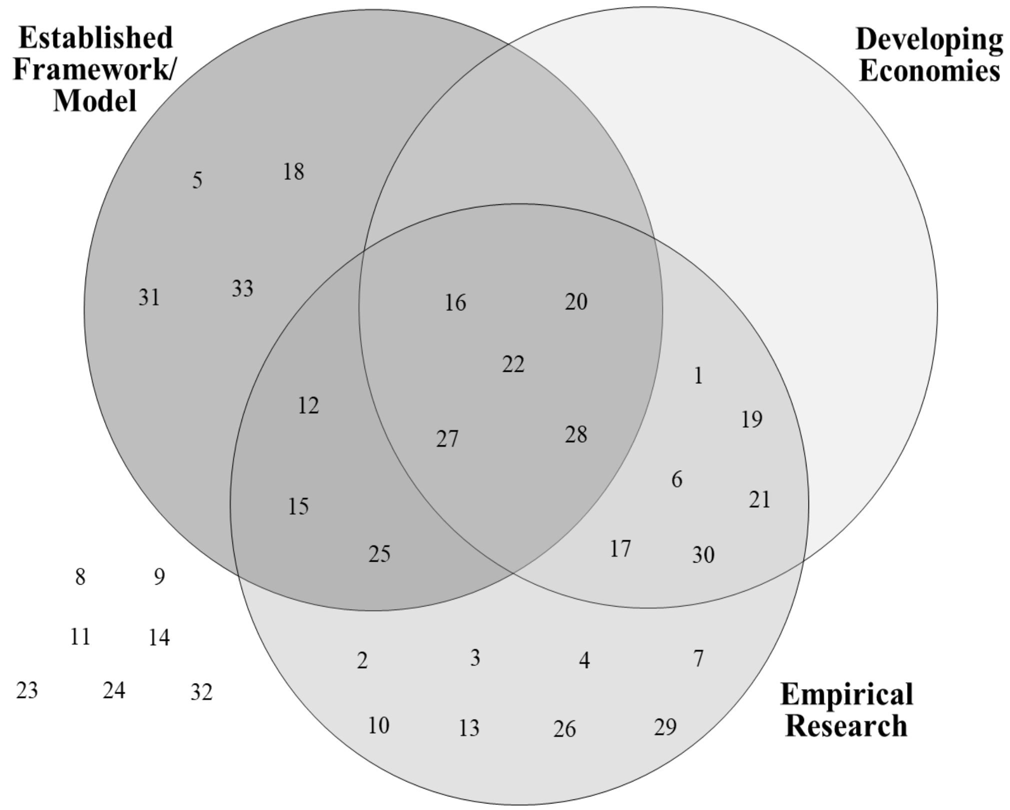


Figure 1: Results of the review, showing the number of papers by year

Among the selected papers, an analysis of their methodological type revealed that 67% (22) were empirical in nature, with 36%, 24% and 6% using qualitative, quantitative and mixed research methods respectively. 21% of the papers were classified as mathematical, modelling or simulation oriented whereas 9% were largely conceptual, theoretical or opinion-based. All the empirical papers adopted cross-sectional studies. Whist this approach provides a snapshot of the organisation under investigation at a particular point in time, it does not capture information before or after that snapshot, so insights into supply chain evolution may have been overlooked – a problem compounded by an industry where projects are typically one-off in nature.

Twelve papers were qualitative in nature. Among these, 83% utilised the case study research method, the exceptions being based upon action research (Eriksson, 2010) and ethnography (Wickramatillake et al., 2007). Within the realm of quantitative studies, survey is widely used. Only one literature paper (Gor and Pitroda, 2018) was identified in the study.

Within the 22 empirical papers, research that has been conducted in developing and developed economies is well balanced, with 11 papers each. Construction supply chain performance research is seen to be relevant in economies of both types, although it is interesting to note that no study to date compares the approaches employed in each. Figure 2 summarises the nature of the papers in the systematic review.



Legend:
[1] Al-Ma'aitah (2018); **[2]** Arbulu et al. (2003); **[3]** Behera et al. (2018); **[4]** Chen (2011); **[5]** Cheng et al. (2010); **[6]** Choi (2018); **[7]** Dainty et al. (2001); **[8]** Ebrahimy et al. (2011a); **[9]** Ebrahimy et al. (2011b); **[10]** Eriksson (2010); **[11]** Gor and Pitroda (2018); **[12]** Halman and Voordijk (2012); **[13]** Hatmoko and Scott (2010); **[14]** Hu (2008); **[15]** Kaare and Koppel (2012); **[16]** Ke et al. (2015); **[17]** Kim and Nguyen (2018); **[18]** Liu et al. (2018); **[19]** Othman and Abd Rahman (2010); **[20]** Pan et al. (2010); **[21]** Quang and de Castro (2017); **[22]** Quang and Hara (2018); **[23]** Setijono (2009); **[24]** Smyth (2005); **[25]** Thunberg and Persson (2014); **[26]** Wang and Hubbard (2017); **[27]** Wibowo and Sholeh (2015); **[28]** Wibowo and Sholeh (2017); **[29]** Wickramatillake et al. (2007); **[30]** Yadav and Ray (2015); **[31]** Yunning and Rong (2010); **[32]** Zhang and Zhang (2012); **[33]** Zhihong et al. (2013).

Figure 2: Nature of Papers in the Systematic Literature Review

3.2 Inferential Analysis

The bulk of the discussions within the selected papers indicate that construction supply chains are distinctive. Understanding their peculiar characteristics is therefore important as it impacts upon practices of performance measurement within the industry. For this reason, Sections 3.2.1 to 3.2.3 address the key features of the industry, while the key themes derived from the literature review are discussed in Sections 3.2.4 to 3.2.8.

3.2.1 The Nature of the Construction Supply Chain

Wickramatillake et al. (2007) assert that supply chain performance measurement in construction differs from that seen in other sectors due to complexity and uncertainty. This complexity has deterred the development of proper models addressing performance issues in the construction supply chain (Ebrahimy et al., 2011a, 2011b).

Construction supply chains can be very complex (Cheng et al., 2010; Setijono, 2010; Hatmoko and Scott, 2010), consisting of separated lifecycle phases such as project decision and concept, design, procurement, construction, installation, winding up, maintenance and even demolition (Hu et al., 2008; Kaare and Koppel, 2012; Bahera et al., 2018). They are generally:

- uncertain in their operational processes due to "wide fluctuating demand cycles, project-specific product demands, uncertain production conditions and has to combine a diverse range of specialist skills within geographically dispersed short-term project environments" (Dainty et al., 2001, p. 163) and "uncertainties associated with equipment, processes, and material handling" (Ebrahimy et al., 2011b, p. 467);
- riskier, compared to other industries, due to the need for facilities and plant to be relocated to construction sites, with uncertain project duration, complicated processes, unpredictable environments, financial intensity and complex structures with a multitude of stakeholders (Quang and Hara, 2018); and
- volatile, unpredictable and unstable because "every construction project is different and delivered to a different client comprising of many fragmented self-protected entrepreneurs with paranoid attitudes" (Kim and Nguyen, 2018, p. 170).

Due to these specific features, it is reasonable to accept the viewpoints of Wang and Hubbard (2017) and Quang and Hara (2018) that construction supply chains are dynamic in nature. In an industry that is characterised by complexity and interconnection, a supply chain that is able to adapt quickly is a necessity, with a performance management regime to match.

3.2.2 Fragmentation in the Construction Supply Chain

Construction supply chains are described as fragmented in Dainty et al. (2001), Arbulu et al. (2003) and Farmer (2016). There are many players in a construction supply chain, typically including clients, architects, main contractors, subcontractors and material suppliers (Setijono, 2010) with the Small to Medium Enterprises (SMEs) performing a critical role as subcontractors and material suppliers (Dainty et al., 2001). The number of these SMEs is high (Cheng et al., 2010; Wang and Hubbard, 2017; Quang and Hara, 2018; Liu et al., 2018) particularly on large-scale projects (Wickramatillake et al., 2007; Hatmoko and Scott, 2010). The staff of SMEs in the sector have been skeptical about the motives of performance measurement initiatives (Dainty et al., 2001), which is unfortunate since Hatmoko and Scott (2010) found the deployment of subcontractors to reduce project delays by 45% – suggesting that these stakeholders can be crucial to the advancement of construction supply chain performance, despite present-day fragmentation.

Suppliers' responsibilities can be diverse, with many involved in multiple projects at a single point in time (Hu, 2008; Kaare and Koppel, 2012). Moreover, there are multiple layers of subcontracting even in a single project setting and this restricts collaboration as members of the supply chain tend to work in isolation (Yadav and Ray, 2015). Cheng et al. (2010) find that fragmentation increases when employees in construction are deployed on a project basis with no clear reporting line. Ke et al. (2015) reveal an additional problem: the high level of uncertainty in operational processes makes managing contracts, relationships and cooperation between players particularly challenging in an environment of constant change; Wang and Hubbard (2017) identified additional problems including cost competition among suppliers, competitive bidding and the substitution of products and materials.

The features identified above confirm the view that construction supply chains are fragmented, underlining the need for relevant stakeholders at all levels – encompassing the supply and demand and networks – to collaborate in the pursuit of better performance.

3.2.3 Uniqueness of the Construction Supply Chains

Every construction project is unique (Wang and Hubbard, 2017; Pan et al., 2010; Quang and Hara, 2018), being characterised variously as "one-off" (Setijono, 2010; Wang and Hubbard, 2017), discontinuous in nature with little or no repeatability due to unique designs and material specifications (Kim and Nguyen, 2018) or simply temporary in nature (Cheng et al., 2010; Kaare and Koppel, 2012).

Furthermore, a construction supply chain does not appear to have well-defined boundaries and connections (Wang and Hubbard, 2017). For example, a construction firm can engage in single or multiple markets, unlike other sectors such as manufacturing (ibid.). Similarly, "the buyer–supplier relationships in a construction project can differ from project to project, organization to organization, and product to product" (Cheng et al., 2010, p. 437). In this regard, comparative studies might be conducted, benchmarking construction supply chain performance against other sectors such as manufacturing or retail, allowing practitioners to identify gaps and improve performance based on the needs of the sector specifically.

3.2.4 Incorporation of Existing Performance Measurement Models

The findings of the literature review show that there is no standard set of measures for construction supply chain performance evaluation. While some organisations were seen to utilise frameworks or models, others relied on a bespoke system. A representative sample of the approaches revealed by the literature review follows:

- Resource, output, flexibility (Ke et al., 2015) – adapted from Beamon (1999);
- Cost and progress capture for manufacturing, resale supply and subcontracted material (Wickramatillake et al., 2007);
- Process cycle times, documentation accuracy, and product conditions upon arrival (Cheng et al., 2010) – adapted from the Supply Chain Operations Reference (SCOR);
- Delays in material, information, labour, 'plant, equipment and temporary works' (Hatmoko and Scott, 2010);
- Reliability, responsiveness, cost and assets (Pan et al., 2010 – adapted from the SCOR);
- Financial and supply chain cash flow (Chen, 2011);

- Financial, customer, internal business, external business, and innovation
- (Halman and Voordijk, 2012) – adapted from Kaplan and Norton's (1992, 1993) Balanced Scorecard (BSC).
- Time, costs, quality, users' satisfaction (Kaare and Koppel, 2012);
- Customer-facing and internal-facing (Thunberg and Persson, 2014; Wibowo and Sholeh, 2015, 2017 – adapted from the SCOR);
- Environmental, economic, and organisational (Al-Ma'aitah, 2018);
- Supplier performance, internal business, innovation and learning, customer service, and finance (Quang and Hara, 2018 – adapted from the BSC); and
- Sustainability, financial, customer, business processes, learning and innovation (Liu et al., 2018 – adapted from the BSC and SCOR in combination).

The studies of Wibowo and Sholeh (2015; 2017) reveal that although the SCOR framework can be adopted as a supply chain performance measurement system in a road construction project, it requires adaptation to suit a specific construction supply chain. Similarly, Halman and Voordijk (2012) used and adapted the BSC to measure and manage supply chain performance in housebuilding. No "one-size-fits-all" approach to supply chain performance measurement can encompass the wide range of products and services offered, the firms involved or the industry norms: Thunberg and Persson (2014, p. 1075) considered the SCOR framework "... either too generic or too manufacturing-oriented for the construction industry" while Pan et al. (2010, p. 1106) report that the "SCOR model cannot perform dynamic simulation or optimization analysis." Cheng et al. (2010, p. 436) support this argument, finding that "the supply chain model framework that describes the interactions across internal business functional units is not suitable for modeling construction supply chains". The majority of the studies reported in the literature did *not* adopt an existing framework, preferring a bespoke performance measurement approach.

3.2.5 Key Performance Indicators Identified

The literature identified a recurring set of measures (or metrics, or indicators) employed by the industry. In exploratory case study research in the private sector, Dainty et al. (2001) concluded that price was the main metric used in the appointment of subcontractors; Kaare and Koppel (2012) found the same in the public sector. Equally, Wickramatillake et al. (2007) argued for the development of practical methods to measure and reduce excessive costs. While one might assess the past financial performance of a supply chain based on historical data, Thunberg and Persson (2014, p. 1068) argue that "the risk with relying too much on historical data is that any bias in the assessment is not apparent, which can lead to the metric being assessed based on faulty data." Other aspects of performance evaluation relating to price such as cash flow management and payment terms are also crucial for the construction sector (Dainty et al., 2001; Chen, 2011).

Measures relating to time are also common. Hatmoko and Scott (2010) found that delays in material flow posed the greatest threat to project completion. They suggested monitoring of delays not only in material flow but also those associated with labour, information, plant, equipment and temporary work. There is some argument surrounding this matter, however. Wickramatillake et al. (2007, p. 59) claimed that using a performance measurement system for management of material supply and delivery may be confounded by the implementation risks of the system. Wang and Hubbard (2017) argued that certain delays may not negatively impact project schedules and that delays are difficult to verify. Nonetheless, these scholars acknowledge the need to evaluate the performance of the supply chain, recommending constant tracking and reporting, with prompt notification of possible delays to avoid knock-on effects.

Setijono (2010) proposes monitoring value-related performance, demonstrating value creation to stakeholders. Ebrahimy et al. (2011a, 2011b) found that storage capacity, effective quality control and the ability to anticipate required lead-time were vital to performance, measured as the total duration of the project. Halman and Voordijk (2012) gave manufacturing lead time, customer response time, on-time delivery to client, on-time delivery of suppliers and client satisfaction as the most relevant performance indicators in housebuilding, while Ke et al. (2015) used six indicators (schedule, quality, cost, flexibility, core enterprise satisfaction and partner closeness) to measure the performance of Engineering, Procurement and Construction (EPC) projects in construction supply chains. Bahera et al. (2018) found quality, finance, logistics and innovation to be critical.

Whilst Halman and Voordijk (2012) believe a robust construction supply chain performance measurement system is better approached with a large number of indicators, Zhihong et al. (2013) called for simple, clear and standardised calculations.

3.2.6 The Role of the Integrated Supply Chain

As reported by Egan (1998), integrated processes and teams are key drivers of improved performance in the construction industry. The view is shared by Wickramatillake et al. (2007, p. 58) who found that good outcomes depend upon "interorganisational collaboration, cooperation and learning". Setijono (2010) also finds integration to be key in value creation. Pan et al. (2010) and Ke et al. (2015) correlated cooperation with performance in bridge construction and EPC projects respectively, while Erikkson's (2010) action research found operating a joint project office and practicing concurrent engineering to be prerequisites to the success of a lean project – a view shared by Setijono (2010), while Arbulu et al. (2003) warned that inefficiencies occur *between* processes, disciplines and organisations.

More recently, Kim and Nguyen (2018) found collaboration improved project performance significantly; Gor and Pitroda (2018) also advocated strong connections between supply chain participants but Yadav and Ray (2015) warn that the involvement of many subcontractors can inhibit an integrated construction process. Thunberg and Persson (2014) suggest that a main contractor should be evaluated by other members of the supply chain such as material suppliers. In this way a performance measurement system can provide feedback (Kaare and Koppel, 2012) overcoming what Dainty et al. (2001) call the "subordinate position", where Smyth (2005) finds contractors serving as "emulators rather than initiators", with reduced productivity and innovation. The papers use varied terms such as cooperation, collaboration and connection, but all discuss integration, a topic of clear significance to the improvement of construction supply chain performance.

3.2.7 Triadic Approaches to Performance Evaluation

A triadic approach toward construction performance is lacking in the extant literature, missing the essence of supply chain management. Arbulu et al. (2003, p. 164) found that "the triadic relationship is conceptually and theoretically complex due to the potential for suboptimization", but they also acknowledge that the performance of a construction supply chain ought to be addressed over its entire length. The wider literature (outwith construction) also largely fails to assess performance in a way that recognises the benefits of integration

(Thakkar, 2012; Tsanos et al., 2014). For instance, “although measures such as order fill rate are likely to be influenced by activities throughout the entire supply chain, they ultimately measure performance at the intra rather than the inter-organizational level” (Shepherd and Günter, 2006, p. 247). To address this gap, it is proposed that comparative studies be conducted at different supply chain tiers, highlighting deficient interfaces and showing how practitioners might improve their performance measurement systems.

3.2.8 Sustainability as A Driver of Performance Measurement

A trend towards increasing ‘green’ performance in construction was seen, the literature showing that companies are incorporating sustainability metrics within their supply chain performance measurement systems. Al-Ma'aitah (2018) and Liu et al. (2018) found that adopting green construction practices actually improved economic performance, while Yunning and Rong (2010) and Liu et al. (2018) consider the advancement of green construction supply chain management to be inevitable. Zhihong et al. (2013) suggest that a green supply chain performance evaluation model should be able to capture quantitative and qualitative performance indicators using a simple, clear and standardised calculation methodology.

4. RECOMMENDATIONS AND CONCLUSIONS

There is a clear need to better understand construction supply chain performance management as it offers a basis to advance the sector in general. Building on the statement from Thunberg and Persson (2014, p. 1075) that “by measuring the supply chain, we know how effective our application of supply chain management is and what to improve”, an assessment of the current state of the art was felt to be valuable, informing future development. The deficiencies in this topic area are now apparent as a result of the systematic literature review.

A principal finding is that few studies addressing construction supply chain performance exist, in contrast to the extensive research found within the supply chain domain as a whole. Although relevant papers show a growth trend, the overall number remains very low, with just 33 papers identified by the systematic literature review. Further insights are required, influencing how performance measurement approaches are adapted and deployed: before a project is commissioned, practitioners ought to consider its requirements, risks and the power dynamic between supply chain partners. When performance expectations are clear, resources can be configured appropriately, varying with project scale, current stage and the unique characteristics of the task at hand, to operate an effective and efficient construction supply chain.

The ideal performance measurement system would serve not only the construction sector as a whole but also the needs of specific projects. Such a ‘configurable construction supply chain performance measurement system’ would address the fragmentation found within the sector in the present day, where projects are one-off and the networks of businesses that deliver them are temporary. This demands a standardised approach, with customisation that produces a tailored system matching the needs of specific projects. Capturing the key performance indicators associated with demand and supply will vary with the client and the set of subcontractors, but selecting metrics from a library of those commonly used in project management and supply chain management will save time and improve accuracy.

Cost- and time-related metrics were prevalent in the literature, while another recurring theme was 'green' performance in the construction industry. This is only tangentially related to supply chain performance, but it adds weight to the argument that future performance management systems will need to accommodate multiple, even competing goals. Zhihong et al. (2013) argued for a balanced approach that captures both financial and non-financial measures, while Wang et al. (2013) sought a green supply chain performance evaluation that took into account both qualitative and quantitative factors.

There is a need to capture the perspectives of multiple players within a construction supply chain such that firsthand insights can be gathered and used to advance knowledge in general. For example, the individual bargaining power of an SME is low, but the power of groups of SMEs in construction supply chains can be significant. While the authorities will certainly intervene if companies collude to prevent or reduce competition, positive cooperation between SMEs could substantially improve performance in the construction sector. Therefore, research that studies the performance of clusters of supply chain partners would be valuable. Additionally, comparative studies involving clusters that address particular commodities, trades or partnerships (including triadic supply chains) will serve to shed light on an undeveloped topic area.

Findings from the review showed that improved construction supply chain performance is associated with an integrated measurement system, representing a project as an interconnected network or system. 'Construction supply chain integration' is crucial as a seamless performance measurement system is found to improve the level of collegiality among members of the supply chain. Subsequently, it allows them to be responsive, cultivating a flexible and agile working environment – key attributes for success in a dynamic industry characterised by high levels of volatility, unpredictability, instability, risk, uncertainty, complexity and fragmentation.

The literature also suggests that performance evaluation methods can and should vary with project scale, although no simple approach to identify the most appropriate regime exists at this time. Taking into account the distinct phases of construction project lifecycles, it will be worthwhile observing supply chain performance measurement as it evolves over an entire project. Additionally, it will be useful to contrast supply chain performance management strategies employed at different phases – within or after the defect liability period, for example. While the sustained data collection effort of such a longitudinal study would be onerous, results from projects at different scales and stages will produce insights and performance improvements with considerable impact.

It is apparent that more research is needed: particularly that which is empirical in nature. Although both qualitative and quantitative streams would be valuable, mixed-methods research was seen to be particularly rare. Overall, it is clear that much work remains to be done, integrating and reinforcing good practices where they exist today, while also addressing knowledge gaps via academic research and collaboration within the industry.

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APPRAISALS OF STUDENT PERSPECTIVES ON FIRE SAFETY PRECAUTIONS IN HALL OF RESIDENCE

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Abstract: Globally, student enrolment in higher institutions has been increasing in recent times, and it is estimated that the growth will continue to improve. This phenomenon results in a situation where the university administrators are confronted with the challenge of managing the scarce accommodation facility among many students. Fire outbreak is a significant challenge confronting hostel management due to a large population of students occupying a single building. Thus, this study appraised fire safety precautions in student hostels using a University in Nigeria as a case study. The study adopted convenience sampling, in collecting data from student occupying the hostel within the school. A total of 100 questionnaires were distributed out of which 87 questionnaires were returned and used for the analysis. The questionnaire was analysed with SPSS adopting frequencies, mean score, and ANOVA test. The findings from the study show that preventing flammable materials into the hall of residence is the major fire safety precautions. Also, the causes of fire within the hall of residence is due to the reactive maintenance approach adopted by hall managers. The study recommends that fire drills should be conducted for students and the hall managers should adopt a proactive management system.

Keywords: Fire safety, fire outbreak, hall of residence, safety precautions.

1. INTRODUCTION

Huseyin and Satyen (2006) and Starr (2019) asserted that fire is essential for the advancement of society due to is a significant contribution to human civilisation. Despite its contribution to human society fire also contributes to the threat of human life and property (Chow, 2004). The fire outbreak experienced in the country in the past couple of months attests to the negative impact of fire on society. According to Ismail and Taib (2013), fire outbreak is one of the most feared disasters anywhere in the world, this is so because of its devastating consequences anytime it occurs. Agyekum et al. (2016) gave another reason in which fire outbreak is a feared disaster. The author believed that the fire outbreak could occur in any form of a building; bungalow, terrace, duplex, tenement and high-rise buildings.

Hall (2000) and You-di (2009) opined that the fire outbreak in high rise buildings is worst in comparison to other forms of buildings classification. Numerous studies have given the reasons for the severe fire outbreak in high rise buildings. Notable amongst them include; Hopkin (2017) believed that high rise building experience more stack effect that encourages the movement of a large volume of heat and smoke during a fire outbreak. Sano et al. (2017) asserted that the fire outbreak is worst in high rise buildings due to the building shape preventing an easy way out in the event of a fire outbreak. Huo et al. (2016) further revealed that a large number of occupants in high rise buildings contributes to making fire outbreak disastrous. This is because most of them panic during a fire outbreak thereby leading to stampeded or taking the wrong exists during the fire outbreak. Thus, it is reasonable to assert that a large number of people occupying the high-rise buildings increase the severity of a fire outbreak.

Ismail and Taib (2013) stipulated that academic hostels are characterised with a large number of people occupying such buildings. Agyekum et al. (2016) provided other characteristics of academic hostels and concluded that most of them are high rise buildings. Ebenehi et al. (2017) discovered that Universities, polytechnics or colleagues of education construct high rise buildings with the intention of housing more students in a lesser space. Globally, student enrolment in higher institutions has been increasing in recent times, and it is estimated that the growth will continue to improve (Salakpi et al., 2014). This phenomenon results in a situation where the university administrators are confronted with the challenge of managing the scarce accommodation facility among a large number of students. Fire outbreak is a significant challenge confronting hostel management due to a large population of students occupying a single building (Agyekum et al., 2016).

Towards confronting the menace of fire outbreak in hostels fire safety culture has been embedded in most higher institutions (Zile, 2018). Fire safety is the reduction of the potential for harm to life because of fire in buildings (Hopkin, 2017). Although, Chow (2004) affirmed that the potential for being killed or injured in a fire cannot be totally eradicated. Fire safety in a building can be achieved by providing building design features intended to minimize the risk of fire outbreak to the greatest extent possible (Huo et al., 2016). Also, Buchanan and Abu (2017) opined that the magnitude of fire outbreak can be reduced only when the structure is designed, constructed, equipped, maintained and operated with a view to save the life and property of its occupant. All the aforementioned opinion indicates the necessary measures required to minimize the risk incidences of fire from the building perspectives while neglecting the occupants.

Nimlyat et al. (2017) discovered that a fire outbreak occurs in building due to the negligence of the occupants. Kim et al. (2017) indicated that a building equipped with the state of the art fire prevention facilities still have a high risk of fire outbreak in the face of occupants with poor fire safety precautions. In support of this assertion. Abdullahi et al. (2017) affirmed that the occupants of a building in which there was a fire outbreak suffer more injury due to their poor knowledge of fire safety precautions. Thus, this study conducts an appraisal from the student perspective on fire safety precautions in their respective hall of residences. The study is expected to reveal the fire safety precautions in the student hostel and the students level of understanding regarding the fire control measures put in place to control the spread of fire. The findings from the study will be significant to the students on the advantage of fire safety precautions and facilities to have at their disposal in the event of fire outbreak. Whereas to the school management, it will reveal the essential fire safety facilities to be installed in the buildings.

2. REVIEW OF LITERATURE ON FIRE IN THE HALL OF RESIDENCES

2.1 Fire

The primitive man was first believed to discover fire by the striking of hard stone together which was used for cooking, warming and lighting his dwelling (Hall, 2000, Buchanan and Abu, 2017). Huseyin and Satyen (2006) asserted that fire is created when oxygen from the air combines with other substance to produce bright light, heat and smoke combustion. Hopkin (2017) describe fire as a useful tool for driving civilisation over the years. Tharmarajan (2007) noted that fire is the combination of heat and light energy with the adverse effect of oxygen to yield up combustion. Osunsanmi et al. (2017) describe fire as a combustion process between the oxidation of fuel in the presence of oxygen with the emission of heat and light. This study defines fire as the product from the combination of oxygen, fuel and heat, while it can be extinguished by removal of any of the parameters.

Hall (2000) gave some conditions for a fire to occur which is highlighted below;

2.1.1 Oxygen; must be at least 16% of the atmosphere to sustain combustion and if it drops below this level, combustion ceases.

2.1.2 Fuel; this can either be in the form of (solid, liquid, or gaseous) must be present in sufficient concentration to form a combustible mixture with oxygen. But if the fuel supply is consumed, separated, or removed, combustion will cease.

2.1.3 Heat; must be sufficient to produce and ignite combustible gases; solid and liquid fuels must be pre-heated to distil these gases before they ignite. Fuels kept or cooled below their ignition temperatures will not support combustion. A fire will also self-terminate if burning fuels do not produce adequate heat to ignite fire gases or distil new fire gases from liquid and solid fuels.

2.2 Classification of Fire

Buchanan and Abu (2017) classifies fire into various classes, and it is highlighted below;

2.2.1 Class A (ordinary combustible solids)

This consists of organic materials like wood, textiles, furniture and plastics. Tharmarajan (2007) believed that this form of fire occurs when the material undergoes combustion and will continue to burn as long as the four components of fire (heat, fuel, oxygen and the sustaining chemical reaction) are available and it can be extinguished by covering the fire with a blanket.

2.2.2 Class B flammable liquids

This type of fire can be divided into non- mixable and mixable. Example of non-mix able liquid includes petrol, oil and paints while mixable liquids are alcohol, methanol and acetone.

2.2.3 Class C (electrical fire)

This type of fire involves electrical appliances such as wiring, circuit breakers and outlets, and is caused by, short-circuiting machinery or overload electrical cables. Buchanan and Abu (2017) suggest that electrical fire may be fought with the following extinguishers carbon dioxide and dry chemical powder extinguishers and even baking soda.

2.2.4. Class D

These fires involve combustible metals, such as magnesium, titanium, potassium and sodium

2.2.5 Class K (cooking oil and fats)

This is the type of fire occurs from cooking oil or fats. Though such fires are technically a subclass of the flammable liquid/gas class, the special characteristics of these types of fires are considered important enough to recognize separately.

2.3 Hall of Residence

Brice (2012) opined that the hall of residence popularly known as student's hostel in some countries originated from Germany. It began when a German teacher during some of the trips organised for his students needed a place to stay during a heavy rainstorm. The teacher found an empty school to seek shelter for the student. During the student stay that the teacher developed the idea of using an empty school as accommodation and called it a youth hostel. Salakpi et al. (2014) stipulated the concept of student hostel flourished in Germany and extended to other European countries like Switzerland, Poland, Norway, England and many others. The growth of hostel accommodation leads to the establishment of European hostelling associations. It can affirm that hall of residence grew from the need to accommodate students.

Abdullahi et al. (2017) avowed that hall of residence in Nigeria came into existence from the need to accommodate and house students. Onojo et al. (2013) indicated that a hall of residence is needed in Nigeria Universities because students are the most critical stakeholders in any university. Agyekum et al. (2016) believed that hall of residence assists in improving the campus life experience of students. The students' academic life experience is improved from the interaction with other students from other faculties residing in the hostel. (Sawyerr and Yusof, 2013) asserted that the hall of residence improves the social life of the students and expose their minds to the community around them. Ogungbe et al. (2018) discovered that the advantage of student's hall of residence is endless but the school authority is confronted with numerous challenges from its management. Agyekum et al. (2016) indicated that the significant problems facing school authorities are ensuring the fire safety of the students and buildings. Thus, some fire safety precautions are often installed in the hall of residence within the schools.

2.4 Fire Safety Precautions in the Hall of Residence

Osunsanmi et al. (2017) avowed that fire safety precautions are measures adopted to prevent or reduce the likelihood of a fire that may result in death, injury, or property damage. Tharmarajan (2007) indicated that fire safety precautions could also be used to alert those in a building on the presence of a fire in the event one occurs. Fire safety precautions also provide measures for those threatened by fire to survive or to reduce the damage caused by fire (Chow, 2004). Buchanan and Abu (2017) indicated that fire safety precautions could be informed of the following;

- Ensuring that flammable material is stored in a safe place.
- Training programs on fire outbreak
- Ensuring that there are explicit or glow in the dark signage indicating exist routes and location of fire safety equipment.
- Conduct fire and evacuation drills regularly
- Ensuring that all areas under renovation are regularly inspected
- Presence of law enforcement that ensures compliance of statutory requirements
- Conducting regular inspection on all electrical installations
- Installing high-tech fire safety equipment
- Implementation of proper and regular housekeeping
- Assign specific personnel as building emergency response staff
- Distribution of pamphlets containing emergency procedure and evacuation plans
- Implementation of the floor warden system

Agyekum et al. (2016) and Hopkin (2017) highlighted some fire safety precautions often installed in hostels to include the following; protection measures installed in high rise buildings which include the following;

2.4.1 Sprinklers; they are often installed inside the rooms within the hall of residence. They work in response to sensors that detect smokes or hot gases. After the detection of smoke water automatically comes out from its nozzles.

2.4.2 Detection and alarm system; this form of fire safety precaution measure is similar to the sprinklers. The similarity originates from their sense of operation as they both rely on sensors to operate. But the difference is that the alarm system only functions as warning the building occupants and cannot put off a fire in the event of a fire outbreak.

2.4.3 Creation of fire compartment; Tharmarajan (2007) indicated that fire compartments are enclosures or rooms within the buildings constructed with fire-resistant materials to provide temporary accommodation for occupants.

2.4.4 Fire extinguisher; Osunsanmi et al. (2017) affirmed that this is the most common form of fire safety precautions adopted in most buildings. Fire extinguisher just like its name is usually adopted for small fires in emergencies.

2.4.5 Hose Reel; this form of fire safety precautions relies on water for its effective functioning. The major disadvantage is that some fires cannot be eliminated with water.

3. RESEARCH METHODOLOGY

The hall of residence provides numerous advantages for the school authorities and the students. However, is management is confronted with numerous problems with fire outbreak rated as one of the major issues. Fire outbreak was ranked as the major problems in student hostel due to the high number of occupants in the room. Ismail and Taib (2013) indicated that the probability of a fire outbreak is more due to the activities of the students. Also, Agyekum et al. (2016) noted that a lot of combustible materials and heating devices are often used in students' hostels which may lead to fire outbreaks if no fire safety measures are taken. Thus, this study conducts appraisals of fire safety precautions in the hall of residence from the student perspective.

The appraisal was conducted through the sharing of a questionnaire to selected hostel occupants within a University located in Lagos Nigeria. The questionnaire was divided into three sections the first section examines the personal characteristics of the students. The second section discusses the causes of a fire outbreak in the hostel from the student's perspective. The last part appraises the fire safety precautions in the hostel and the suitable control measures for reducing the spread of fire. The study adopted convenience sampling, in collecting data from student occupying the hostel within the school. A total of 100 questionnaires were distributed out of which 87 questionnaires were returned and used for the analysis. The questionnaire was analysed with SPSS adopting mean score, and the ANOVA test was used to test the hypothesis.

4. DATA ANALYSIS AND DISCUSSION OF FINDINGS

4.1 Personal Characteristics of the Respondents

The personal characteristics of the respondents examined include their gender distribution, academic level and age distribution presented in table 1. Table 1 shows that the majority (62.1%) of the respondents are females, and the remaining 37.9% of the total sample population is male. The result demonstrates that most respondents that took part in this study were female respondents. Regarding the student's year of study within the institution, the table shows that the response was provided from all the various level of undergraduate students. Regarding the students' academic level, the table shows that 500 level students provided 31.9% of the response, 21.8% of the response was sourced from 400 level students, 100 level students provided 37.9%, 4.6% of the response was gotten from 200 level students and 4.6% of the respondents are 300 level students. This implies that the respondents are well educated and knowledgeable hence can give reliable information about the fire outbreak in hostel buildings. The age distribution of the respondents shows that almost all (62.1%) of the respondents are within the age bracket of 16-20 years old, 23.0% of the respondents are within the age bracket of 21-25 years and 14.9% are within the age limit of 26-30 years. This implies that the respondents are well matured and hence can give reliable information about fire outbreak in hostel buildings.

Table 1: Personal information of the respondents

Personal Information	Frequency	Percentage
Sex		
Male	33	37.9
Female	54	62.1
Total	**87**	**100**
Students level		
100	33	37.9
200	4	4.6
300	4	4.6
400	19	21.8
500	27	31.0
Total	**87**	**100**
Age distribution of respondents		
16-20 years	54	62.1
21-25 years	20	23.0
26-30 years	13	14.9
Total	**87**	**100**

4.2 Possible Causes of Fire Outbreak from the Students' Perspectives

The respondents were asked to rate the probable causes of fire outbreak in their hostel using a five-point Likert scale from (1) Nil. (2) Low. (3) Moderate. (4) High. (5) Very high and their response is presented in Table 2

Table 2: Causes of fire outbreak within the student's hostel

	Mean score	Rank
Electrical equipment faults	3.80	1
Carelessness	3.66	2
Negligence	3.50	3
Electrical cable faults	3.41	4
Candles	3.22	5
Ignorance	2.60	6
Arson (willingly setting a building on fire)	2.35	7
Smoking	2.30	8
Natural cause	2.09	9

Table 2 revealed the mean scores (MS) and ranks of the causes of fire outbreaks in various halls of residence in the study area. From the table, it is apparent that the major cause of the fire outbreak is electrical equipment faults (MS= 3.80); and other causes in decreasing order are: carelessness (MS= 3.66), negligence (MS= 3.50), electrical cable faults (MS= 3.41), candles (MS= 3.22). It further revealed that ignorance (MS= 2.60), arson (MS= 2.35), smoking (MS= 2.35), natural cause (MS= 2.09) are not causes of fire outbreak in the student's hostels. This implies that faults from electrical fittings, fixtures or appliances are the major causes of fire outbreak in various halls of residence. It also suggests that fire outbreak within the hall of residence are rarely caused by the student's activities (ignorance, arson, smoking and natural causes) but are due to the hall managers activities such as poor maintenance of the electrical equipment's.

4.3 Fire Safety Precautions in the Hall of Residence

This study measured fire safety precautions in the hall of residence using the activities performed by the hall managers. Thus, the respondents were asked to indicate the activities undertaken by the hall managers to prevent fire outbreak in their hostel. Their response was ranked using a five-point Likert scale from 1 represented as never, 2 denoted as rarely, 3 signified as sometimes, 4 representing frequently and 5 stands for very frequently with the outcome presented by table 3.

Table 3: Activities to prevent fire outbreak

	Mean score	Rank
Prohibiting flammable materials	4.32	1
Fire signs and exit	3.99	2
Maintenance of all electrical fittings and safety equipment	3.50	3
Escape routes	3.22	4
Regular enlightenment of students by the facility manager about fire hazards	2.51	5
Constant fire extinguisher check test	2.10	6
A routine check on all appliances whether it's on or off	1.92	7
Fire drills	1.85	8

A look at the table shows that all the activities have a low mean score excluding prohibiting flammable materials with a mean score of 4.32. Which implies that the major activities undertaken by the hall managers to prevent fire outbreak are prohibiting flammable materials from entering the hostel followed by; fire signs and exit, maintenance on all electrical fittings, escape routes, regular enlightenment of students by the facility manager about fire hazards, constant fire extinguisher check test. Whereas activities such as routine check on all appliances whether it's on or off with a mean score of 1.92 and fire drills with a mean score of 1.85 are rarely carried out by the hall managers

4.4 Suitable Control Measures for Reducing Fire Outbreak

Hopkin (2017) affirmed that a fire outbreak is often control through the installation of some fire safety equipment. Thus, this section examined the suitable control measures for reducing fire outbreak from the student's perspective. The student's respondent's response is presented in table 4 and the table revealed that the respondents perceived that automatic sprinkler system would be the most suitable control measure to reduce the vulnerable spread of fire outbreak followed by an automated fire alarm, portable fire extinguisher, hose reel, high-pressure pumps, and compartmentalization by using fire-resistant walls.

Table 4: Suitable control measures to reduce the spread of fire

	Mean score	**Rank**
Automatic fire alarm	3.84	1
Automated sprinkler system	3.75	2
Portable fire extinguisher	3.64	3
Fire alarm	3.53	4
Hose reel and hydrant	3.44	5
Portable fire extinguisher	3.42	6
High-pressure pumps	1.74	7
Compartmentalization by using fire-resistant walls and floors	1.52	8

4.5 ANOVA Test for The Significant Difference between the Student's Academic Year and their Understanding of Fire Safety Precautions.

The study seeks to determine if the student's understandings of the fire safety precautions are a function of their academic level. Thus, a positive and alternative hypothesis was formulated. Analysis of variance (ANOVA) was used for testing the hypothesis with the students' academic level used as the differentiating factor, and the outcome is presented in table 5.

Table: 5 ANOVA for the difference between student's academic year and their level of understanding with fire safety precautions

	Sum of square	df	Mean square	F	P value	Sig.	Decision
Between groups	0.131	1	0.131	0.608	0.440	Not Sig	Ho accepted
Within groups	10.168	47	0.216				
Total	10.299	48					

From the table, the p-value is higher than 0.05 level of significance (95%) which shows that there is no significant difference between the student's academic year and their level of understanding with fire safety precautions. This suggests that no matter the academic level of the students their level of understanding with fire safety precautions in their hostel is the same. It can also be deduced that the students are not trained about fire safety in their academic curriculums.

5. CONCLUSION AND RECOMMENDATION

Among diverse types of disaster in buildings, fire constitutes a significant threat to life and property in urban and rural areas because a fire can happen at any time at any place. It can also occur at any structure, irrespective of its occupancy status (residential, commercial, industrial, hospitals, theatre, malls, institution and so on). Its effect on any structure has the potential to cause harm to its occupants and property. This characteristic of fire will make the uncontrolled spread of fire in a student's hall of residence disastrous due to the number of people that occupy students and the huge capital involved in erecting a hostel.

Thus, this study appraised fire safety precautions in the student hall of residence using a University in Nigeria. It concludes that the hostel managers still adopt a reactive fire safety precautions for managing fire outbreak as most of the fire control measures concentrate around when the fire outbreak as occurred judging from the firefighting measures and equipment installed in the hostel. The hall managers have not yet approached a pro-active method of combating fire outbreak such as doing fire drills and educating the students on the use of various firefighting equipment available in the hostel.

Finally, the study concludes that the students are averagely safe in their hall of residence or hostel judging from their poor understanding of the firefighting equipment and weak enforcement of the hall manager to the fire safety precautions. The study recommends that the students should be trained on fire safety precautions, firefighting equipment and probable causes of fire outbreak. Also, fire drills should be carried out at intervals to enlighten students on the availability, usage, and functionality of the fire service equipment.

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A FRAMEWORK FOR POSITIVE CONSTRUCTION SAFETY CULTURE FOR IMPROVED SME CONTRACTOR PERFORMANCE IN GHANA

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Abstract: Poor safety culture among construction Small and Medium Size Enterprises (SMEs) in Ghana creates an environment for errors and violations, which leads to accidents, injuries and fatalities. Ideal safety culture is the engine that drives the system towards the goal of sustaining the maximum resistance towards its operational hazards. It is therefore essential that a positive safety culture is fostered by SMEs since this promotes safety principles and helps to prevent accidents. There is an urgent need to address the inadequate safety culture practices among SME construction firms in the Ghanaian construction industry. This paper describes the current state of research on safety culture and its related issues among construction SMEs. From the reviews, the components that are needed to develop a framework for positive construction safety culture for improved SME contractor performance in Ghana is unravelled.

Keywords: Construction, Ghana, safety culture, SMEs

1. INTRODUCTION

The current increase in population growth globally has called for an equal increase in the provision of shelter, workplaces and many more leading to an expansion in the construction market since the industry is the backbone of many economies across the world (Amiri, Ardeshir and Fazel Zarandi 2017). The industry is recognized as a significant contributor to gross domestic product (GDP) globally (Mustapha, Aigbavboa and Thwala, 2018; Amiri, Ardeshir and Fazel Zarandi 2017). Despite this enormous contribution to economic development, the industry is still considered as the most dangerous industry worldwide. The rate of injuries and fatalities in the construction industry is worrisome (Musonda, Lusenga and Okoro 2018; Awwad, EI Souki and Jabbour 2016).

Accident prevention and investigation have become crucial as a result of the enormous damage that it inflicts on both victims and construction companies, especially Small and Medium-Sized Enterprises (SMEs). Ardeshir and Mohajeri (2018) are of the view that poor safety culture in a construction firm leads to unsafe work practices that result in injuries and fatalities among these construction firms. In order to identify the root causes of accidents, researchers have come out with theories of accident causation through different developmental stages. The stages include the technical stage where accidents were believed to have occurred as a result of mechanical malfunctioning of equipment. The next stage is where the cause of the accident was based on a mistake by people. The sociotechnical stage followed with the assumption that accidents occurred through the combination of both human and the equipment they used. The new stage is the organizational culture period in which it was noted that employees do not work in isolation of technology, but instead do their ordinary duties as harmonized teams of organization personnel who are embedded in a particular culture (Wiegmann, Zhang, von Thaden, Sharma and Gibbons 2004)

According to the Council for Technical and Vocational Education and Training (COTVET) (2010), the contribution of Ghana's construction industry over the years to gross domestic product (GDP) is over $600 million. The industry is so large in Ghana that there are over 23,000 registered contractors and many industry associations, including professional bodies (COTVET 2010). It is the fastest-growing industry in Ghana. In 2006, the growth rate was 8.2%, as against the national growth rate of 6.2% with annual employment growth rate at 10–12% (COTVET 2010). This simply means that developing good health and safety policies/regulations in the country's construction sector has huge potential for increasing economic growth and generating more jobs. According to Kheni (2008), the issue of health and safety in the construction industry is a major concern for governments, project participants, employers, and employees. When safety norms are well structured in an organisation, it leads to a positive safety culture in that organisation. It is therefore important that a positive safety culture is fostered in the organisation, since this promotes safety principles and helps to prevent accidents (Wong and Lee 2016). Studies have shown that one of the key challenges in implementing health and safety practice in Ghana is that the country does not have any comprehensive national health and safety policy (Annan, Addai and Tulashie 2015). According to Annan et al. (2015), there is inadequate research attention to health and safety practices in Ghana, and existing research tends to focus on the causes of occupational health and safety (OHS) issues while neglecting necessary empirical and scientific interventions, since there has not been research on business cases, OHS interventions, OHS attitudes, and a health and safety culture. The main rational of this paper is to identify the components that are needed to develop a framework for positive construction safety culture for improved SME contractor performance in the Ghanaian construction industry. To do this, the current state of research on safety culture is presented to unravel the components. The reviewed literature presented in the next section of the paper will enable the researcher to identify the safety culture components that inform the constructs to be examined in the future primary data collection exercise. Following the literature review is a succinct version of the research method. A discussion of the conceptual framework links the constructs together to form coherent ideas on how to take the study forward as highlighted in the concluding remarks.

2. LITERATURE REVIEW

2.1. Definition of Safety Culture

In the current dispensation, researchers have zoomed their research lenses onto safety culture due to its positive impact in reducing injuries and fatalities in the construction industry (Merry, 2016). Safety culture is a significant component of organizational culture, and its main objective is to create a positive environment within the organization that allows both management and employees to be aware of accidents and to prevent them from occurring. Safety culture has many different definitions as shown in Table 1. According to Lee and Harrison (2000), every safety management system is a social system, which mainly relies upon the employees who manage it. The success of this system depends on the scope of the system, how knowledgeable the employees are about the system, and how committed all the employees are to help the system work. In order to address these three core ideas, the concept of safety culture has emerged. According to Kim and Wang (2009), all these definitions suggest that safety culture comprises of many and varied components such as beliefs, attitudes, perceptions and behaviours.

Table 1: Source of safety culture definitions

Year	Author	Safety culture definition
1991	Cox and Cox	Safety culture is attitudes, beliefs, perceptions, values and behaviours that are shared among organizational members about safety issues
1998	Merry	Safety culture is made up of the beliefs, values, attitudes and behaviours of people within and organization
2000	Cooper	How people feel (psychological aspects), what they do (behavioural aspects) and how the organization operates (situational aspects) concerning safety
2000	Guldenmund	Safety-related norms (or underlying assumptions) values and practices shared by groups
2011	Bluff	Safety culture is regarded as the underlying values, assumptions and beliefs embedded in an organization that impacts on health and safety
2013	Wamuziri	States that safety culture may be considered as a subset of an organizational culture
2014	Nielsen	A subset of organizational culture that affects attitude and behaviours which intern influences the level of safety in an organization
2015	Institute of Occupational Safety and Health (IOSH)	Safety culture as shared values (what is important) and beliefs (how things work) that interact with an organization's structure and control systems to produce behavioural standards (the way things are done)

2.2. Positive Safety Culture

Aburumman, Newman and Fildes, (2019) are of the view that poor safety culture in an organisation creates an environment for errors and violations of rules and practices which leads to an increase in accidents. It also exposes the management's inability to address safety-related issues in the organisation. A positive (ideal) safety culture is the engine that drives the system towards the goal of sustaining the maximum resistance towards its operational hazards (Choudhry, Fang and Mohamed, 2017; Aburumman et al. 2019). Vecchio-Sudus and Griffits (2004) maintained that a positive safety culture is an effective means by which safety can be improved within an organisation if it is well developed and maintained. Choudhry et al. (2017) have come out with some essentials for a positive safety culture within an organization. These include the importance of safety, involvement of workers at all levels, role of safety staff, the caring trust (that all parties to have a watchful eye and helping hand to cope with inevitable slips and blunders), openness in communication, belief in safety improvements and integration of safety into the organization. Positive safety culture is when everyone knows their role regarding safety and all in the organization are truly committed to safety. The following, according to Grebenšek and Kosel (2015), show signs of negative safety culture in an organization.

- Where staff concerns about safety are not consistently addressed.
- Where staff does not learn from past events.

- Where safety cases indicate that the system is safe, but operational staff believes that the accident is inevitable.
- Where there is a belief that safety is the responsibility of someone else.

2.3. Measuring Safety Culture

Choudhry et al. (2017) have identified five critical components of positive safety culture that can be used in its measurement. These include management commitment to safety, management concerns for the workforce, mutual trust and credibility between management and employees, workforce empowerment, and finally continuous monitoring, corrective action, review of the system and continual improvements to reflect the safety at the worksite. Vecchio-Sudus et al. 2004 stipulated that positive safety culture can be promoted through, management commitment, changing attitudes and behaviours, employee involvement, promotional strategies, training and seminars and unique campaigns. Wiegmann et al. (2004) in their work have come out with five key components to assess safety culture namely; organizational commitment, management involvement, employee empowerment, reward systems, and finally reporting systems. Piers et al. (2007) have also identified six main components, which they named the characteristics of safety culture, and these are commitment, behaviour, awareness, adaptability, information and justness. For this research work, these six main components shall be considered to measure the safety culture within SME construction firms in Ghana. These include:

- Commitment - which reflects the extent to which every level of the organisation has a positive attitude towards safety and recognises its important
- Behaviour - which talks about the extent to which every level of the organisation behaves such as to maintain and improve the level of safety
- Awareness - which deals with how aware both management and employees are about the risks for themselves and any other person involves in the operations in the organisation
- Adaptability - the wiliness of both employees and management to learn from past experiences and take corrective actions necessary to enhance the level of safety within the organisation
- Information - how information on safety issues are distributed to the right people at the right time in the organisation and
- Justness - how people are encouraged to behave safely, report safety issues and how they are rewarded for reducing unsafe behaviour within the organisation

3. RESEARCH METHOD

The central research question for this study is “how would a safety culture engender positive and progressive performance by SME construction companies in the Ghanaian construction industry?”

In order to answer the above primary research question, the following sub-questions were compiled:

- What are the components that shape the safety culture within SME construction companies in Ghana?
- How do the shaping components influence the safety culture within SME construction companies in Ghana?

- How do the shaping components influence safety performance within SME construction companies in Ghana?
- How does the positive construction safety culture influence the performance of SMEs contractors in the Ghanaian construction industry?
- Which practical action plans can SMEs in the construction industry in Ghana implement to improve their safety culture in order to improve their performance?

The aim of this research, which takes a cue from the central question, is to develop a framework for a positive construction safety culture that will engender positive and progressive performance among SME contractors in Ghana. The empirical work will help to identify the components that shape the safety culture within the SMEs. Both quantitative and qualitative data will be collected to determine how these components influence the safety culture. The data collection methods will include employee observations, Delphi method, and historical information reviews. With the measurement strategies, employees of construction SMEs and health and safety experts will participate in the research. The quantitative approach will numerically measure safety culture through highly structured interviews, surveys and questionnaires. In the quantitative measurement strategies, employees and management of these SME construction companies will serve as respondents to set of questionnaires of the Delphi method will help answer the research questions.

In the second phase, several rounds of the Delphi method will be used to validate the indicator metrics for their importance and impact in improving H&S within SMEs, where a structured questionnaire with open-ended questions will be used to validate the elements of the framework. Ludwig (1997) and Custer, Scarcella and Stewart (1999) say that the Delphi process is designed to yield consensus in several rounds of iterations. This research will therefore use several rounds to achieve consensus in the Delphi process. In the third and final phase, a pilot questionnaire survey will be conducted, before the primary questionnaire survey is administered to SMEs to test the refined conceptual framework in phase 2. The ultimate goal of this study is to develop a 'best fit' positive safety culture framework for improved SME contractor performance in the Ghanaian construction industry, which will lead to a reduction in injuries and fatalities. The research process is indicated in Figure 1.

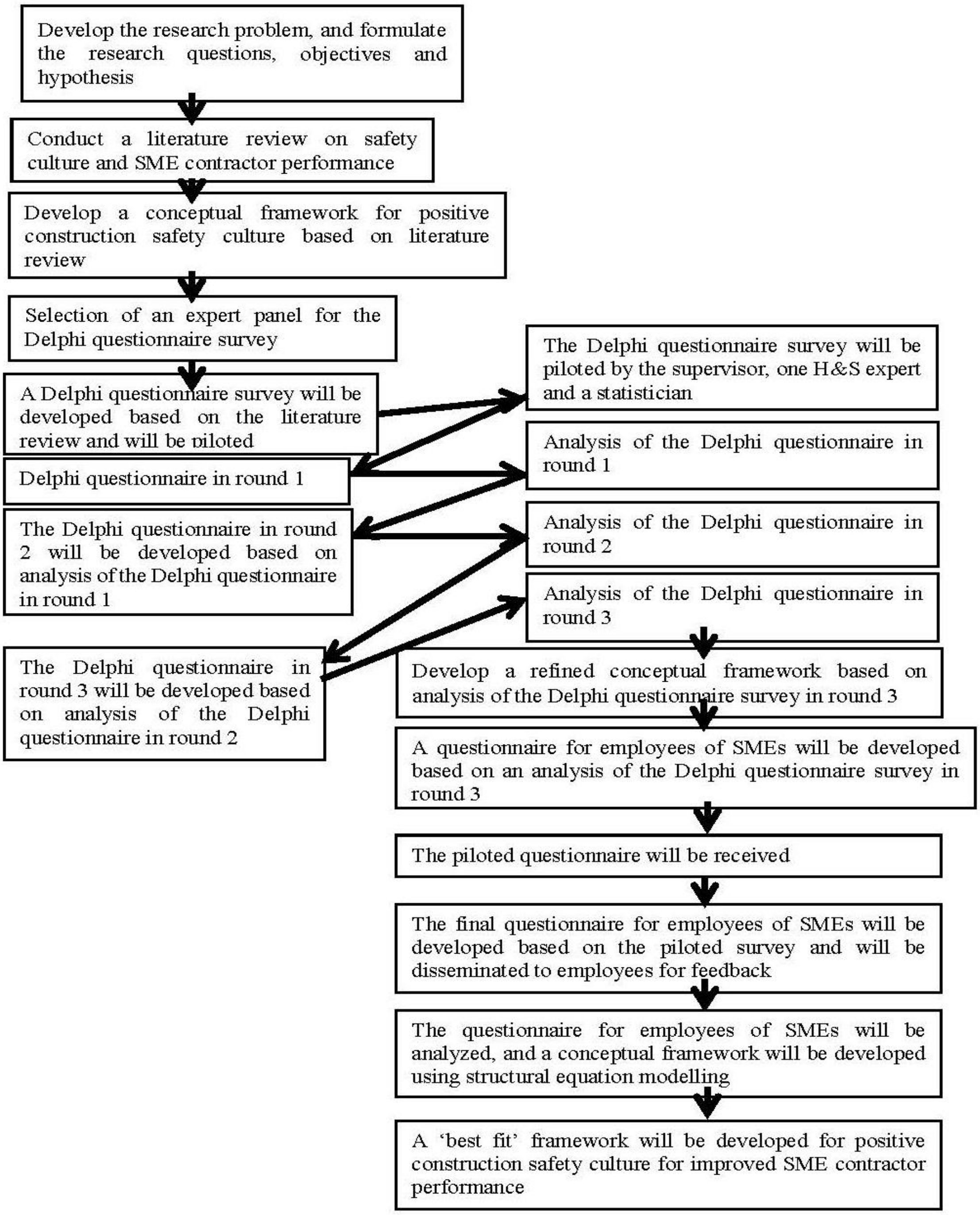

Figure 1: The research process for developing a positive construction safety culture framework in Ghana (Modified from Agumba, 2013)

4. DISCUSSION ON THE CONCEPTUAL FRAMEWORK

The conceptual framework that will guide the additional investigation supports the development of a favourable construction safety culture that will improve SME contractor performance in Ghana. Figure 2 is a pictorial representation of the framework while Table 2 provides information on associated indicators. The six characteristics proposed by Piers et al. (2009) are used.

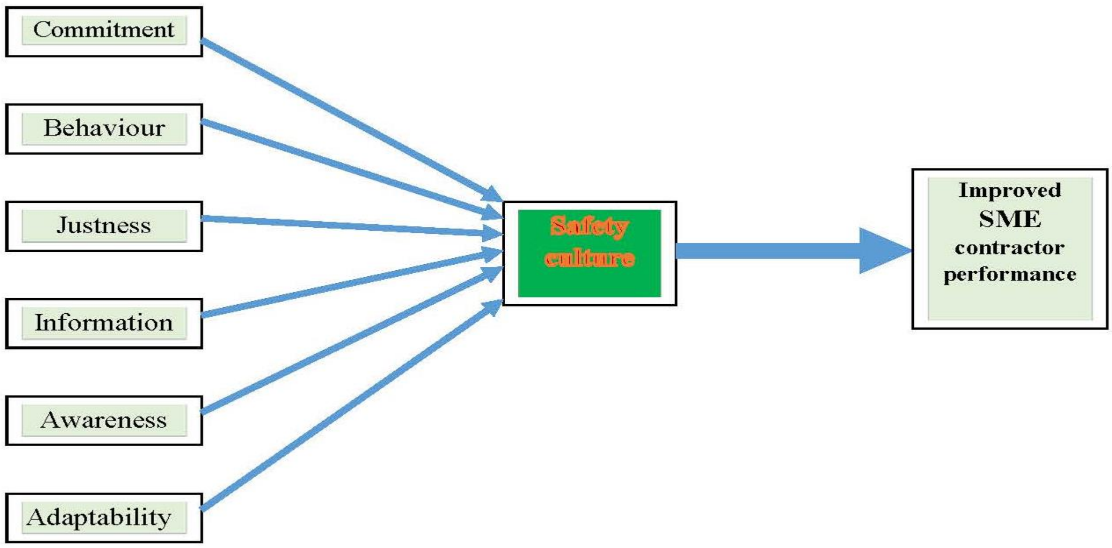

Figure 2: Conceptual framework for developing a positive construction safety culture in Ghana (Source: Author 2019)

Each of the above characteristics has been expressed in more measurable terms, which are called the indicators as well as how each of these indicators can be measured or assessed. The indicators of commitment as illustrated in Table 2 can further be broken down into items such as; management's decision making concerning safety, management's provision of adequate resources which will determine management's concern about safety. Critical safety issues and employees' concern for safety will be used to understand the perception of the importance of safety in the SME construction companies. Prioritization of safety within the SMEs can be assessed based on whether safety is given more priority over profit and performance as well as the level of investment of money and effort to improve safety within the companies. Review of safety procedures and routines together with expectation with regards to following safety procedures will be used to measure how safety procedures and requirements are taken care of in the organization. Personal involvement and responsibility about safety within the construction companies will be determined by employees' responsibility for safety and management behaviour concerning unsafe operations or activities. The indicators of behaviour can be measured using employee behaviour for safety, mutual expectations and encouragement will be measured using acquirement of colleagues' respect by safe records as well as mutual expectations of employees regarding safe behaviour. Job satisfaction will depend on employees' contact with one another and appreciation of work among colleagues. Measurement of adequate equipment will depend on how easily equipment will be accessed by employees as well as the condition of this equipment'. Indicators of awareness will be measured based on the following items. Awareness of job-induced risk depends on awareness by management and employees of their own risk and that of others on the job while attitude towards unknown hazards depends on belief in the existence of unidentified hazards and good practice covers more than known hazards.

Table 2: Safety culture indicators

Characteristic	Indicators
Commitment	• Management concern • Perception of safety culture • Prioritization of safety • Safety procedures and requirements • Personal involvement and responsibility
Behaviour	• Employee behaviour concerning safety • Mutual expectations and encouragement • Job satisfaction • Adequate equipment
Awareness	• Awareness of job induced risk • Attitude towards unknown hazards • Concern for safety
Adaptability	• Pro-activity to prevent occurrences • Actions concerning occurrences • Employee input
Information	• Availability of information • Communication of work-related information • Training • Safety issues reporting system • Willingness to use the reporting system • Consequences of safety reports • Communication of safety-related information • Information exchange about safety issues
Justness	• Evaluation of safety-related behaviours • Perception of evaluation • Passing of responsibility

Source: Piers et al. (2009)

Concern for safety within the SME companies will be measured using exaggeration of safety concern and the importance of safety for business continuity. The following items will be used to measure adaptability indicators. Proactive accident prevention will depend on the fact that events are not the only input for safety improvement by employees since other interventions through reporting could be implemented. Encouragement of employees to suggest improvement together with the assignment of the right persons to solve safety problems will effectively assess employees' inputs with regards to safety issues within the company. Measurement of information indicators will depend on the following items. Availability of work-related safety information within the organization and how precise these instructions are to employees will determine how easily available safety information are in the organization. It will also depend on the communication between different teams within the SME construction companies in Ghana and the clarity about who shall communicate which work-related information to whom. Safety training and emergency training in respect to safety will determine the level of relevance SME construction companies attach to safety training within the companies.

The importance of safety issues reporting system and motivation to bring concerns up will help determine how willing every member of these SMEs are to use the accident reporting systems.

The ability of management to appreciate employees reporting safety issues and how to satisfy employees are about the way safety reports are dealt with will determine the consequences of safety reports. Communication of safety-related information depends on how safety issues are communicated to employees at the same time informing employees of changes affecting safety within the company. Information exchange about safety issues depends on talking about safety issues amongst employees and how they are reviewed. Justness indicators will be measured using these items. A clear distinction between acceptable and unacceptable behaviour as well as consequences of reporting safety issues within the company measure the extent to which safety-related behaviours are evaluated among SME construction companies. Perception of evaluation of safety behaviours can only be known when there is a fair judgment after safety occurrences and clarity of the evaluation systems. Finally, the passing of responsibility depends on acknowledgement of own errors by management and looking for a scapegoat after safety occurrences.

5. CONCLUSIONS

There is a growing concern about the need for a positive safety culture in the construction industry. This paper describes the research on safety culture and its related issues among construction SMEs. From the literature reviews, the components that are needed to develop a framework for positive construction safety culture for improved SME contractor performance in Ghana is revealed. The identified components that are needed to develop a framework for positive construction safety culture for improved SME contractor performance in Ghana have been adopted from the work of Pier et al. (2009). In sum, the ongoing doctotral research provides a platform to develop a framework that will aid SME contractors in their quest for no harm or limited harm on their project sites. A positive safety culture will ensure that both workers and employers in the SME construction sector in Ghana shifts their mind-sets in how accident prevent and control is viewed and implemented.

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IDENTIFICATION OF THE CONTRACTOR SELECTION CRITERIA FOR PUBLIC PROJECTS IN TURKEY

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Abstract: Procurement in public projects is regulated by the Public Procurement Law in Turkey, and the bid price is the most effective criterion in contractor selection. This may lead employing unskilled, inexperienced, and financially unstable contractors in public projects. This study aims to identify the several criteria which must be used for the selection of the most suitable contractor candidate along with the bid price, to ensure the optimal use of public resources. Following an extensive literature review, 9 main criteria and 69 sub-criteria were identified. A survey was delivered to technical staff responsible in procurement projects in public institutions, and 53 were fully completed and returned. The relative importance levels of the identified main and sub-criteria were computed using ranking analysis. The internal consistency of the questionnaire was checked with reliability analysis. The findings of this study can be used to reveal the most effective criteria in developing a multi-criteria selection model for the best contractor candidate selection in public projects.

Keywords: Contractor, public projects, ranking analysis, reliability analysis, selection criteria.

1. INTRODUCTION

In Turkey, public projects are awarded based on the Public Procurement Law (PPL) which became effective in 2003. The aim was to improve competition, transparency, integrity, efficient use of resources and also to comply with European Union (EU) acquis (Emek and Acar, 2015; Ardiyok and Kil, 2018). The public procurement share was nearly 24% in the GDP of Turkey in 2018 (Ardiyok and Kil, 2018). Since its enforcement, the procurement law has been subject to numerous amendments, some of which caused it to deviate from its main objectives (Emek and Acar, 2015). Especially a recent change in evaluating bidding process related to identifying abnormally low tenders may cause non-transparency issues and violating equal treatment. The evaluation of tender process significantly depends on bid price in Turkey which may cause significant time and resource loss when used as the sole criterion. Therefore, other criteria should be used in bidding process to increase the rate of successfully completed contracts and efficient use of resources, particularly encompassing quality, technical ability, past performance, safety, financial, time and environment outcomes of construction projects.

This study aims to identify alternative criteria for contractor selection in public construction projects, to be used by public institutions in selecting the most appropriate contractor candidate for tenders. In this context, the insights of technical staff responsible in bidding processes of public institutions gain importance, as they are the potential key informants for the bidding processes, representing vast real-world experience. They may both reveal weaknesses and improve or enhance features of tendering process.

Research on contractor selection problem in construction industry have significantly expanded since 1990s with many studies focusing on different aspects. Some tried to set criteria while others proposed new techniques or tools to solve this problem. This study identifies the most frequently used criteria used by previous studies and develops an integrated framework to evaluate contractor candidates in broader perspective by identifying 9 main 69 sub-criteria for the contractor selection problem. Besides integrating various previous frameworks for the evaluation, the particular contribution of this study is the inclusion of key professionals and decision makers in public sector with relevant experience or expertise. As these participants have been serving in bidding department of public institutions as administrative or professional employees, they have substantial exposure to the decision making processes, therefore, positioning them as key informants with great potential to evaluate the problem.

In this study, a survey was designed and applied to determine importance levels of the identified criteria derived from the relevant literature. Frequency, reliability and ranking analyses are conducted on the collected data, findings of which indicated that multiple criteria should be taken into account in the contractor selection process. Overall, selecting contractors based on the lowest bid price criterion may result in serious consequences. These include but are not limited to: working with unqualified, inexperienced, and/or insufficient contractors, as well as non-conforming outcomes in terms of quality specifications and/or requirements, while also possibly causing increases in reworks which may lead to substantial time and resource losses.

2. RESEARCH METHODOLOGY

The methodology of this study is consisted of four main steps which are (1) identifying main and sub-criteria for contractor selection based on literature review, (2) designing a survey questionnaire using information derived from literature review on contractor selection in public sector, (3) conducting the survey research in the public institutions to reveal importance levels of criteria, and (4) carrying out frequency, reliability and ranking analyses on survey data. The steps of the methodology used in this study are discussed in detail in the following sections.

2.1 Identification of Main and Sub-Criteria for Contractor Selection

Following a comprehensive literature review on contactor selection criteria (Ulubeyli, 2008; Aksay, 2008; Cifcioglu, 2013, Marzouk et al., 2013; Ng and Skitmore, 2014; Kaplan, 2014; Kaya, 2016), 69 criteria were identified that may be used by the public institutions to select the most appropriate contactor to bid. These were categorized into nine main criteria as follows:

1. ***Financial Criteria***: (*1*) Bank references of the contractor, (*2*) credit references of the contractor, (*3*) turnover history of the contractor, (*4*) income statement of the contractor.
2. ***Past Performance and Experience Criteria***: (*1*) Successful completion rate of the previous contracts, (*2*) type and size of the completed projects, (*3*) successful completion rate in similar projects, (*4*) the highest budgeted completed project, (*5*) Number of references, (*6*) project experience, (*7*) number of ongoing law suits, (*8*) garnished security deposits from the previous projects, (*9*) capacity of accurate bidding, (*10*) relations with the labourers, (*11*) relations with the sub-contractors.
3. ***Technical Capacity Criteria***: (*1*) Having adequate number of technical staff (architect, engineer, technician, OHS specialist, etc.), (*2*) experience of technical staff, (*3*) having qualified workforce, (*4*) having adequate number of technical equipment (fixtures, tools, machines, etc.), (*5*) providing necessary technical equipment.
4. ***General Criteria***: (*1*) Field of Activity (national & international), (*2*) organizational Structure, (*3*) reliability & reputation, (*4*) competitiveness against other companies, (*5*) the distance between the headquarter and current projects, (*6*) ability to control the

contract, (*7*) ability to use labour resources effectively, (*8*) communication skills, (*9*) current workload, (*10*) percentage of work outsourced to subcontractor, (*11*) technical coordination ability, (*12*) ability and experience regarding application of the risk management methods.

5. ***Cost Management Criteria***: (*1*) Ability to apply the cost control methods, (*2*) completion of the project in accordance with the cost plan, (*3*) using of information technologies in the cost management system.
6. ***Time Management Criteria***: (*1*) Ability to apply time control methods, (*2*) completion of the undertaken project within the specified time period, (*3*) using of information technologies in the time management system, (*4*) developing and updating the project schedule.
7. ***Quality Management Criteria***: (*1*) Having Quality Management System (QMS), (*2*) applying Quality Management System (QMS), (*3*) inspecting Quality Management System, (*4*) having quality assurance certificates, (*5*) having Quality Assurance (QA) and Quality Control (QC) programs, (*6*) the ability to find technical facility and solutions for meeting quality standards, (*7*) conformity of the used materials to the quality standards, (*8*) applying quality control program, (*9*) cost of poor quality, (*10*) quality performance in the previous projects.
8. ***Health and Safety Management Criteria***: (*1*) Establishing and inspecting occupation health and safety plan, (*2*) having Occupational Health Safety and Management Systems (OHSAS 18001) certificate, (*3*) having comprehensive knowledge of occupational safety legislations, (*4*) taking precautions for the occupational safety, (*5*) checking and inspecting taken safety and health precautions regularly, (*6*) the frequency of the arranged safety meetings, (*7*) number of fatal accidents in the previous projects, (*8*) number of injuries in the previous projects, (*9*) providing regular safety trainings, (*10*) providing personal protective equipment, (*11*) number of ongoing lawsuits due to previous accidents.
9. ***Environment Management Criteria***: (*1*) Having environment management, control policy and protection plan, (*2*) having Environmental Management Certificate, (*3*) taking sufficient measures in the field regarding environment protection, (*4*) inspection regarding environment protection in the field, (*5*) waste management (construction/demolition waste), (*6*) inspecting air and water pollution, (*7*) protection of cultural and archaeological assets, (*8*) number of previous environmental accidents, (*9*) number of ongoing lawsuits due to previous environmental accidents.

2.2 Questionnaire Design

The identified main and sub-criteria were used as the basis of the survey questionnaire design. This questionnaire is consisted of three parts and *35* questions in total. First part has *5* questions revealing the personal attributes of the respondents. In the second part, *20* questions were asked to specify the bidding system in public institutions respondents are serving for. Third part comprises of *10* questions to address the importance levels of the identified criteria that may affect contractor selection in public projects. The *5*-point Likert Scale was used to identify importance levels where "*5*" represents the highest importance and "*1*" represent the lowest importance. The questionnaire was sent with a cover letter to 110 technical and administrative staff serving in the bidding department of the public institutions in the city of Sirnak in Turkey.

2.3 Data Analysis Methods

In this study, the reliability analysis was conducted to test the internal consistency of the used scale which is utilized to measure the perceptions of the respondents about the identified criteria. Cronbach's alpha technique was used to apply reliability analysis (Gliem and Gliem, 2003). This technique helps to check homogeneity of each item and consistency of the overall questionnaire. The Cronbach's Alpha Value can be determined by using Equation 1.

$$\alpha = \frac{N}{(N-1)} \times \left[\frac{\sigma_x^2 - \sum_{i=1}^{N} \sigma_{yi}^2}{\sigma_x^2}\right] \tag{1}$$

where N is the number of items on the test, σ_x^2 is the variance of the observed item scores, and σ_{yi}^2 is the sum of all i item variances. The range of Cronbach's alpha value is between 0 and 1, whereas closer to 1 indicates high reliability of the used scale. In exploratory studies, Cronbach's alpha value being equal or higher than 0.60 signifies that it can be accepted in terms of the reliability of the used scale (Pallant, 2007). According to Field (2013), the Cronbach's Alpha Value can be increased by deleting one or more variables with low internal consistency.

After conducting reliability analysis, the ranking analysis was performed on the collected data. To determine most important criteria in the contractor selection for the public projects, summary statistics were used in evaluating the relative importance and order ranking of the identified criteria. The arithmetic means were both used to determine relative importance and ranking order.

3. FINDINGS OF THE STUDY

3.1 Sample Characteristics

The survey was sent to technical and administrative staff serving in the bidding department of the public institutions. Among the 112 respondents targeted in survey, 53 fully completed questionnaires, with a survey response rate of 47.3%. These respondents worked in 6 different public institutions representing majority of the public tenders held in the city.

General characteristics of the respondents are summarized in Table 1. Based on the findings, 56.1% of them are engineer, 1.8% are architecture, %17.5 are technician, and the rest 24.5% represent other professions. The experience of the respondents in the bidding department are as follows: 1.8% have experience between 11 to 15 years, 24.6% have experience between 6 to 10 years and 59.6% have experience between 0 to 5 years. The type rates of the contracted projects that respondents are in charge of were: highways 19.8%, infrastructure 23.4%, superstructure 35.1% and others 21.6%. According to the responses, 33.3% of the respondents attended between 0 to 5 tenders, 29.8% attended between 6 to 10 tenders, 19.3% attended between 11 to 15 tenders, 5.3% attended between 16 to 20 tenders, and 12.3% attended more than 21 tenders each year.

Table 1: General characteristics of respondents

Characteristics	Options	Frequency (%)
Profession of respondents	Engineer	56.1
	Architecture	1.8
	Technician	17.5
	Other	24.6
Years of the experience in bidding department	0-5	59.6
	6-10	24.6
	11-15	14.0
	16-20	1.8
	>21	-
Types of contracted projects	Highway	19.8
	Infrastructure	23.4
	Superstructure	35.1
	Other	21.6
Number of tenders attended annually	0-5	33.3
	6-10	29.8
	11-15	19.3
	16-20	5.3
	>21	12.3

The distribution of procurement types used by public institutions are given in Table 2. Based on the findings, open tender procedure was used in most of the contracts, negotiated tendering was in the second order and restricted tender procedure was least used one.

Table 2: Procurement types

Types	Options			
	% 0-25	% 26-50	% 51-75	%76-100
Open tender procedure	3	3	25	23
Restricted tender procedure	12	5	1	3
Negotiated tendering	16	7	4	2

The distribution of contract types used by public institutions are presented in Table 3. According to the findings, public institutions preferred to use lump sum in most of the contracts. On the other hand, unit price was in the second order and mixed contracts were not much preferred by institutions.

Table 3: Types of contracts

Types	Options			
	% 0-25	% 26-50	% 51-75	%76-100
Lump sum	3	5	17	24
Unit price	15	10	9	8
Mixed contract	5	1	-	-

3.2 Reliability of the Questionnaire

The relative importance of 69 sub-criteria-under 9 main groups- were asked to rate via 1 to 5 Likert Scale (i.e., "*1*" represents the lowest importance and "*5*" represents the highest importance). Cronbach Alpha technique was used to test the reliability of the used scale via statistical package SPSS 26.0®. Cronbach Alpha values of each main group are presented in Table 4.

Table 4: Cronbach's alpha values

Main Criteria	**Number of Sub-Criteria**	**Cronbach's alpha values**
Financial Criteria	4	0.919
Past Performance & Experience Criteria	11	0.904
Technical Capacity Criteria	5	0.931
General Criteria	12	0.963
Cost Management Criteria	3	0.948
Time Management Criteria	4	0.955
Quality Management Criteria	10	0.963
Health & Safety Management Criteria	11	0.981
Environment Management Criteria	9	0.983

As can be seen in Table 4, all main groups have higher than 0.9 Cronbach Alpha values which indicates that the used scale is accepted as excellent in terms of internal consistency based on these findings.

3.3 Ranking Analysis

This section is consisted of the rank orders of 9 main groups and their constituent 69 sub-criteria. The collected data were analysed based on statistical indicators (i.e., arithmetic mean and standard deviation). Besides, the number of responses for each score for each criterion are determined and presented in this section. The rankings of each criteria by their category and overall ranking are also shown in related tables.

Findings of ranking analysis of *Financial Related Criteria* are presented in Table 5 in which 4 sub-criteria were identified. As can be seen below, "*Bank references of the contractor*" has highest importance score in this group, while "*Credit refences of the contractor*" has the lowest importance.

Table 5: Ranking analysis of Financial Criteria

No	**Sub-Criteria**	**Respondents Scores**						**Mean**	**Standard Deviation**	**Ranking by Category**	**Overall Ranking**
		0	**1**	**2**	**3**	**4**	**5**				
1	Bank references of the contractor	7	5	7	16	13	9	2.88	1.56	1	47
2	Credit references of the contractor	8	5	4	22	15	3	2.70	1.44	4	59
3	Turnover history of the contractor	9	3	5	20	13	7	2.81	1.55	2	54
4	Income statement of the contractor	11	2	6	15	15	8	2.79	1.66	3	55

The ranking analysis of 11 sub-criteria of *Past Performance and Experience* group are illustrated in Table 6. Based on the findings of ranking orders displayed below, "*Successful completion rate in similar projects*" has highest ranking score in this group, whereas, this sub-criterion has the second highest ranking score in overall ranking. Conversely, the lowest score criterion is "*Relations with the labourers*" in this group which has the second lowest importance in the overall ranking.

Table 6: Ranking analysis of Past Performance & Experience Criteria

No	Sub-Criteria	Respondents Scores						Mean	Standard Deviation	Ranking by Category	Overall Ranking
		0	**1**	**2**	**3**	**4**	**5**				
1	Successful completion rate of the previous contracts	3	2	4	18	18	12	3.44	1.28	3	7
2	Type and size of the completed projects	1	2	4	24	12	14	3.51	1.14	2	4
3	Successful completion rate in similar projects	2	1	4	17	17	16	3.65	1.21	1	2
4	The project with the highest budget completed by the main contractor	6	4	4	24	8	11	3.00	1.49	4	27
5	Number of references	11	8	11	16	7	4	2.21	1.51	10	67
6	Project experience at the global scale	6	4	7	22	6	12	2.95	1.52	5	35
7	Number of ongoing law suits	11	6	8	11	8	13	2.67	1.80	8	61
8	Garnished security deposits from the previous projects	7	3	12	14	8	13	2.91	1.60	6	41
9	Capacity of accurate bidding	9	6	7	13	8	14	2.82	1.75	7	51
10	Relations with the laborers	13	9	10	12	7	6	2.16	1.64	11	68
11	Relations with the sub-contractors	11	8	11	15	8	4	2.23	1.52	9	66

Table 7 shows the ranking analysis of *Technical Capacity* main group in which 5 sub-criteria are identified. According to the ranking orders, "*Having adequate number of technical staffs*" criterion has the highest-ranking score in both its main group and overall ranking, whereas, "*Providing necessary technical equipment*" criterion has the lowest ranking score in this group.

Table 7: Ranking analysis of Technical Capacity Criteria

No	Sub-Criteria	Respondents Scores						Mean	Standard Deviation	Ranking by Category	Overall Ranking
		0	1	2	3	4	5				
1	Having adequate number of technical staffs	4	1	4	14	10	24	3.70	1.46	1	1
2	Experience of technical staff	4	2	7	14	10	20	3.47	1.50	2	5
3	Having qualified workforce	8	2	5	16	11	15	3.14	1.65	4	16
4	Having adequate number of technical equipment	5	0	4	21	9	18	3.46	1.44	3	6
5	Providing necessary technical equipment	6	2	7	22	7	13	3.07	1.50	5	19

The ranking analysis of 12 sub-criteria identified under the *General Criteria* group are illustrated in Table 8. Based on the ranking orders, the most important criterion is "*Reliability & Reputation*" in this group. This criterion is also ranked as in the third order in overall ranking, whereas, "*The distance between the headquarter and current projects*" criterion has the lowest rank order in both its group and overall ranking.

Table 8: Ranking analysis of General Criteria

No	Sub-Criteria	Respondents Scores						Mean	Standard Deviation	Ranking by Category	Overall Ranking
		0	1	2	3	4	5				
1	Field of Activity (National & International)	10	0	5	20	12	10	2.95	1.61	4	36
2	Organizational Structure	11	1	8	18	14	5	2.67	1.56	9	62
3	Reliability & Reputation	4	3	2	15	13	20	3.58	1.47	1	3
4	Competitiveness against other companies	6	7	5	13	13	13	3.04	1.63	2	21
5	The distance between the headquarter and current projects	14	6	12	13	7	5	2.14	1.61	12	69
6	Ability to control the contract	7	2	6	24	6	12	2.98	1.52	3	31
7	Ability to use labor resources effectively.	7	2	7	24	10	7	2.86	1.42	7	49
8	Communication Skills	9	2	8	16	11	11	2.89	1.63	6	45
9	Current workload	12	3	8	18	7	9	2.56	1.68	11	65
10	Percentage of work outsourced to subcontractor by the main contractor	10	4	7	18	10	8	2.67	1.61	10	63
11	Technical Coordination	7	5	8	15	15	7	2.82	1.52	8	52
12	Ability and experience regarding application of the risk management methods	8	7	5	13	10	14	2.91	1.73	5	42

Table 9 displays the ranking analysis of 3 sub-criteria grouped under *Cost Management Criteria.* As can be seen, "*Completion of the project in accordance with the cost plan*" criterion is ranked in the first order with the highest score and "*Ability to apply the cost control methods*" criterion ranked in the last order with the lowest score in this group.

Table 9: Ranking analysis of Cost Management Criteria

No	Sub-Criteria	Respondents Scores						Mean	Standard Deviation	Ranking by Category	Overall Ranking
		0	**1**	**2**	**3**	**4**	**5**				
1	Ability to apply the cost control methods	7	5	10	16	13	6	2.72	1.48	3	58
2	Completion of the project in accordance with the cost plan	7	1	7	19	10	13	3.11	1.54	1	18
3	Using of information technologies in the cost management system	6	4	8	19	12	8	2.89	1.46	2	46

The ranking analysis of 4 sub-criteria identified under the *Time Management Criteria* group are shown in Table 10. According to the ranking analysis of this group, "*Completion of the undertaken project within the period given by the employer*" has the highest-ranking order, whereas, "*Ability to apply time control methods*" has the lowest-ranking order.

Table 10: Ranking analysis of Time Management Criteria

No	Sub-Criteria	Respondents Scores						Mean	Standard Deviation	Ranking by Category	Overall Ranking
		0	**1**	**2**	**3**	**4**	**5**				
1	Ability to apply time control methods	5	5	4	23	11	9	3.00	1.43	4	28
2	Completion of the undertaken project within the period given by the employer	5	1	7	18	8	18	3.35	1.50	1	8
3	Using of information technologies in the time management system	4	3	8	19	12	11	3.14	1.39	2	17
4	Developing and updating the project schedule	6	2	8	18	13	10	3.05	1.47	3	20

Table 11 presents the ranking analysis of 10 sub-criteria grouped under *Quality Management Criteria*. Based on the rankings, "*Conformity of the building materials being used to the quality standards*" criterion has the highest-ranking order in this group, whereas, "*To have Quality Assurance and Quality Control programs*" criterion has the lowest ranking order.

Table 11: Ranking analysis of Quality Management Criteria

No	Sub-Criteria	Respondents Scores						Mean	Standard Deviation	Ranking by Category	Overall Ranking
		0	1	2	3	4	5				
1	Having Quality Management System	7	2	6	22	10	10	2.98	1.49	6	32
2	Applying Quality Management System	6	2	8	21	10	10	3.00	1.45	5	29
3	Inspecting Quality Management System	7	3	8	17	11	11	2.96	1.56	7	33
4	Having quality assurance certificates such as I.S.O - 9000-9001-9004.	5	4	9	17	10	12	3.04	1.50	3	22
5	Having QA (Quality Assurance) and QC (Quality Control) programs	9	4	10	17	9	8	2.65	1.57	10	64
6	The capacity to find technical opportunity and solutions for the sake of meeting quality standards.	5	7	5	17	10	13	3.04	1.57	4	23
7	Conformity of the building materials being used to the quality standards	5	2	8	13	14	15	3.30	1.51	1	9
8	Applying quality control program	4	8	6	20	9	10	2.91	1.47	9	43
9	Cost of poor quality due to production under the quality standards	5	6	5	22	9	10	2.95	1.47	8	37
10	Quality performance in the previous projects	7	3	2	19	10	16	3.23	1.61	2	14

The ranking analysis of 11 sub-criteria identified under the *Health & Safety Management Criteria* group are shown in Table 12. As it is presented, "*Providing personal protective equipment to employees*" criterion is ranked in the first order with the highest score and "*To provide trainings regarding occupational safety on a regular basis*" criterion ranked in the last order in this group.

Table 12: Ranking analysis of Health & Safety Management Criteria

No	Sub-Criteria	Respondents Scores						Mean	Standard Deviation	Ranking by Category	Overall Ranking
		0	1	2	3	4	5				
1	Establishing occupation health and safety plan and inspecting it.	7	2	5	14	12	17	3.28	1.63	2	11
2	Having Occupational Health Safety and Management Systems (OHSAS 18001) certificate	5	7	5	19	12	9	2.93	1.49	8	39
3	Having comprehensive knowledge of occupational safety legislations.	7	5	3	13	11	18	3.23	1.71	5	15
4	Taking precautions in the field regarding the occupational safety.	8	2	4	13	12	18	3.28	1.69	3	12
5	Inspecting whether precautions regarding the occupational safety and laborer health are complied with or not.	8	4	3	11	12	19	3.26	1.75	4	13
6	The arrangement frequency of the meetings about the occupational safety.	8	6	6	12	11	14	2.95	1.72	7	38
7	Number of fatal occupational accidents in the previous projects	10	5	4	12	12	14	2.93	1.79	9	40
8	Number of occupational accidents involving injuries in the previous projects.	7	6	7	12	10	15	3.00	1.70	6	30
9	Providing trainings regarding occupational safety on a regular basis.	9	7	5	13	10	13	2.82	1.75	11	53
10	Providing personal protective equipment to employees	8	3	3	12	12	19	3.30	1.73	1	10
11	Number of ongoing lawsuits due to previous occupational accidents	12	3	7	10	9	16	2.86	1.87	10	50

Table 13 presents the ranking analysis of 9 sub-criteria grouped under *Environment Management Criteria*. According to the ranking order of this group, "*Inspection regarding environment protection in the field*" criterion has the highest score and ranked in first order whereas "*ISO 14000 Environmental Management Certificate*" criterion is ranked in the last order with the lowest score.

Table 13: Ranking analysis of Environment Management Criteria

No	Sub-Criteria	Respondents Scores						Mean	Standard Deviation	Ranking by Category	Overall Ranking
		0	1	2	3	4	5				
1	Having environment management system, environment control policy and environment protection plan.	11	4	4	12	14	12	2.88	1.78	6	48
2	ISO 14000 Environmental Management Certificate	10	4	6	20	8	9	2.68	1.62	9	60
3	Taking sufficient measures in the field regarding environment protection	9	3	6	15	8	16	3.02	1.73	3	26
4	Inspection regarding environment protection in the field	9	4	6	12	9	17	3.04	1.78	1	24
5	Waste management (construction / demolition waste disposal)	11	3	4	9	15	15	3.04	1.83	2	25
6	Inspecting air and water pollution	10	4	5	12	11	15	2.96	1.79	4	34
7	Protection of cultural and archeological values	9	8	3	16	8	13	2.79	1.74	7	56
8	Number of previous environmental accidents	10	6	4	10	13	14	2.91	1.81	5	44
9	Number of ongoing lawsuits due to previous environmental accidents	11	6	3	15	8	14	2.79	1.81	8	57

Out of 69 sub-criteria, the first ten criteria are ranked as follows: (*1*) *Having adequate number of technical staff*; (*2*) *Successful completion rate in similar projects*; (*3*) *Reliability & Reputation*; (*4*) *Type and size of the completed projects*; (*5*) *Experience of technical staff*; (*6*) *Having adequate number of technical equipment*; (*7*) *Successful completion rate of the previous contracts*; (*8*) *Completion of the undertaken project within the period given by the employer*; (*9*) *Conformity of the building materials being used to the quality standards*; and (*10*) *Providing personal protective equipment to employees*. These findings indicate that respondents attribute great importance mostly to criteria related to the contractor’s technical ability, past performance, and reputation. These criteria directly affect construction project performance which is completing project under contract requirements. Respondents believe that throughout the contractor selection process, ability and experience of the technical staff, past project experience, reputation, meeting quality standards, delivering on time, and providing safety equipment criteria should be taken into account.

4. CONCLUSIONS

This study aimed to explore the potential weaknesses and pitfalls of the public tender processes which may cause significant time and resource losses, and eventually to find solutions and make suggestions for the improvement of these processes by determining the most optimal set of selection criteria. The selected population in this survey research represents potential key informants in the field as they are the technical staff serving in the bidding department with substantial experience and exposure to the tender processes, therefore, purposefully helping to address the research question. In order to move beyond the common practice of using solely the bid price as the key criteria in tender process, 69 criteria were identified and categorized in 9 main groups in this research. This diversified set of criteria, and their obtained importance levels determined by the ranking analysis has potential to enhance the bidding process, by shifting from the solely price-based tender to a better informed and reliable decision in contractor selection process. Overall, the findings of this study contributed to our empirical understanding over contractor selection question in public tenders, as it (1) revealed the need or requirement to improve them with the multiplicity of additional criteria, (2) provided a grounded approach to improve the transparency in tender processes, and (3) set an empirical ground to ensure means and ways for more efficient use of public resources and higher rates of successfully completed contracts. The scope of this study has limitations, since the sample size must be improved in future research. Also, similar research can be conducted in different cities to generalize the framework of this study for Turkey. In future, the findings of the study can be used as a basis to develop a comprehensive multi-criteria selection model for public projects in Turkey.

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EMBEDDING SUSTAINABILITY ETHOS ACROSS CONSTRUCTION PROJECT'S LIFECYCLE: A REVIEW OF PROJECT MANAGEMENT COMPETENCIES

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Abstract: Despite the emergence of terminologies like green and sustainable construction, green and sustainable supply chain management, the incidence of certain anthropogenic activities within the industry remains unabated. Although recent studies have sought to investigate the instrumentality of different managerial competencies in tackling this challenge, few studies have explored the relationship between the deployment of the right set of project management competencies and effective incorporation of SD ethos across the construction project lifecycle. Based on these observed gaps, this study embarked on an identification of project management competencies required to achieve optimal incorporation of SD ethos in this context. A phenomenological research design is adopted for data elicitation. Semi-structured interviews are used to gather data from a purposively selected sample of built environment (BE) professionals practicing in the Free State province of South Africa. Qualitative content analysis (QCA) is deployed for data analysis. Findings from the study enable an identification of the right mix of PM competencies required for successful incorporation of SD ethos at different phases of the construction project lifecycle. This study holds salient implications for project managers practising within the BE domain as it provides a platform for further engagement towards the attainment of a sustainable construction process.

Keywords: Built environment, competencies, construction project lifecycle, project management, sustainability.

1. INTRODUCTION

The quest for sustainability has been identified as one of the most important challenges facing society in contemporary times (Li, et al., 2018) This challenge appears to be most prevalent in the construction industry given its penchant for waste generation and for serving as a domicile for other anthropogenic activities which negate the attainment of sustainability (Senaratne , et al., 2017). Based on the foregoing, scholars have suggested the need for the industry to engender a shift from overt concentration on the iron triangle towards the incorporation sustainability dimensions during the execution of projects as success criteria for projects (Silvius & Schipper, 2015). Obviously, the incorporation of sustainability dimensions in projects will affect the processes in a positive manner (Gareis, et al., 2013).

Furthermore, scholars advocate that the concept of sustainable construction be used as a tool to achieve this phenomenon (Gou & Xie, 2017). This has led to the introduction of stringent control measures for containing the incidence of waste generation in the industry (Marcelino-Sadaba, et al., 2015). Benefits accruing from existing sustainable construction practices include a reduction in hazardous gas emissions and further reduction in energy usage during the various phases of the project lifecycle (Zhang, et al., 2015). Green building codes such as, Green Building Decree, Qatar Sustainability Assessment Systems (QSAS), have been introduced, and have had some impact (Saleh & Alalouch, 2015) Demands for the construction of buildings with lower running costs is increasingly becoming the norm rather than an exception amongst industry stakeholders (Saleh & Alalouch, 2015), thereby leading to a shift towards decisions on product and processes being premised on whole-life value instead of front end costs. The use of suitable construction materials which reduces the waste is highlighted as a probable pathway for sustainable construction (Mousa, 2015).

Sustainable construction has been implemented for the past few decades globally (Gan , et al., 2015). Globally, all countries including developing countries are expected to implement these concepts in projects (Dobrovolskiene & Tamosiuniene, 2016). Yet, construction projects in developing countries have being reported as posting underwhelming performances as it pertains to sustainable construction practices. This has stimulated the government of these countries to assist financially in encouraging increased inclination towards sustainable construction practices (Chang, et al., 2016). Such assistance has impacted positively on the incorporation of sustainability dimensions within construction projects in these climes (Chang, et al., 2016).

Notably, these efforts have brought about improved levels of awareness among stakeholders on the need to contribute towards sustainable development through the adoption and implementation of sustainable construction practices. Yet implementation performance of these sustainable construction methods remains varied. It appears that extant approaches heralding the shift towards sustainable construction has dwelt more on technicalities without adequate consideration of managerial competencies (Silvius & Schipper, 2015). Given the socio-technical nature of construction projects, achieving the right mix of technical and managerial competencies in ensuring successful project delivery becomes imperative. Therefore, the observed fixation on the technical aspects of sustainable construction solely has the potential of undermining the performance of various approaches being deployed towards the amelioration of the negative impact of construction activities. The quest to achieve this integration of appropriate managerial and technical competencies makes this study, imperative.

Existing sustainable construction practices do not appreciate the potential of project management practices to influence the degree of incorporation of sustainability dimensions into construction project, until recently (Alvarez-Dionisi, et al., 2016; Gemunden, 2016). The incorporation of sustainability factors through the identification and adoption of relevant project management competencies has been highly encouraged in the corpus of emerging relevant literature as a means of delivering construction projects in a sustainable manner (Marcelino-Sadaba, et al., 2015). Yet, few studies attempt to identify the right project management competencies for engendering successful incorporation of sustainability dimensions across different phases of the construction project lifecycle. This is gap which this study seeks to bridge. This study has been structured as follows: a review of the existing literature, justification of the research methodology used, a presentation and discussion of findings under the chosen themes and conclusion.

2. LITERATURE REVIEW

2.1 Sustainable Development

According to the Brundtland Commission's, sustainable development is defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own (World Commission on Environment and Development, 1987).

Also, sustainability is defined as comprising of the management of the environment as prescribed by the TBL including other perspectives such as supply chain, people, profit, etc. (Martens & Carvalho, 2017). The three common dimensions that have been identified are social, environmental and economic sustainability. They have been thus being referred to as the Triple-Bottom Line (TBL) (Sebestyen , 2017). The TBL encourages the use of all three dimensions during the execution of a project in an integrated manner (Martens & Carvalho, 2017). The values in strategy alignment for projects are now associated with the TBL (Oke & Aigbavboa, 2017). Scholars have agreed that the incorporation of the TBL into projects allows projects to achieve sustainability concepts (Li, et al., 2018).

A four-dimensional framework has been proposed, the dimensions would be the social, economic, environmental and technology. The incorporation of these dimensions would result in strategic planning and targets being met in a convincing manner (Gou & Xie, 2017). However according to Elkington (2012) the most vital yet ignored dimension is social sustainability. The reasoning is that the dimensions are not stagnant but rather controlled by the political influence, economic climate, and environmental.

A recommendation has been put out to break down the dimensions to isolate their factors to the following; sustainable innovation business model, stakeholder management, economic and competitive advantage and environmental policies and resources saving (Martens & Carvalho, 2017). The breakdown of the TBL has been conducted to indicate the components of each dimension.

On the other hand, project management is defined as the application of knowledge, skills, tools and techniques to achieve project objectives. There are five process groups in which project management is divided into. They are initiating, planning, executing, monitoring and controlling and closing (PMBOK, 2013). The project manager is appointed to ensure that the project reaches its intended objectives by leading the appointed team. (PMBOK, 2013). Introduction of guidelines for sustainability within the PM context has been proposed within the sustainability context (Silvius & Schipper, 2014). Guidelines such as sustainable project products, processes, organizational commitment to sustainability and sustainability trained and aware persons (Marcelino-Sadaba, et al., 2015). However, sustainability concepts have been overlooked due to the need to achieve economic growth, in developing countries (Chang, et al., 2016).

2.2 Competencies Required by a Project Manager for Managing Sustainability during Project Delivery

A Project Manager's competencies may be defined as the ability to have a different approach to the classical management functions while integrating the required skill, foreseeing of possible risks and being time cautious to ensure that all tasks are completed within the stipulated timeframe (Dziekonski, 2017). The Project Manager (PM) needs to ensure that the following needs are achieved namely, task needs, team needs and individual needs. Task needs can be associated with knowledge and activities that need to do for the project. Team needs can be associated with the performance of the appointed team and what they need to accomplish. Individual needs are aligned with the personal capacity or wellbeing of the team (PMBOK, 2013). The PM needs to understand or implement strategies within a project by interconnecting the environment, economic and social aspects.

It is however stated that having the ability to integrate certain tools and techniques does not equate to being able to apply effective project management. The application of effective project management requires the following; knowledge, performance and personal. The PM needs to be knowledgeable about project management and this will allow effective performance to be practiced within the project. Lastly personal capacity refers to attitudes, character and sense of leadership (PMBOK, 2013). Skills such as; leadership, team building, motivation, communication, influencing, decision making, political and cultural awareness, negotiation, trust building, conflict management and coaching, are required (Podgórska & Pichlak, 2019). There are three categories of competencies which have been identified, which include; behaviourist, generic and cognitive (Boyatzis, 2009).

3. METHODOLOGY

Research methodology can be described as the manner in which researcher choses to conduct the research to better understand the problem or find the solution (Antwi & Hamza, 2015). A qualitative research approach was adopted for the study thereby enabling the choice and use of semi-structured interviews for data elicitation. The interviews were conducted in a face-to-face encounter with PMs within the Free State, South Africa. The sampling size was fifteen PM of whom six were professionally registered. On average, each interview lasted for 25 minutes and confidential information pertaining to participant identity and other confidential information of the company was not disclosed.

Received data from interviewees were analysed using QCA and the interview questions were categorized based on pre-set themes, Theme 1: The manner in which sustainability dimensions are embedded into the lifecycle of construction projects, Theme 2: Understanding the role which project managers play incorporating sustainability dimensions, and Theme 3: Project management competencies required to incorporate sustainability. The basis for these three themes were designed to retort to the central research question of the study as well as its objectives.

4. FINDINGS

4.1 Theme 1: The Manner in which Sustainability Dimensions are Embedded into the Lifecycle of Construction Projects

Sustainability is becoming a growing dynamic within the industry and this can be associated with the inclusion of SEE within construction projects Data collected from respondents indicated that any ideas which are presented to them by the client are worked through during the planning and designing phase of the project. Simultaneously, ideas are thrown and incorporated and any changes which need to be made are considered at that stage. More to that, respondents highlighted that the use of software programmes assist effectively in terms of budgeting, time and resources usage, thus, it becomes easier to plan and monitor the lifecycle of a project without having to start over from which is time consuming and costly.

The design teams are more interested in the 3D modelling which allows for the client to actually see how the end product will look like and this also allows for the client to play a more active role through the designing phase and these technological advances also allows for more adequate monitoring of the three main concepts of any projects namely, cost, quality and time.

Even though the professionals offer advisory services to the client during each stage of the project, they go an extra mile to assess whether the client's views/needs are in line with the required standards and regulations. This is supported by (Alwan , et al., 2017) who highlights that software should be implemented to meet the demands of the stakeholders and the business meeting the required standards and strategies.

4.2 Theme 2: Understanding the Role which Project Managers Play incorporating Sustainability Dimensions

The inclusion of sustainable development within project can be highly influenced by the roles and responsibility of the PM during the lifecycle of the construction project. From the collected data, it was found that a PM should be registered as a professional by the Council in order to act in the full capacity of a PM. However, it was highlighted that even through it is a prerequisite to registered with a council some companies do not have registered PMs, thus, it moves you away from the PM responsibilities and accountability. Registration allows for accountability to taken by the Council should anything wrong happen and the PM needs to have a recognized qualification and to some extend minimum of five years' experience within the BE is also required. Likewise, respondents indicated that the primary role of a PM should be assess the quality, time and cost of the project.

These three will then give rise to the secondary duties which are derived from those three which would be: (a) Project planning including preparation of project management plans, (b) good communication and Co-ordination entails making sure that the project runs smoothly, (c) Integration in terms of making sure stakeholders work together (Li, et al., 2018), (d) Ensure that the various stakeholders comply with the programme and tasks, (e) Control in terms of quality assurance, (f) Co-ordinate contractual and financial instances, (g) Liaison with the stakeholders who are directly and indirectly involved, (h) Manage of conflicts and any potential risks that might occur such as strikes, weather, etc. (i) Project risk management, (j) Occupational Health and Safety within their projects, and (k) Need to be able to come up the required strategy, concur.

4.3 Theme 3: Project Management Competencies required to incorporate Sustainability Dimensions

Apart from the required PM skills there is a need to gain skills which will allow for effective SD inclusion within projects. Data obtained from respondents have a common trait that PM needs to have construction background and also understand the other related construction disciplines including experience which seem to be the most critical. More to that, they indicated the need for PMs to have more skills in order for them to be declared competent (summarized under table 1). The above-mentioned skills have been formatted into a table which indicates the manner in which respondent indicated the need for a certain competency during the lifecycle of a project.

The collected data also indicate that PMs are unable to incorporate sustainable measures even though they engage in short courses. It was highlighted that the short courses offered only expose them to general management instead of exposing them to what happens in the construction industry and the technical work done on the grounds (Ahsan, et al., 2017). Similarly, PMs are promoted based on successful project completion instead of the capacity to keep up with emerging technological advancement (Alwan , et al., 2017) and sustainable measures. Hence, respondents suggested that PMs need through trainings and attend workshops in order for them to keep up with what is happening in the construction industry and also continuous personal development which aligns to statements by (Meng & Boyd, 2017; Podgórska & Pichlak, 2018).

Table 1: Expected PM competencies throughout the project lifecycle and the expected sustainability outcomes.

Project lifecycle	Processes	PM Competencies	Sustainability outcomes
Initiating Process Group	Develop project charter Identify stakeholders (project stakeholder management)	Formal qualification within the BE, experienced, time management, computer literacy, cost management, advisory services, planning skills, communication, strategic, ability to plan ahead, ability to assess required resources	Technological efficiency included, resource allocation done effectively, cost management, time management, effective planning, innovative thinking
Planning Process Group	Develop project management plan, Plan scope management, Collect requirements, define scope, create work-breakdown-structure (project scope management), Plan schedule management, define activities, Sequence activities, Estimate activity resources, Estimate activity durations, Develop schedule (project time management), Plan cost management, Estimate costs, Determine budget (project cost management), Plan quality management (project quality management), Plan human resource management (project human resource management), Plan communication management (project communication management), Plan risk management, Identify risks, Perform qualitative risk analysis, Plan risk responses (project risk management), Plan procurement management (project procurement management), Plan stakeholder management (project stakeholder management)	Formal qualification within the BE, experienced, time management, computer literacy, cost management, advisory services, planning skills, communication Knowledgeable about the contract suits, conflict management, quality management skills, co-ordination skills, strategic, ability to draw up risk assessment methods, knowledgeable about the other disciplines, technical skills, knowledgeable about construction methods, negotiation skills, mediator, ability to work under pressure, people skills, leadership skills	Effective planning, stakeholder orientation, time and cost management, resource inclusion and management, organizational efficiency, technological efficiency

Executing Process Group	Direct and manage project work (project integration management), Perform quality assurance (project quality management), Acquire project team, develop project team, manage project team (project human resource management), Manage communications (project communication management), Conduct procurements (project procurement management), Manage stakeholder engagements (project stakeholder management)	Leadership skills, ability to prioritize certain tasks, vigilant, ability to work under pressure, solving skills, lifecycle costing skills, facilities management skills, grievance management skills, Quality management skills, ability to verify payment certificates, risk management skills, conflict management skills, motivation skills, communication skills, co-ordination, integration of stakeholders, management skills, controlling skills, firm, disciplined, time management, cost management, experienced, knowledgeable about the contract suites and required standards, passionate, tactful, technical experience	Technological efficiency, time and cost management, effective planning, managerial efficiency, procurement orientation, stakeholder orientation, innovative and visionary thinking and implementation, effective resource allocation and usage
Monitoring and Control Process Group	Monitor and control project work, Perform integrated change control (project integration management), Validate scope, Control scope (project scope management), Control schedule (project time management), Control costs (project control management), Control quality (project quality management), Control communications (project communication management), Control risks (project risk management), Control procurements (project procurement management), Control stakeholder engagements (project stakeholder management)	Communication, strategic, tactful, conflict management Quality management skills, time management, cost management, ability to verify payment certificates, firm, discipline, knowledgeable about the contract suites and required standards, human resource management	Technological efficiency, time and cost management, effective planning, managerial efficiency, effective monitoring, resource efficiency, stakeholder orientation
Closing Process Group	Close project (project integration management) Close procurements (project procurement management)	Communication, knowledgeable about the contract suites and required standards, firm, disciplined, time management, verification of payment certificates and closing, quality management skills, cost management skills, human resource management	Technological efficiency, time and cost management, effective planning, managerial efficiency, stakeholder orientation

5. CONCLUSION

The industry is growing and emerging in terms of the technology and machinery that is now available and being utilized. The competencies of the PM of fifteen years ago and those required now are still relevant but there is a need for them to be improved. Data collected from the respondents has indicated that change is constantly happening and thus, one needs to keep up especially when concepts such as “efficiency”, “sustainable construction”, or “green” emerge this can be instilled by incorporating the required competencies. Competencies which include “soft skills” such as communication and “hard skills” such as technical expertise are required in incorporating sustainability within projects. Literature and data collected also indicated that there is a need to improve on the above-mentioned skills for effective incorporation. Therefore, there is a need for PMs to fully engage with construction trends and catch up on new ways to incorporate sustainability. One manner which can be utilized would be engaging in workshops which allow for improved knowledge to be gained in incorporating sustainable measures. The gap can ultimately be filled with improved knowledge within the industry and the improvement of the already acquired “soft skills” and “hard skills”.

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CONCEPTUALISING A PROJECT MANAGEMENT FRAMEWORK FOR EMERGING CONTRACTORS IN THE FREE STATE

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Abstract: This research focuses on developing a project management framework (PMF) for ensuring the economic sustainability of emerging contractors (ECs) in the Free State Province of South Africa. The economic sustainability of ECs is a major concern in the South African construction industry where most of them often exit the business within the first five years of operations. The reported attrition rates of the ECs necessitate the use of project management techniques considered important for project success. The aim of this paper is to present the conceptualisation of a PMF for the success of ECs. The conceptualisation relies on the PMF, which entails project lifecycle, project control cycle, templates and tools. It is herein argued that the adaptation of the PMF to ECs context will enhance their project and business success. This argument is premised on literature that established construction enterprises, which apply the PMF in their operations are associated with significant project and business success.

Keywords: Construction, emerging contractors, project management framework, economic sustainability.

1. INTRODUCTION

This study focuses on the development of a project management framework (PMF) for ensuring the economic sustainability of emerging contractors (ECs) in the Free State Province of South Africa. Economic sustainability is the ability of an organisation to indefinitely support a level of a defined economic production and profitability (Massotte and Corsi, 2015). The economic sustainability of ECs is a major concern in the South African construction industry where most of ECs often exit the business within the first five years of entry. The ECs programme was instituted by the South African government to use the construction industry to redress the economic marginalisation of previously disadvantaged population group of blacks, women, disabled, coloured and Indians (CIDB Act 38, 2000). Given that, the construction industry plays a major role in the socio-economic development of the countries which South Africa is no exception (Abbott et al., 2008). In the attempt to derive full benefit from the construction industry, the Construction Industry Development Board (CIDB) was established to lead stakeholders, including ECs, in the growth and transformation of the construction industry (CIDB Act 38, 2000). A major part of the CIDB mandate is to ensure the strategic growth of the construction industry as well as the economic sustainability of ECs. The economic sustainability of ECs is important for government because of its role in the economic empowerment of the previously disadvantaged population groups of the country referred to above, which is only possible if ECs undertake project activities in a manner that makes them economically viable. Proper project management by ECs is imperative because, virtually all ECs activities are in the construction industry where activities, by their very nature, are project endeavours (Larson & Gray, 2017). Generally, projects are delivered successfully with the use of project management knowledge, skills, techniques and tools (Larson & Gray, 2017; Maley, 2012; Meredith & Mantel, 2010). For a project to be considered successful, it must meet the constraints of time, cost, scope and consider the effects on stakeholders and the environment

(Carruthers, 2008). This implies ECs that can deliver projects within agreed constraints of time, cost, scope as well as stakeholder and environmental considerations could be assumed to be on the road to economic sustainability since they could be working towards profitability in their project delivery. This paper thus aims to develop a PMF to support the economic sustainability of ECs in the Free State Province of South Africa.

1.1 Research Rationale

Ledwith et al. (2010) recognise a strong link between project management use in small business and the sustainability of such businesses. This scenario supports the promotion of the use of project management techniques and tools in ECs. Generally, the construction industry is by nature project-based (Abbott et al., 2008). Thus, it is safe to state that ECs should be using project management knowledge, skills, techniques and tools in their project activities if they are to achieve successful project outcomes (Larson & Gray, 2017; Maley, 2012; Meredith & Mantel, 2010). However, research has shown that most ECs lack project management knowledge and skills and are therefore not using any project management methodology in their project activities (Thwala & Mofokeng, 2012; CIDB, 2011). This assertion raises concerns about the economic sustainability of ECs. It is our belief that an appropriate PMF could support ECs to become sustainable. This stance arises because of the belief that with such a framework in place, it would be easier for ECs to consistently use project management techniques and tools in executing their project activities thereby increasing their chances of delivering their projects successfully, which could lead to their eventual long-term economic sustainability. There is, therefore, a need to model a PMF to support the activities of ECs in the Free State province.

While this study was prompted by the need to model a PMF to support the project management activities of ECs to ensure their economic sustainability, it was also motivated by numerous complaints about the activities of ECs (see Table 1). Several authors noted that project activities undertaken by ECs are often unsuccessful due to poor capability, cost overruns, unreliable delivery schedules, and poor workmanship (Thwala & Mofokeng, 2012; CIDB, 2011). Zunguzane et al. (2012) also found that several low-income houses built by ECs failed to conform to quality expectations. Zunguzane et al. (2012) again found that poor workmanship and the use of unskilled labour are the major contributing factors to the poor quality of project activities undertaken by ECs in the building of low-income houses in the country. The inability of ECs to deliver successful projects has been attributed to inadequate project management knowledge, lack of construction knowledge and experience (Mavetera et al., 2015; Kolver, 2007).

Table 1: Complaints about ECs activities in the construction industry

Complaints	**Description**	**Source**
Poor workmanship	Poor delivery of work on the project scope concerning the technical and physical requirements of the project	Zunguzane et al. (2012)
Project Cost overrun	ECs require additional funds in order to complete projects due to unplanned expenditure	Thwala & Mofokeng (2012)
Project delays	ECs project activities often failed to meet project deadlines	Thwala & Mofokeng (2012)
Inadequate use of project management processes	ECs do not use formal project management methodologies in their project activities.	CIDB (2011)

The lack of project management skills is detrimental to the economic sustainability of ECs because the activities in the construction industry are project-oriented (Larson & Gray, 2017). Thus, one would expect that individuals or businesses which operate in the construction industry should be able to use project management techniques and tools to deliver a project successfully. The observed inadequate project management knowledge within ECs is understandable when one considers that owners and managers of these ECs are known to have been discriminated against during the apartheid regime in terms of access to higher education. Statistics show that only 8.3% and 7.4% of blacks and coloured respectively (see Figure 1), the majority of who own and operate the ECs had access to higher education (Stats SA, 2012). CIDB (2011a) indicates that 45% to 65% of ECs do not have formal qualifications. Yet it is a common knowledge that access to education is crucial to skills formation and higher education is no doubt considered a key stage for acquiring skills and techniques needed for business and managerial decision making. Because projects are successfully delivered with the application of proper project management methodologies (Larson & Gray, 2017; Maley, 2012; Ledwith et al., 2010; Meredith and Mantel, 2010), this makes the use of project management techniques and tools a key instrument for the economic sustainability of ECs. However, as indicated earlier, the economic sustainability ECs remains doubtful. In fact, research indicates that most ECs fold up within less than three years of their establishment. In addition, other stakeholders including clients complain about the quality of project activities undertaken by ECs (Zunguzane, 2012; CIDB, 2011; Department of Trade and Industry, 2008; Lazarus, 2008).

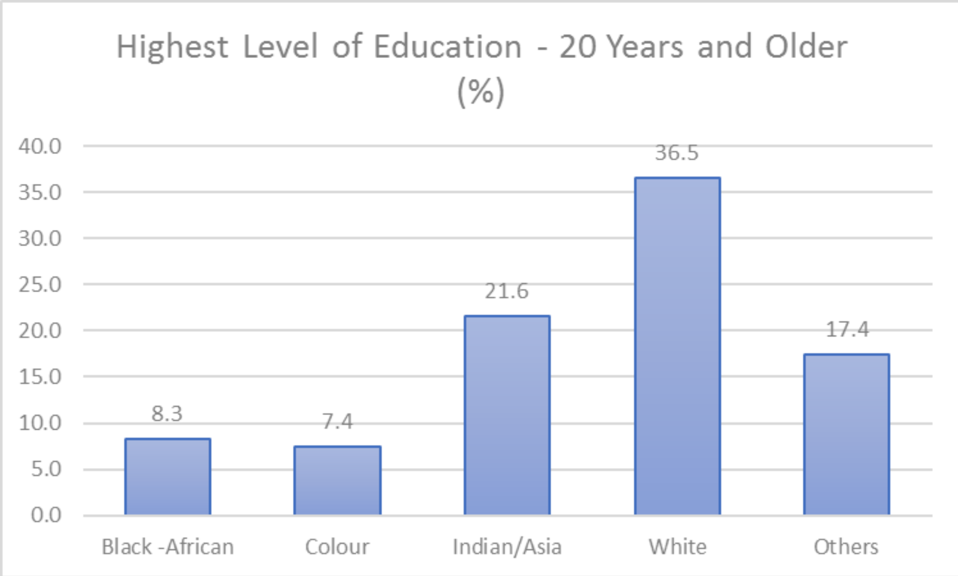

Figure 1: The highest level of education of people 20 years and older in percentages

The above overview highlights the importance of the application of project management techniques and tools crafted into the PMF whose application by ECs could facilitate their achievement of successful project outcomes. Additionally, it highlights the inability of ECs to use the project management techniques and tools in their project endeavours. For ECs to deliver successful projects the review has highlighted the need for a project management application to their project activities for the attainment of economic sustainability.

2. LITERATURE REVIEW

2.1 Conceptualising ECs in The Small Business Domain

Generally, small construction firms are defined according to small business definitions applicable globally. For instance, in the United Kingdom (UK), the United State (US) and the European Union (EU), small construction firms are considered as small businesses and are accordingly defined based on the parameters of defining small businesses in these countries (Small Business Administration, 2015; Stoke & Wilson, 2010; Abbott et al., 2008). In South Africa, ECs belong to the small business category of business classification. They are therefore defined in South Africa as small business entities that are owned and managed in the construction industry by individuals from the previously disadvantaged population groups (BBBEE Act 2003; CIDB Act 38, 2000). Although the South African definition of small construction differs from their global counterparts, their activities and operations are still considered as small businesses. For this study, small construction firms will be referred to as ECs when considering them within the South African context.

2.2 The Role and Challenges of ECs in South Africa

2.2.1 The Role of ECs in South Africa

The important role played by ECs in the construction industry in South Africa and globally is widely acknowledged (Abbott et al., 2008).

The importance of ECs is not only because of their direct contribution to the construction industry and the socio-economic wellbeing of programme participants. Equally important is that they are critical in the construction industry because they play an important role in the performance of larger construction firms. For example, ECs often act as subcontractors and are expected to deliver on a certain level of outsourced work for larger construction firms (Kamal & Flanagan, 2014).

It is also suggested that ECs activities result in cost reduction for the government in its infrastructure development activities especially in the rural and remote areas of the country where ECs are made to undertake such construction activities (CIDB, 2011). The activities of ECs are also beneficial in addressing unemployment. Stats SA (2019) has indicated that though the general unemployment rate is estimated at 29 per cent, employment in the construction industry has been on the increase. Small businesses (including ECs) in South Africa are reported to have contributed 12 million employment opportunities in 2010 although 67 per cent of these jobs were only for the owners (Finmark Trust, 2011). In addition, small businesses (including ECs) are reported to have created an estimated 27 per cent jobs for one to four individuals in addition to the owner (Finmark Trust, 2011). Furthermore, an estimated 63% of employment created in the construction industry in 2014 was by small businesses including ECs (Finmark Trust, 2011).

2.2.2 The Challenges of ECs in South Africa

Literature highlights several challenges faced by ECs in the performance of their project activities. CIDB (2011) and Ncwadi and Dangalazana (2006) for instance have identified the following as some of the challenges faced by ECs in the South African economy regarding their project activities. These challenges include slow delivery of projects, low productivity, cost overruns, poor workmanship, poor cash flow, lack of capital equipment, high start-up cost, lack of access to funding from banks and delay payments (Chauke, 2013; Ncwadi & Dangalazan, 2006). The CIDB (2011), Ncwadi and Dangalazana (2006), Mavetera et al. (2015) and Kolver (2007) concur that many challenges faced by ECs are due to their lack of construction knowledge and skills, project management knowledge, skills and experience. These skills are considered key to achieving project success in the construction industry. Thus, the lack of these critical knowledge and skills mentioned above could be argued to be the reason most ECs are not successful in their project endeavours, thereby affecting their ability to be economically sustainable.

2.3 Conceptualizing Projects, Project Management and Project Management Framework

The literature indicates that a PMF refers to the combination of processes, tasks and tools used to manage a project from start to finish. For example, McConnell (2012) defines PMF to be a subset of tasks, processes, tools and templates used in combination by the management team to get insight into the major structural elements of the project to initiate, plan, execute, control, monitor, and terminate the project activities throughout the project management lifecycle. Naybour (2016) mention that PMF consists of three parts namely; a project lifecycle, project control cycle and tools and templates. These three parts are used to facilitate the execution of the project to achieve the desired outcomes (Naybour, 2016). Additionally, the main idea behind the PMF is to create and share a clear understanding of the basis of a project and share this understanding among all stakeholders, including the project team. This would, therefore, help the project to be accomplished according to the chosen methodology and subsequently deliver the expected outcome (McConnell, 2012). Naybour (2016) mention effective decision making, controlled project scope, better problem resolution, controlled project cost, clients knowing what to expect, struggling projects are more quickly identified and projects teams are more motivated and happier, as some of the benefits of having PMF in place. The researchers believe these benefits are paramount to the economic sustainability of any organisation, which is, to be profitable and economically viable over a long time and conduct activities in such a way that they remain a going concern. It can, therefore, be surmised that the economic sustainability of ECs could depend on the use of a sound PMF.

2.4 Essential Components of a PMF

2.4.1 Project Lifecycle

There is some consensus in literature that a project lifecycle is a series of phases that a project passes, from its initiation to its closure (Meredith & Mantel, 2010; Fox & Van der Walt, 2007). Others like Oosthuizen and Venter (2011) consider project lifecycle to be a logical sequence of activities aimed at accomplishing the objectives or goals of a project. On the other hand, others like Burke (2011) believe a project lifecycle subdivides the project into a number of separate phases where each phase produces a distinct deliverable or result. Burke (2011) argues that the structure of the project lifecycle naturally forms the backbone of most, if not all project methodologies. There are various generic types of a project lifecycle, but Burke (2011) and Naybour (2016) argue that the choice of a particular one is dependent on the business needs and the requirements of the project to be undertaken. For instance, Larson and Gray (2017), Kloppenborg (2015) and Meredith and Mantel (2010) indicate four phases for their prescribed generic project lifecycle to include defining, planning, executing, and closing. On the other hand, Naybour (2016) makes a case for six phases to include business development, tendering, contract negotiation, project mobilisation, project implementation and project closeout.

Based on Burke (2011) and Naybour (2016) who argue for the primacy of choosing a project lifecycle that best suits the business needs, it is important not to forget the resource constraints of ECs that affects small businesses. Considering that ECs lack resources, one would have to tailor the project lifecycle activities to suit their resource constraints while not hampering its effectiveness.

2.4.2 Project Control Cycle

Project control cycle describes how each stage of the project lifecycle is planned and managed and serves as a navigation system for the project through the roadmap defined by the project lifecycle (Naybour, 2016). McConnell (2012) considers the project control cycle to be series of steps and processes that the project manager and other project team members carry out to control the project in terms of progress, quality, changes, commitment and other critical concerns. For McConnell (2012), the main purpose of project control is to manage work during each stage of the project lifecycle and to prepare the project for the next stage. Although Naybour (2016) and McConnell (2012) have a similar view on the purpose of the project control cycle, they tend to have divergent views on the steps or the process that should be undertaken during the project control process. For instance, McConnell (2012) proposed a five-step approach in applying the project control cycle which includes holding meetings, perform quality control, track work progress, respond to changes, and manage issues. On the other hand, Naybour (2016) advocates the use of a simple approach based on the Plan, Do, Check and Act process in dealing with the project control cycle. Though the approach of Naybour (2016) and McConnell (2012) involve different steps, a critical review shows they have similar contents in dealing with the project control cycle. However, by the unsophisticated nature of ECs, it would be advisable to adopt a more straightforward approach, based on the proposed five-step approach by McConnell (2012) in dealing with the project control cycle.

2.4.3 Templates and Tools

A critical element of project management is the use of tools and templates. Naybour (2016) advocates the use of simple templates and tools to support the implementation of project management within an organisation and advice that such templates and tool must be made relevant to the size, risk and scope of the project to ensure its effectiveness in supporting project managers and project team members in delivering a successful project. This advice is most relevant to ECs that are small.

2.5 Project Management and the Economic Sustainability of ECS

Project management is considered to be an effective approach to achieving a successful project outcome in both large and small projects. Many researchers have suggested that businesses or enterprises that adopt and use project management approach in undertaking their project activities tend to have better outcomes than those who do not use the approach (Mavetera et al., 2015; Thwala & Mofokeng, 2012; CIDB, 2011; Ledwith et al., 2010; Kolver, 2007; Ncwadi & Daganlanzana, 2006). From this perspective, it makes perfect sense that ECs that undertakes projects need to set up an appropriate PMF in order to achieve successful project outcomes. Generally, it could be reasonably expected that a business that delivers successful projects would most likely be considered for repeat business (subsequent projects) from satisfied clients or stakeholders in the future, thereby increasing their chances of long-term economic sustainability.

Economic sustainability is seen by most researchers as the ability to indefinitely support a level of defined economic production or profitability (Finkbeiner et al., 2010). For example, Finkbeiner et al. (2010) define economic sustainability as having the ability to generate, at any time enough cashflow to ensure liquidity and produce a persistent long-term return such that the economic needs of the business and its stakeholders are met. It can, therefore, be inferred that for ECs to achieve economic sustainability, their project activities in the construction industry must consistently lead to long term profitability, a condition that is only possible if their projects meet the requirements of the clients or stakeholders.

To sum up the discussion so far, it is evident from the literature that an economically sustainable EC programme would in no doubt be a major boost for the government in achieving the economic emancipation of individuals from the previously disadvantaged population groups via the construction industry. However, anecdotal reports and research continue to indicate that many ECs in South Africa collapse within five years. Additionally, it emerged from the literature that many of the ECs are guilty of noncompliance and underperformance issues, these issues can easily be addressed by the adoption of an appropriate PMF. Yet many of these noncompliance and underperformance issues are also key determinants of the economic sustainability of ECs in their project activities in the construction industry (Larson & Gray, 2017). It is also clear from the discussion that an appropriate PMF could enhance the economic sustainability of ECs. However, such a framework must be affordable to ECs due to their resource constraints.

3. RESEARCH METHOD

This is a theoretical paper, where literature review was relied on as a method to produce this paper. However, it has practical implications. The specific approach was to use principles of project management from literature to create a framework that can guide the development of a detailed PMF for ECs that operate in the Free State province in South Africa. This approach falls within the realm of an interpretivist paradigm. Moreover, interpretivism studies usually focus on meaning accordingly, in line with this philosophy, we assumed that reality is socially constructed through our own interpretations of the literature to come up with the following conceptual framework (Blumberg, Cooper, & Schindler, 2014; Saunders, Lewis, & Thornhill, 2009).

Conceptually, this study is framed in terms of ECs, PMF, and economic sustainability. The desirable outcome of the EC programme is a sustainable business that will economically empower individuals from the previously disadvantaged population groups. The enabler in this relationship is an appropriate
PMF. Alternatively, we argue in this paper that, the development and use of an appropriate PMF could lead to the economic sustainability of ECs, thereby enhancing their contribution to the socio-economic development of Free State province. This conceptual framework is depicted in Figure 2.

3.1 Conceptual Framework

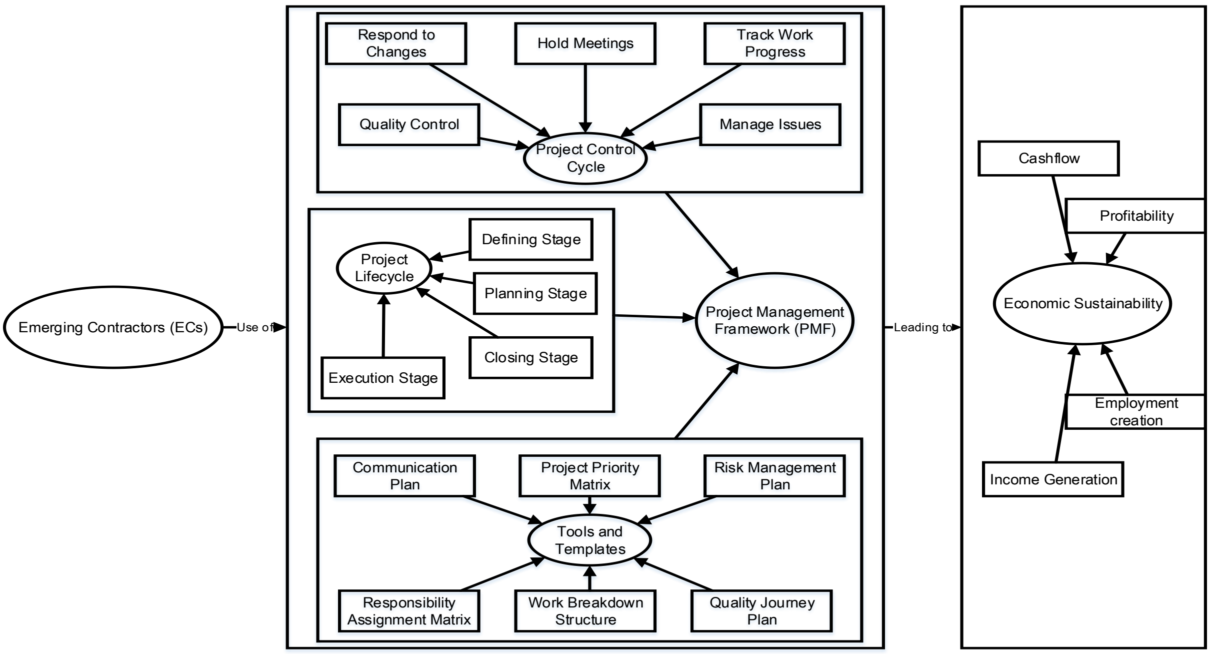

Figure 2: Economic sustainability of ECs using a dedicated PMF

The framework (see Figure 2) assumes that ECs could achieve economic sustainability using a dedicated PMF. This is because the use of the dedicated PMF could enable ECs to undertake projects successfully. The ability of ECs to undertake and deliver successful projects make them a viable option for subsequent projects in the future. ECs success would result in continuous cash flow, employment creation, income generation and profitability which are considered the essential components of economic sustainability (Finkbeiner et al., 2010). The proposed PMF comprises; project lifecycle, project control cycle, and tools and templates. For ECs to achieve the project lifecycle component of the PMF. ECs project activities should include the four stages prescribed to include defining the project, planning the project, executing the project and finally closing the project. Regarding the project control cycle, ECs must incorporate activities such as responding to changes, holding meetings, track progress of work, manage issues on project and conduct quality control activities. Finally, the tools and templates that should be used by ECs include communication plans, project priority matrix, risk management plan, responsibility assignment matrix, work breakdown structure and quality journey plan. The assumption is that the combination of these three components should greatly enhance the project management practices of ECs thereby leading to project success which in turn could enable ECs to generate income, create job opportunities, have adequate cash flow, becomes profitable in their business and project activities. All these combined should lead to the economic sustainability of ECs in the construction industry of South Africa.

4. CONCLUDING REMARKS

By utilizing PMF, ECs can achieve economic sustainability in their business activities which are basically project by nature. ECs can do this by focussing their project endeavours on the use of a suitable PMF that takes their circumstances into consideration. The effectiveness of such a suitable PMF includes the consideration of the key components consisting of project lifecycle, project control cycle as well as templates and tools. The conceptual framework (see Figure 2) could assist ECs to achieve economic sustainability in their business activities.

The proposed conceptual framework is expected to guide the development of a dedicated PMF for ECs. Its simplicity should lie in the focus on only three, but very important project management aspects namely, project lifecycle, project control cycle, tools and templates. By restricting such a framework to only a few but very important elements, it becomes much easier for owner/managers to focus their scarce resources on critical success factors.

The paper has given some direction to the underlying project management activities that should be included in any simple to use PMF for ECs in the Free State province context. The adoption and use of this framework should thus lead to the achievement of economic sustainability in their business and project endeavours.

In conclusion, the suggested conceptual framework needs to be subjected to empirical investigation in order to arrive at a PMF that is useful for ECs in their business and project activities in order to enable the achievement of economic sustainability.

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FACTORS AFFECTING MATERIALS MANAGEMENT ON LIBYAN CONSTRUCTION SITES

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Abstract: Materials management is crucial in construction projects. It contributes to the achievement of the project on time and, as such, affects the overall economy of any country. Inappropriate materials management results in cost and time overruns that delay the overall project. The purpose of this paper is to identify and analyse the factors affecting materials management on Libyan construction sites. A survey questionnaire was distributed to professionals on construction projects: owners, contractors, site supervisors, consultants, engineers, and suppliers. The questionnaire comprised four sections of pre-defined factors: human, management, technology, and political and civil war issues. The Statistical Package for the Social Sciences (SPSS) was employed, and the factors were analysed. The most significant factors identified affecting materials management were: the contractors' experience and skills, factors related in materials on the site (receiving, storing, handling and tracking), and site supervision. The results of this paper will provide awareness and a better understanding of factors affecting materials management on Libyan construction sites.

Keywords: Materials management, construction site, contractors and technology

1. INTRODUCTION

Construction projects play a significant role in the Libyan economy, creating and retaining jobs and wealth for the country. They represent an important business that contributes 5.2% of the national Gross Domestic Product (GDP) (Omran et al., 2012). However, construction projects in Libya face several problems that prevent achievement of their goals, including materials, labour, machinery and the market. An important factor that adversely affects the performance of construction projects is the inappropriate handling of materials during site activities (Yap et al., 2017). There are major issues which affect materials management activities such as constraints on storage areas, site logistics with regards to materials handling and distribution, and also ordering and delivery of materials to the construction site.

Previous research has highlighted materials management issues such as inappropriate storage (Ahmed, 2017), the requirement for large storage capacity. (Agapiou et al., 1998), transportation difficulties and inappropriate materials delivery (Tedla, 2018). Other issues include manual processes and non-compliance with specifications (Dey, 2001), late delivery (Aibinu & Odeyinka, 2006), and shortage of materials (Alfakhri, 2017). According to the Libya General Council for Planning (GCP) (2002), construction projects began under trying circumstances and then entered into a process of evolution after oil was discovered in 1951. Construction projects were dependent on oil income.

Over the last four decades, the public construction sector in Libya has improved, becoming an important business that contributes 5.2% of the gross domestic product (GDP). Nagab (2007) pointed out that, given the availability of raw materials, Libya has the largest cement factories in North Africa, located in Derna in the east of the country, as well as factories in Tripoli, Benghazi and Sabha, and an iron and steel factory in Misrata. On the other hand, Salah and Bloomer (2013) highlighted that sources of construction and building materials in Libya are cement, reinforced steel, blocks and finishing materials.This means that materials management must be applied to deliver materials to site projects on time, because its primary objective in construction projects is to reduce time (Handfield et al., 2005).

Murali and Yau (2007) agreed and added that any delay will increase cost, reducing the feasibility of the project and failing to contribute to the development of society. Libyan researchers have conducted several studies on delays in construction over recent years, although mostly without recommending the need for materials management (Shebob et al., 2012; Abdullah et al., 2002; Abdelnaser et al., 2005). The exception is Mustafa (2009), who identified that most delays are related to materials management because it has an essential role in saving time and reducing costs while retaining quality.

One of the difficulties faced by construction projects in Libya is that they mostly depend on foreign experts. Currently, the projects need improvement and development in order to meet the national housing supply and infrastructure needs: new homes, airports, ports, railways and roads. Hotels, office buildings and resorts are also required to meet the needs of potential tourism (Ngab, 2007; Mostafa, 2009; Shebob et al., 2012). There are several approaches materials management, including proper planning of materials logistics and Just-In-Time (JIT) concepts to resolve the problems of space constraints, and the implementation of Information and Communication Technologies (ICT) such as barcoding for automatic tracking of materials. However, there are few positive examples of the successful use of these tools to improve materials management on construction sites. Therefore, the objectives of this paper are to:

- Explore the current level of awareness of materials management among Libyan construction professionals.
- Assess the potential factors affecting materials management on construction sites.
- Outline and rank the expected factors hindering successful construction materials management in Libya.

This study was conducted to identify the level of awareness of materials management and the critical factors affecting Libyan construction sites and is the first of its kind. It provides a critical overview of the implementation of materials management in Libya, through its originality and the consideration of specific factors contributing to the body of knowledge. This study will provide Libyan professionals in the construction sector, such as owners, consultants and contractors, with a clear view of materials management. It contributes to an understanding of materials management on Libyan construction sites.

2. LITERATURE REVIEW

Fundamentally, management of construction materials is related to arranging, formulating plans, acquiring information and material, stockpiling and ensuring the flow of material. It guarantees that the correct materials are in the correct place, in the quantities required. Wild, (2017) showed that the structure of material management requires organizing procedures to take into account co-ordination and supervision of the supply chain of materials, with a specific end goal of utilizing the assets in a judicious manner and keeping expenditure down to the bare minimum. According to Mogalli and Hussein (2017) this must be implemented in design and planning procedures, the arrangement of resources and ensuring sufficient warehousing, supervision of the use of materials, and ultimately bearing the material costs. All these efforts are interdependent. Doleeb (2016) defined the process of managing materials as sequential procedures to arrange the availability of the necessary material and equipment at the opportune moment in the place where it is needed. It is performed to minimise the cost of the production process and to control the supply of materials effectively.

2.1 Importance of Materials Management

Materials management is the process, which links supplies and organisations in order to obtain a standard of service ensuring that the right materials are available on the construction site at the right time and at the lowest cost (Safa, 2014). The criterion of successfully completing any construction project is always incumbent on the management of materials in an efficacious manner. (Patil and Pataskar 2013, Gulghane and Khandve 2015) agreed that fluctuation of costs of such material, concerning the completion of the projects, could amount to any extent between 20-70% of the complete construction project expenditure and on occasions, this could exceed the general cost ceiling of 70 %. Sustainable management of material generally yields several advantages. Many authors identified the importance of material management. (See table 1.)

Table 1. Importance of materials management

Authors	The Importance of Material Management
Hannure and Kulkarni (2014)	Materials management is a scientific technique concerned with preparing, organising and control of the flow of materials from their initial purchase to the end.
(Safa, 2014)	Materials management is the process, which links supplies and organisations in order to obtain a standard of service ensuring that the right materials are available on the construction site at the right time and at the lowest cost.
Abdulbagei et al. (2012)	Materials management is essential to manage productivity and cost efficiency because these contribute the major portion of expenses in construction projects. Moreover, it can reduce total project costs and complete the project on time by controlling procurement, carrying value.
Kasim (2010)	Proper management of construction material could be defined as the methodical procedure of formulation of plans, acquisition and preservation and transportation of such materials which could be necessary for construction purposes.
(Doleeb, S. 2016)	Materials management is a sequential procedure to arrange the availability of the necessary material and equipment at the opportune moment to the place where it is necessitated.
(Mogalli & Hussein 2017)	The structure of materials management is necessary to be actualised to design and planning procedures, arrangement of resources and making sure of the qualitative warehousing and preservation, supervision of the utilisation of materials, and ultimately bearing the material costs.
Salah and Bloomer (2014)	The associated factors material management are; inventory management, store operations, handling of purchased materials and transportation of the finalised products and components.
Omran (2014)	Proper material management improves labour productivity. For instance, work time can become unproductive or idle time due to the lack or shortage of equipment and tools in the right place at the right time.

This paper investigated the need for material management, the conclusions of a number of authors are reported below:

Adita and Sabihuddin (2013**)** conducted a “Study of material management techniques on construction projects” and showed that planning and material take off, vendor evaluation and selection, purchasing, expenditure, shipping, material receiving, warehousing and inventory, and material distribution are the most important functions in the construction industry. They conducted a survey of the industry, determining various formats for materials management, tracking systems and software technology developed for the management of construction materials. They recommended that the total cost of material may be 52% of total costs; so, it is important for the contractor to consider timely availability of material as contributing to successful completion of the project. Materials management is thus a key to successful project management.

Kabede et al. (2018) assessed the problems of construction materials management in residential projects, addressing current practices to identify issues and apply always better control (ABC) analysis and S-Curve analysis. However, there is a problem in introducing new technologies such as RFID, ICT and bar coding for material tracking and management. Therefore, the researcher recommends further study in this area.

Caldas (2014) stated that the programme of comprehensive materials management contributes to reducing cost, improving productivity, and better-quality and more predictable project outcomes. The author concluded that although the role of materials management is expanding in the early phases of capital project planning, IT systems continue to improve real-time coordination and course correction. The study recommended that materials management should influence IT system selection and integration during project planning, and training programmes should be integrated to improve the use of materials management IT systems.

Mishra (2018) presents a possible solution for managing material delivery problems in construction projects: a shipment tracking-based approach for inventory transparency and proactive timely material availability. The study recommends the Last Planner framework (Ballard, 2000) to shape workflow, address materials needs and improve relationships between among team members. The study found two challenges to material flow management with the Last Planner methodology that had not previously been addressed in detail. First, the Last Planner needs to have access to comprehensive information on the materials available for individual project tasks; and second, the materials should be reliably available at the project site. Previous studies showed that there are factors related to contractors, and other consultants, owners and materials as follows:

2.1.1 Factors Related to Contractors

It is the responsibility of the contractor to provide materials, labour and services for the construction project, in addition to hiring sub-contractors to implement all or parts of the work on the construction site. Hughes (2015) stressed that the contractor has the greatest responsibility of all the parties involved to complete the undertaking on time. On the other hand, Shabbar et al. (2017) stated that time schedule overruns and excessive costs are the responsibility of contractors. As a general rule, contracting is a complex and often difficult venture. Leung (2014) and Salloom et al. (2017) agree on the necessity of maintaining a strategic distance from any overruns, be it costs or time; the contractors have to regularly shoulder complete liability for the outcomes of the performances the sub-contractors and other workforce personnel.

Fundamentally, the process through which the contractor manages to perform specific responsibilities indicates the actual nature of the work (Shi & Arditi, 2001). Walker (2015) adds that the ability of the contractor to complete the task according the agreed timetable chiefly relies upon two aspects: accessibility of assets (consolidating cash, labour, materials, hardware and mechanical apparatus); and efficient administrative capability. There are two sources of labour: the sub-contractors and from direct recruitment. If the sub-contractor's insufficient workforce contributes to delays in the agreed time schedule, then both the project and property owners and the primary contractor have to resolve this issue. However, Mpofu et al. (2017) in a study in the United Arab Emirates (UAE) recommended that many different variables may result in schedule overruns, categorized as construction materials, machinery, labour force management and performance management.

2.1.2 Factors Related to Consultants

Consultants lead the process of planning and designing the project and also contribute to cost control and estimation of resource structure necessities as well as quality control mechanisms. In some circumstances, postponement resulting from the consultants might occur during the design selection and approval phase, the reception of construction blueprints, accepting plan endorsements from contractors or client, and in evaluating the best management methodology. Postponement may result from relative lack of experience of qualifications of the consultancy staff, faulty communication channels, and failure to co-ordinate the multitude of processes and personnel (Shebob, 2012). According to Omran and Ibrahim (2018), inspections required by the consultants could slow down the entire undertaking. Accordingly, the contractors must resolve these problems from multiple angles. The consultants may fail to meet expectations, resulting in assigning the work to other practices. Effective supervision and management of the operations on the construction site are important for timely project completion.

2.1.3 Factors Related to Owners

One of the most significant decisions in this respect is the length of the agreement and the owners need to focus on resolving this first. Many owners prefer quick completion of the work. Careful deliberation must be given to the terms of the agreements, and the owner must be in a position to hand over the site to the contractor. The owner's leadership in different issues may determine the pace of the of the undertaking. According to Allen and Iano (2019), the obligations and duties of the clients and owners, as key players, are onerous; it is usually necessary to introduce other professional assistance regarding the project ventures. First-hand management groups and units are available to provide the entire range of skill sets, as central administrators to deal with management control (Mohammadi et al., 2018). Mohammadi et al. (2018) stressed the interdependence between the owners and the working personnel; this relationship must create trust between these two groups of stakeholders. The owners must take an interest in all aspects of the venture, but without interfering with the working procedures of the contractor.

2.1.4 Factors Related to Materials

According to Myers (2016), construction materials are basic to any construction undertaking and indicate the actual extent of expenses for the business owner. From the point of view of the contractor, obtaining and transporting materials is crucial at the various phases of the undertaking (Ibrahim, 2015). The inability to deliver the right materials and to store them safely may result in postponements and time overruns, as may theft or deterioration. According to Odeh and Bataineh (2002), the consistent provision of materials is an essential obligation of the contractor on-site. Koushkiet et al. (2005) opined that this is another key viewpoint with respect to material costs. Rising material costs may prevent the owner from procuring more, particularly in large-scale building ventures. Deciding whether to postpone purchase until the price falls is critical. Infrastructural shortcomings may also result in delay in the supply of materials. In short, securing there are many reasons why the delivery of new materials may be delayed (Wiguna & Scott, 2005).

3. RESEARCH METHODOLOGY

This research is a quantitative study using a questionnaire survey to provide an overview of the current skills in materials management of Libyan construction personnel, and the potential benefits from materials management techniques for Libya. This research method was chosen because of its ability to gather a wide range of views from individuals, to cover a large number of respondents, to have a better generalizability of the results, and for its cost-effectiveness (Shang & Sui Pheng, 2014a; Sarhan et al., 2017; Tezel et al., 2018). In addition, this technique fits in with the quantitative approach that enables the statistical testing of the data to obtain meaningful interpretations that provide a better understanding of the survey topic (Abawi, 2008). The research process followed in this study can be seen in Figure 1.

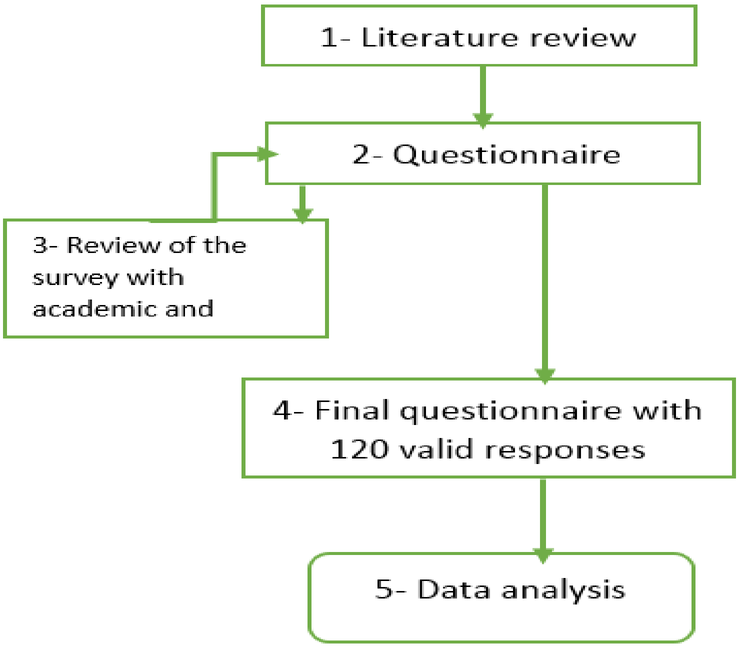

Figure 1: Research process

Before producing the final version of the questionnaire, ten leading academics in the Libyan construction field were invited to evaluate the first draft to ensure the relevance of the questionnaire and to examine the suitability of the extracted factors in the Libyan context. They recommended reformulating some of the questions for more clarity. The revised questionnaire was then distributed online in English and Arabic. The survey consists of four units: respondent's position and experience; S materials management factors; a section designed to collect general information about construction operations on-site; and finally, communication and technology.

3.1 Results and Discussion

The researcher used SPSS to analyse the questionnaire. Q1 asked about the respondent's position and experience. The chart below shows that over 50% were engineers. Second was contractors (18.3%), followed by owners (11.7%), site supervisors (6.7%), surveyors and project managers (both 3.3%). (See figure 2).

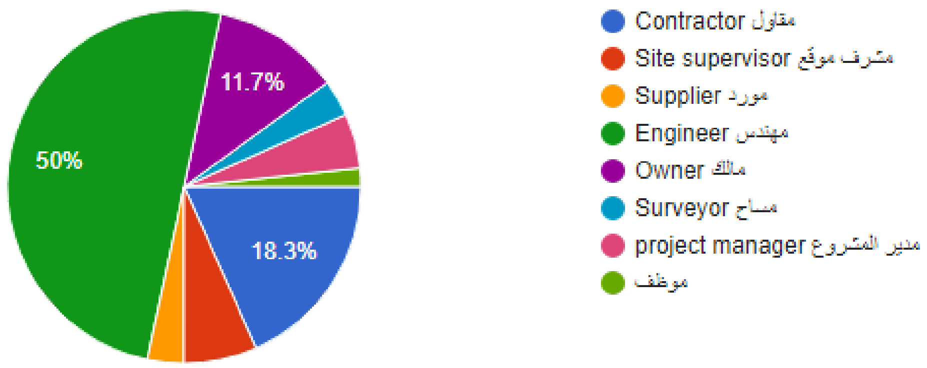

Figure 2: Respondents position

45% of the participants had 6-10 years' experience in the construction industry, and 21.7% less than 1-5 years. only 13.3% had experience of more than 20 years. These and the remaining figures are shown in figure 3.

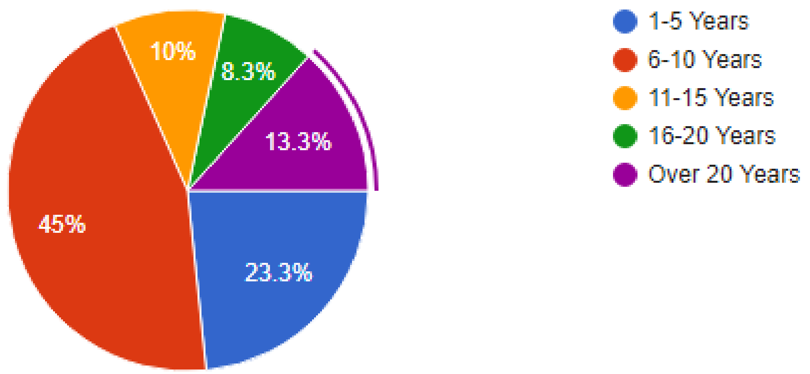

Figure 3: Respondents experience

Q2 asked about the importance of consultants, contractors, owners, designers and surveyors in materials management. Only 48% thought that consultants are important in materials management, 20% considered designers as important, 10% surveyors and 56% owners. However, 65% of the respondents believed that contractors play an important role in materials management, while the other 35% disagreed. (See figure 4).

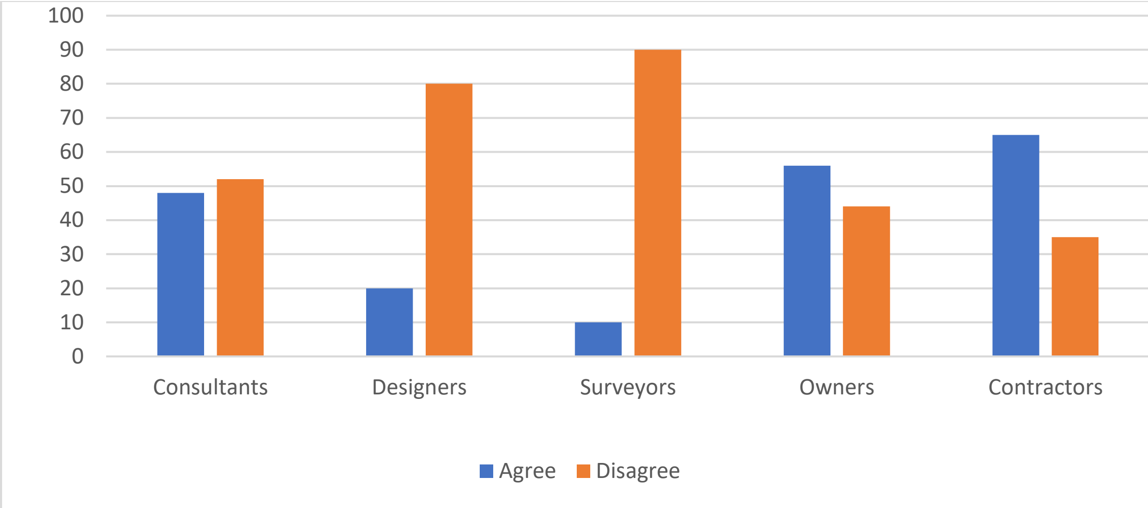

Figure 4. The Important Actors of Materials Management

Q3 asked respondents to rank (1-10) the effects of: poor experiences of contractors and sub-contractors, poor stores, procuring management process of material handling, materials delivery, quality control, poor management and supervision of the site, use of old technologies, shortage of materials on-site, and control. 50% of the participants ranked materials management as important or extremely important. but not related to the expertise of the contractors (mean ranking 8.26). 63% of the participants replied that by improving the procurement process, the materials management system could be considerably improved (mean 9.26). Only a handful of the participants did not have a positive outlook towards the aspect. 25% of participants ranked improving the process of material handling as 8 out of 10, while 23.3% ranked it as zero (mean 7.41). 51% of participants believed that minimizing the shortage of materials on site and controlling their flow can be very useful in improving the materials management function (mean 8.56). 60% of respondents agreed that better quality control can be most effective in improving material, while 20% ranked it as zero (mean 9.06, meaning that the majority of the participants considered this to be an extremely important factor in improving materials management. (See table 2.)

Table 2: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
The purchasing of the materials.	120	1.00	10.00	9.1167	1.63050
Minimise the wastage of materials on site.	120	1.00	10.00	8.6167	1.98390
Improvement in the process of material handling	120	2.00	10.00	7.4167	2.01083
Minimise the shortage of material on site.	120	1.00	10.00	8.5667	1.98623
Materials delivery.	120	1.00	10.00	8.5333	2.02892
Poor stores	120	1.00	10.00	8.6167	1.90613
Poor site management and supervision.	120	1.00	10.00	9.1500	1.42987
Poor contractor experience.	120	2.00	10.00	7.8833	1.94972
Effect of using old technology.	120	1.00	10.00	4.6333	2.79836
Valid N (listwise)	120				

The majority of respondents ranked materials delivery as extremely important (mean 8.53). With a mean of 8.61, the factor of poor stores has a significant impact, although it is not the most important. Half the total population responded in its favour of this factor. Poor management and supervision of the site were found to be a very important factor, with a mean of 9.15. 56% of the total population agreed with this, while 8.7% disagreed considered it negligible. A mean of 4.63 was recorded for the use of older technologies. 25% of the total population stated that they make very little use of them, although a considerable number still use them to a limited degree. It appears that all companies are slowly phasing out the old technologies and tools in favour of new ones, as they are faster and more efficient.

Regression

Regression analysis was applied to determine the impact of different factors on the role of materials management, through an additive scale. Individual variables for the role of materials management were added, and material management was the dependent variable. The independent variables were Changes in materials' prices, Poor stores, Inappropriate construction methods, Materials delivery, Inappropriate project planning and scheduling, Poor contractor experience, Minimizing the shortage of material on-site, Poor site management and supervision, Improved productivity of the available labour force, and Better quality control. See the model summary in table 3.

Table 3: Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.449[a]	.201	.128	11.88945

a. Predictors (Constant): as listed above.

The model shows the extent of the impact of independent variables on the dependent variable. The value of R^2 is calculated 0.201, showing that with a change of 100% in the independent variables, there will be a 20.1% chance of change in the dependent variable. However, whether this variation is significant or not can be determined through the ANOVA analysis (Table 4).

Table 4: ANOVA test

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3881.727	10	388.173	2.746	.005[b]
	Residual	15408.140	109	141.359		
	Total	19289.867	119			

a. Dependent Variable: Role of Material Management

b. Predictors (Constant): the independent variables listed above.

To analyse the impact of the independent variables on the dependent variables, ANOVA test was carried out with the result F (10, 109) = 2.746; p = 0.005. Since the p-value is less than the critical alpha value of 0.05, it can be said that the impact of the independent variables on the dependent variable is statistically significant.

a. Dependent Variable: Role of Material Management

The coefficients are presented in (Table 5). The significance value of improved productivity, minimising shortage of material**,** Better quality control, poor site management and supervision and inappropriate construction methods are below the critical alpha value of 0.005, indicating that they have a statistically significant impact on the dependent variable. However, the statistically remaining variables do not have a statistically significant impact on the dependent variables. Emphasis should therefore be placed on the variables that can significantly enhance the role of materials management for the construction industry.

Table 5: Coefficients analysis

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	67.011	9.743		6.878	.000	47.700	86.322
	Improved productivity on the part of the available labour forces.	1.748	.836	.262	2.092	.039	.092	3.404
	Minimize the shortage of material on site.	-2.055	.797	-.321	-2.579	.011	-3.634	-.476
	Better quality control.	3.730	1.227	.455	3.040	.003	1.298	6.162
	Materials delivery.	-.277	.634	-.044	-.437	.663	-1.534	.979
	Poor stores	-.197	.676	-.029	-.291	.772	-1.536	1.143
	Poor project planning and scheduling.	-.069	.817	-.010	-.085	.933	-1.689	1.550
	Poor site management and supervision.	-2.610	1.202	-.293	-2.170	.032	-4.992	-.227
	Inappropriate construction methods.	1.646	.751	.232	2.192	.030	.158	3.134
	Poor contractor experience.	-.079	.730	-.012	-.108	.914	-1.526	1.369
	Changes in materials prices.	-.093	.790	-.012	-.118	.906	-1.659	1.472

4. CONCLUSIONS

This study was conducted to identify the level of awareness of materials management and the critical factors affecting Libyan construction sites and is the first of its kind. It provides a critical overview of the implementation of materials management in Libya, through its originality and the consideration of specific factors contributing to the body of knowledge.

In assessing the current level of materials management among Libyan construction professionals, the results showed that several factors require greater recognition; for example, fewer than half the respondents considered the role of consultant as important, although two-thirds recognized the contribution of contractors. However, 70% believed that delivering and storing materials was the most important aspect of effective materials management.

The Libyan construction professionals do recognize the role of materials management in meeting deadlines and delivers the project on time. However, communicating the benefits of materials management, especially those related to the reduction of time and cost, should be encouraged through conferences and seminars, while researchers should be aware of the current lack of studies related to materials management. This research will help construction companies and researchers in the Libyan construction sector to focus on the significant issues necessary concerning people-related barriers such as lack of knowledge about materials management, labour productivity and supply chain management.

Finally, this study investigates factors affecting materials management. The findings will help academics and professionals in the construction sector of Libya and similar countries to understand the benefit of materials management and to conceive a roadmap for its implementation in the construction industry.

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ICT, Technology and Engineering

INVESTIGATION ON COMPARATIVE ROLES OF MAJOR STAKEHOLDERS FOR BIM IMPLEMENTATION IN A TRADITIONAL CONSTRUCTION PROJECT ENVIRONMENT

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Abstract: The revolutionary effect of Building Information Modelling (BIM) towards the conventional Architecture Engineering and Construction (AEC) industry has been appraised by many specialists as a constructive force to change AEC's conformist technologies and management principles. Even though BIM has been appraised as an integrator of technology and construction project management, it also has been misguidedly identified in the eyes of many professionals to consider BIM as a '3D model' which is in genuinely, a 'process' to achieve an exceptional alliance in between each construction project stakeholder. However, the complexities in a traditional construction supply chain have far more accelerated with the intervention of BIM where project stakeholders are at an edge of ambiguity to ascertain their supply chain roles and duties in a BIM environment. Therefore, this paper aims to study on roles and duties of BIM project stakeholders concerning the construction supply chain as in BIM Standards and how those standard roles have been embraced in real-life setups. To achieve the aim, comprehensive literature was conducted which is largely based on BIM standards to identify the theoretically established roles and duties of BIM project stakeholders. However, the theoretical aspects may not be the same in real-life scenarios where the project stakeholders may have to alter themselves following the BIM project context. Therefore, BIM expert interviews were directed to extract the opinions of professionals who are virtually involved in the BIM environment to identify how the theoretical aspects had differed. Consequently, this paper acknowledged unsung stakeholders in a theoretical context that are inevitable to consider in actual implementation. Moreover, the experiences of respondents brought up the added duties and responsibilities of stakeholders than identified in BIM standards. Finally, the collected data were illustrated through the cognitive mapping technique which would help the traditional construction project stakeholders to identify and adopt their extended or modified roles to achieve a successful BIM implementation.

Keywords: Building Information Modelling (BIM), BIM Standards, supply chain management, Construction Supply Chain (CSC), construction project stakeholders**.**

1. INTRODUCTION

BIM is being deliberated as the cutting-edge revolution in the construction industry, where Information Technology (IT) and traditional construction techniques have been unified into a collaborative environment (Aouad and Arayici, 2010). Accordingly, numerous viewpoints and features have been conveyed on BIM. However, as to derive the indicated research aim on BIM project stakeholders, the concept of BIM has been defined about the management concept on how the BIM to be implemented as technology in the construction industry.

Even though BIM was in practice for more than 20 years, it is only very a few years ago that the stakeholders of the construction industry were attracted by BIM potentials which promised to makeover the design, construction and operation procedures of buildings in a more rationalized and efficient way (Coates et al., 2010). Subsequently, employers started to insist on architects and other related design and construction experts and contractors to adopt BIM to achieve the utmost sustainability and cost-efficiency of unique construction outputs (Mihindu and Arayici, 2008).

As in the initial stages, only the prefabricated structural steel production market as a component of the construction industry applied the parametric 3D modeling in its designing process. However, in recent times, a wide range of BIM applications have become freely accessible for professionals in the AEC industry which are considered to be an incentive of the AEC industry's pledge to deploy BIM in the past 20 years (Eastman, Teicholz, Sacks, and Liston, 2011). Therefore, literature significantly highlights, AEC industry’s ability to recognize the technological progress in orthodox methods through BIM implementation. This paper comprehends the primary outcomes of the literature synthesis and analysis of data obtained from semi-structured interviews with BIM experts in the AEC industry. Accordingly, the literature synthesis has discussed how the traditional stakeholders in the construction project environment affected by BIM and work scopes upon BIM standards as with special particulars to BIM level 02 introduced by the United Kingdom (UK). Consequently, the data extracted from BIM expert interviews were scrutinized to highlight the deviations of stakeholder roles and duties as anticipated in BIM standards.

2.0 RESEARCH METHOD

This research pursues to address the research problem of ‘how the traditional construction project stakeholders have been effected through the intervention of BIM and the deviation of work scopes and roles of anticipated stakeholders of BIM standards in an actual implementation’. Accordingly, a qualitative research approach was appraised, as the qualitative methods can be useful in forming thorough studies on incipient concepts and in an instance where the research has an insignificant basis of literature. Consequently, findings of this research are presented in two components of investigative results on literature synthesis and manual content analysis results of BIM experts’ interview results. As in conclusion, the collective attempts on two components were presented as a cognitive map on the roles and duties of BIM construction project stakeholders.

2.1 Cognitive Mapping Technique

Eden and Ackerman (1998) highlighted the use of cognitive maps to arrange complex and bulk quantity of data in a more organized manner. Furthermore, Sandelowski (1995) identified the easiness of the decision making the process and determining conclusions through the structured arrangement of cognitive maps. Therefore, the cognitive mapping was used in presenting the discussion outcomes of the data analysis and literature synthesis while arousing the link in between the empirical data and theoretical perspectives.

2.2 Semi-Structured Expert Interviews

For expert interviews, six numbers of professionals who are related and exposed in BIM with construction project environment and professionals who have been involved in studies of BIM were selected. However, the selection of respondents was centered on their involvement in BIM under which CSC stakeholder role of a BIM project. Accordingly, the diversification of respondents was extended up to the roles of Contractor, Consultant, Engineer, Sub-contractor/Supplier, and BIM Standards regulator (The Government).

The basic details and composition of the experts are given in Table 01. As the BIM application for on-site construction in Sri Lanka is in a preliminary stage, it was required to pay an extra effort in finding out the professionals with required practical knowledge and exposure. Therefore, it was later decided to conduct expert interviews with the professionals who had the practical exposure of BIM application in foreign context as well.

Table 01: Composition of BIM Experts

Respondent	Industry Experience (years)	Involvement in BIM under which CSC Stakeholder Role	Based Country
A	20	Contractor	Sri Lanka
B	8	Government Standards Provider	UK
C	10	BIM Consultant	Dubai
D	7	Contractor	Sri Lanka
E	12	BIM Engineer	Dubai
F	8	Supplier/ Sub-Contractor	Dubai

3.0 INFLUENCE OF BIM TOWARDS THE CONSTRUCTION INDUSTRY

De Valence (2010) has described the construction industry as its features of the assorted, extensively spread industry, where the two outputs of the industry are not sharing the same characteristics which are also the uniqueness of the construction industry. In the same way, Fellows, Langford, Newcombe, and Urry (2002) explained the construction industry and its components as of logically aligned organizations, highly intensive on manpower and have derived demand.

Therefore, it is reasonable to identify, that the construction industry holds a greater impact on global economic strategies and produces extremely unique outcomes compared with other industries. However, the recent studies have revealed the construction industry's extreme effort in implementing certain modifications to upsurge the main three criteria of efficiency, value, and sustainability of productions and to reduce lifespan overheads, and overcome interoperability among participants in construction projects (Noor, 2008). Consequently, it is inevitable to notice that those deficiencies have been caused by the late adoption of new technologies to the construction industry where it is still heavily depending on the labor force. Accordingly, many governments have recognized the critical factors that may affect the efficiency of the construction industry (Guillen et al., 2016). As a result, different directorial standards have been hosted that either validate or mandate the use of BIM as a scheme to address on lack of productivity. The compulsory mandating of BIM Level 02 by the United Kingdom (UK) Government can be identified as a recent uprising of BIM deployment to protect the significance of the construction industry (Kassem, Kelly, Dawood, Serginson, and Lockley, 2015). Because of mandating BIM Level 02, the UK government expected to minimize the 80% of construction waste due to accidental decisions which also declare the BIM’s prominent nature towards the image of the construction industry as a unique and global economic impact (Noor, 2008).

4.0 LITERATURE FINDINGS ON BIM PROJECT STAKEHOLDERS

It is a mutual verdict among BIM scholars that BIM has created a strict engagement-based atmosphere among the project participants. Takim et al. (2013), suggested that BIM enables more transparency in decision making, reducing the risk factor in decisions, improving data reliability and steadiness of information over the lifecycle of the project. As found in research studies conducted by Fernando, Bañuelos, and Haibo (2014), the majority of the research population has believed that BIM has overcome the challenge of interoperability throughout the project life cycle by 64%.

Accordingly, Sebastian (2011) enlightened that an efficient cooperative setting consisting of multidisciplinary experts can achieve the optimal status in BIM usage. Furthermore, Sebastian (2011) argued that this cooperative environment needs clear administrative definitions of important positions instead of modifications. Moreover, these settings will be effective through the rescheduled contractual relations and re-engineered integration process.

4.1 Characteristics of BIM Project Stakeholders

Recent studies disclosed the need for BIM practitioners to be involved in the successful execution of BIM (Allen Consulting Group, 2010). As stated by Olatunji (2011), with certain changes and training for usual project professionals, experts with the desired professional expertise can be attained. Therefore, stakeholder training should be consistent with the specific requirements of BIM software. Arayici et al. (2012) pointed out that BIM partners should have contemporary leadership abilities with a unique focus on assistance from outside parties. Scientific studies are therefore aimed at effectively redeveloping advisers within the BIM crew that promote the completion of the model's deliverables.

As Ashcraft (2008) proposed, the indivisible dedication and service towards stakeholders in the BIM project is quite crucial when creating a BIM model. The primary objective of such a collaborative climate should be the development of an extensive BIM model with decreased conflicts between project participants. Under BIM overlay by the Royal Institute of British Architects (RIBA, 2012), this point of perspective was again addressed as intended work profiles and services to be performed by the corresponding stakeholders within a BIM project. A study on the above-mentioned facts identified necessity protocols to identify the BIM project team profiles for efficient BIM execution. Nevertheless, the validity of these protocols depends strongly on the background of the project. Wallbank (2011) suggested the compatibility of protocols with BIM CAD standards as a parameter to authenticate the goals of BIM.

4.2 Roles and Responsibilities of BIM Project Stakeholders

The order of the BIM group and the intellectual property rights of its participants will mostly be resolved by the completion of the project. However, by the moment the model is created, the anticipated use of techniques and methods can be assessed. Consequently, the administration of BIM projects with such nature will be done by a panel of BIM experts consisted of BIM architects, BIM managers, model developers, and draftsmen (Olatunji, 2011). Even though particular professional titles in the BIM setting are still unfamiliar with the standard configuration, traditional experts with BIM expertise are still useful as replacements for BIM work profiles. However, many BIM deployment surveys identified the lower level of BIM acceptance by conventional experts such as engineers and developers compared to designers (McGraw-Hill Construction, 2010; NBS, 2012). Accordingly, Sher, Sheratt, Williams, and Gameson (2009), provided with an alternative to disregard the compact level of BIM acceptance among specialists by providing an evident set of skills for effective BIM processing by practitioners.

As identified by Aranda-Mena, Crawford, Chevez, and Froese (2009), 'project manager' is one of critical BIM project team members which is be distinct with the BIM and technological interference Moreover, studies of Kassem, Iqbal, Kelly, Lockley, and Dawood (2014), highlighted the role of 'BIM coordinator' as the main professional acts in behalf of the client with a professional liability and the job profile has been recognized by the BIM protocol as a central role in CDE.

CIC BIM protocol (2013) suggested that lead designer and BIM coordinator should work together to embrace the contractual obligations related to the BIM model work distribution. Moreover, the protocol recommended on 'BIM manager' on regulating the administrative and procedural rules related to BIM model management to preserve the collaborative nature and the duties attached to the BIM concept. BIM overlay to RIBA (2012), introduced several professional profiles associated with the BIM project team which are significantly different in compared to the traditional project team stakeholders. Accordingly, Table 2 shows on specific profiles in a BIM-enabled construction project team as identified by RIBA BIM overlay.

Table 2: Identified roles and duties of project stakeholders from literature

Job Title	Key duties within the BIM environment
Main Designer/ Architect	The lead designer ensures the co-ordination of various designs involved in a particular BIM environment and most importantly checking the reliability of the information of the model, how that information produced and whether those have amended to the model as produced. Rather than the traditional lead designer role, lead designer in BIM projects makes effective design decisions based on a collaborative working process. Since there is another role called IM engaged with design management, the distinguish points must be established between design management and design leadership.
Client Representative	A descriptive role from the client's party which acts on behalf of the client at every stage. He has the delegated power to make vital project decisions, appointing technical advisors and delivery managers.
Technical Advisors	Assistances regarding the technical aspects of the BIM model are given by the technical advisors to the client or the client's representative. Technical advisors may include the development of the intelligent brief and other in-use aspects, and tactical advisors regarding the project program. RIBA (Royal Institute of British Architects) client advisors execute this role and employed by the client's representative.
Delivery Manager	The delivery manager is accountable for ensuring the regulatory supply chain compatible with the project program. The client's representative forms this role within the BIM team.

(Source: Rathnasinghe et al., 2019)

5.0 EXPERT INTERVIEWS FINDINGS AND DISCUSSION

To investigate on CSC, it is essential to comprehend the stakeholders who would be involved in that CSC. Since their capacity as a part of the project is crucial for an efficacious BIM collaborative environment. Therefore, the respondents were questioned on any transformation of project stakeholders in the BIM environment compared to the traditional construction phenomena.

Sinclair (2012) also suggested that there is a set of BIM related roles which are contrasted to the conventional project members and the differentiation among conventional vs. BIM related roles should be clearly defined. Furthermore, as it was intended the respondents had identified seven main roles as the BIM project stakeholders for the CSC as namely; employer, lead designer, information manager, delivery manager, technical advisors, contractors, and sub-contractors /suppliers. During the interviews, all the respondents clearly stated that the traditional project stakeholders such as engineers, consultants, suppliers, and sub-contractors would apply to the BIM environment with the same capacity and responsibilities. However, they all established that there is an addition of responsibilities to traditional roles as with technological knowledge and some roles related to Information Technology (IT) had been introduced for the effective performance of BIM in technological aspects.

Additionally, Respondent A highlighted the fact on the BIM specific designations such as BIM Information Manager, BIM Coordinator, and BIM Consultant. According to Respondent A, those designations are not required to appoint separate professionals and the traditional dignitaries can hold those with the required level of BIM capability. However, Respondent B was more specific on the roles incorporated in real-life BIM implementation in the UK. Further to that respondent, rather than the IT personnel such as draftsmen, technicians, and BIM modelers, government authorities like **"Digital Built Britain"** is a must for government construction projects to achieve the expected UK standards.

Furthermore, Respondent C has brought upon the contribution of the representative from a BIM software company as an essential stakeholder since their service is required to preserve the common IT platform among every stakeholder of the CSC. Additionally, it was highlighted on the identification of survey companies in the initial stage as a stakeholder in most of Middle East BIM projects. According to Respondent C, this was mainly due to preserving the consistency of work platforms among the different parties involved in the BIM environment.

Accordingly, the following sub-sections discuss in brief on the roles and duties that the respondents have identified that they have experienced in the actual setup of BIM implementation. Further, the identified roles and duties were cross-referred with the literature sources to provide an evidence-based analysis.

5.1 Employer/ Employer's Representative

The majority of the BIM experts (4 out of 6) aroused the significance of the employer's liability towards the successful BIM initiating step as with a comprehensive EIR document. Similarly, respondent A stresses out the following information which gives a clear identification of the expectations of BIM professionals towards the contribution of an employer's in the BIM environment. As identified by Respondent A, depending on the nature of an employer's capability, the input of information to the CSC would differ. And it is not expected by the BIM experts that the employer to have a comprehensive knowledge of BIM but at least a broad view on what it requires in his side for a smooth BIM implementation. However, BSI (2013) on PAS 1192:2 has not conveyed about such an appointment and it requires the employer to prepare the EIR document within the given instructions.

5.2 Lead Designer

All the respondents have identified the substantial weight in the role of the lead designer within the spectrum of BIM CSC. However, several experts expressed their opinions on the lead designer's role in different perspectives influenced by the duties of a real lead designer which had been observed by them. Respondent A determined the lead designer's role as an integrator of various parties to a common platform where the lead designer is the main planner of virtual construction and the main regulator of necessary BIM standards towards all other stakeholders of the CSC while satisfying any breaches of the information flow.

In addition to that viewpoint, Respondent E determined the role of the lead designer as the only person who is authorized to federate various disjointed information models feed into the Common Data Environment (CDE) and validates the information in CDE by the any of the stakeholders. Further, Respondent E pointed out the nature of the lead designer's role as a facilitator to the other professional bodies who were not achieved sufficient BIM capability. In such an instance, the lead designer should determine the mitigating actions to minimize the course of negative effects for an effective BIM implementation.

Accordingly, the respondents' opinions on the authority to be borne by the lead designer as to whether it is project planning oriented or design management-oriented were similarly aroused in BIM overlay to RIBA (2012) where it suggests the clear distinction to be defined on the decision making authority towards the collaborative environment. Because the information manager is said to hold this authority as identified by the CIC BIM protocol (2013).

5.3 BIM Information Manager

As BIM is a modern evolution to the traditional orthodox of construction, professionals in the industry expect to be guided by the standards for effective implementation. BIM-related standards by various leading institutions perform this service where all the respondents agreed the effect of BIM standards for a successful BIM implementation is inevitable. Therefore, in the interview guideline, it was questioned on the awareness of the BIM Protocol and its content which was answered positively by all the respondents. Hence, BIM Protocol by the UK Construction Industry Council has mandated the appointment of an 'Information Manager' which was known by all the respondents.

However, all the respondents believed in the following information that whether it is essential to appoint a separate professional under this portfolio or an existing BIM professional can overlook the duties of an information manager. Accordingly, it has been denoted that in practical BIM implementation most of the time the BIM information manager would be considered under the designation of the lead designer or project manager where a separate person will not be appointed.

Furthermore, Respondent B identified the duties of an information manager to holds one of the critical issues in BIM implementation on deciding the copyrights of the stakeholders to the BIM model. As BIM is a collaborative effort, the end product of it would be a collection of knowledge, effort, time and pioneering of various professionals which has to be clearly defined on the boundaries of ownership among each of them. However, empirical data raised a reasonable question on whether it is highly necessitated to appoint a separate professional just only for the management of CDE. In contrast to this opinion, the CIC BIM protocol (2013) mandates the appointment of a professional called 'information manager' under the main four duties related to the management of CDE and implementation of BIM protocol guidelines.

5.4 Technical Advisors

It is a known fact that BIM is a concept that is heavily involved with IT where the professionals in respective industries and society may not have the ability to understand the core values for a successful implementation. Therefore, Respondents B, E, and F highlighted the roles related to technical assistance. Similarly, Sher et al. (2009) confirmed this phenomenon while highlighting the need for BIM technological capability holders to abstract the effective output of BIM and its informational models. Henceforward, Arayici et al. (2012) acknowledged the role of BIM draftsmen and modelers to the BIM project team as a facilitating body to the professionals in performing the BIM related activities. According to Respondent A, BIM modelers are considered to be the linking channel among the 2D documentation and the BIM models.

Therefore, BIM modeler has to generate, abstract and improve project 2D documentation related to BIM implementation from the BIM models. However, Respondent F specified on representatives from BIM software companies and survey companies as project stakeholder which is a fresh opinion compared with other respondents. Further to him, it is essential to appoint the agents from BIM software companies because during the project implementation all the users are needed to use the same software package which needs to be customized according to the project context. In such a requisite, it is essential to have a representative to seek advice on BIM software to improve project efficiency. Moreover, Respondent F highlighted the UK's practice to appoint survey companies as technical partners through amending the BIM protocol to improve the work consistency of project activities from the initial stage onwards.

5.5 Delivery Manager

All the respondents suggested that the integration of BIM and CSC of a project enables the easiness of procedures related to material logistics. Henceforth, it was questioned on the professional who is responsible if the material logistics is intervened with BIM. Respondent A and B determined that the BIM information manager who would also be called as the project manager is responsible in this field of service. In contrary to that view, Respondents E and D shared the importance of material logistics combined with BIM technology which would attract the construction professionals to implement BIM to achieve more productivity. Hence, they suggested that rather than replacing the delivery manager's role upon the information manager, it would be more efficient to appoint a BIM modeler on this task. It was further justified by them as the BIM modeler's task is combined with creating the geometry to BIM models and feeding information to the BIM models, it would be more explicable by asking them to perform that duty.

5.6 Contractors and Suppliers

All the respondents believed that the contractor and his parties; sub-contractors and suppliers play a vital role in CSC of a BIM project. It was further justified by them upon the collaborative nature of BIM which pressures all the project stakeholders to actively participate in the due course of the project whether they are appointed by the employer or not. To discuss the role of the main contractor in CSC of a BIM project, it is necessary to investigate how the 'most suitable' contractor would be selected among bidders in a BIM project. In answer to this issue, Respondent A specified that the contractor selection in a BIM project is the same as in the traditional procurement pathway where it evaluates the capabilities of the respective bidders and the BIM is a component of this evaluation which has to be measured. Furthermore, Respondent A suggested that this evaluation be done as a pre-qualification mechanism upon requesting the respective bidders to submit necessary BIM-related documents.

In addition to that view, Respondent B has commented on the selection of the sub-contractors and suppliers in a BIM environment. Accordingly, it was suggested that the main contractor should verify its parties on their BIM capabilities and whether they are ready for such commitment. Additionally, it was identified on how the recruitment of third parties would be done by the main contractor. The procedure of asking shreds of evidence was suggested to preserve the accuracy of the information supplied and as a guarantee of their BIM capability to the employer.

Furthermore, Respondent C specified the role of sub-contractors and suppliers in the process of BIM model development. It was conveyed that those parties may have the ability to participate in this development upon the main contractor's preference. However, it has to be decided on whether those parties have the actual capabilities on BIM. Hence, in any situation where no such capability is achieved, those parties can outsource this responsibility to another outer party upon the fondness of the project administration.

5.7 Government Authorities

It was highlighted on the aspect of the intervention of government authorities for the successful BIM implementation during the interview process. In the answers for the respective sections of the interview guideline on the BIM project stakeholders, only Respondent B has identified the intervention of government authorities to the BIM project context. NBS (2012) conveyed the exact ideology while expressing the UK government's future expectation towards the inauguration of BIM level 03 to the construction industry.

Further to Respondent B, the UK government has decided to intervene in BIM construction projects which are implemented under Public-Private Partnerships (PPP). It is because the UK government has mandated the BIM utilization in the construction industry from the last decade onwards where a proper government supervision mechanism on feedback was suggested. Accordingly, Respondent B revealed on such institution which is a collaboration among the UK government and the University of Cambridge, named "Centre for Digital Built Britain". This institution is formed to promote a smart digital economy for the UK construction industry while enhancing the construction professionals' interest with ways of improving productivity and efficiency in projects with the use of digital technologies.

Therefore, government institutions like "Digital Built Britain" can also be considered as the BIM project stakeholders which were an abandoned fact to the rest of BIM experts. However, other respondents also agreed with the Respondent B's view on proper government intervention mechanism to be prepared if the government has mandated the use of BIM technology in the construction process. Therefore, as in a whole picture, Arayici et al. (2012) recommended the

BIM project stakeholders to refine the organization's abilities on BIM through a detailed process involved with the philosophies of BIM scholars.

To illustrate the extracted information from an extensive discussion on the BIM project stakeholders and related literature, a cognitive map was developed as a method of presenting the roles and duties of project stakeholders in a much-structured way while highlighting the inter-relationships among them. Therefore, Figure 1 illustrates the structured arrangement on the discussion of findings related to BIM project stakeholders, and their roles and duties.

Furthermore, the developed cognitive map has mainly concentrated on clarifying the significance of identified BIM project stakeholders concerning their contribution and requirements towards the origination of information flows and outputs. Additionally, the cognitive map has illustrated the interconnections among the information flows and information outputs respectively. The main reason for having such a well-structured cognitive map was to enable the easiness of understanding and come up with conclusions for the enthusiastic audience of construction professionals who are interested in BIM implementation

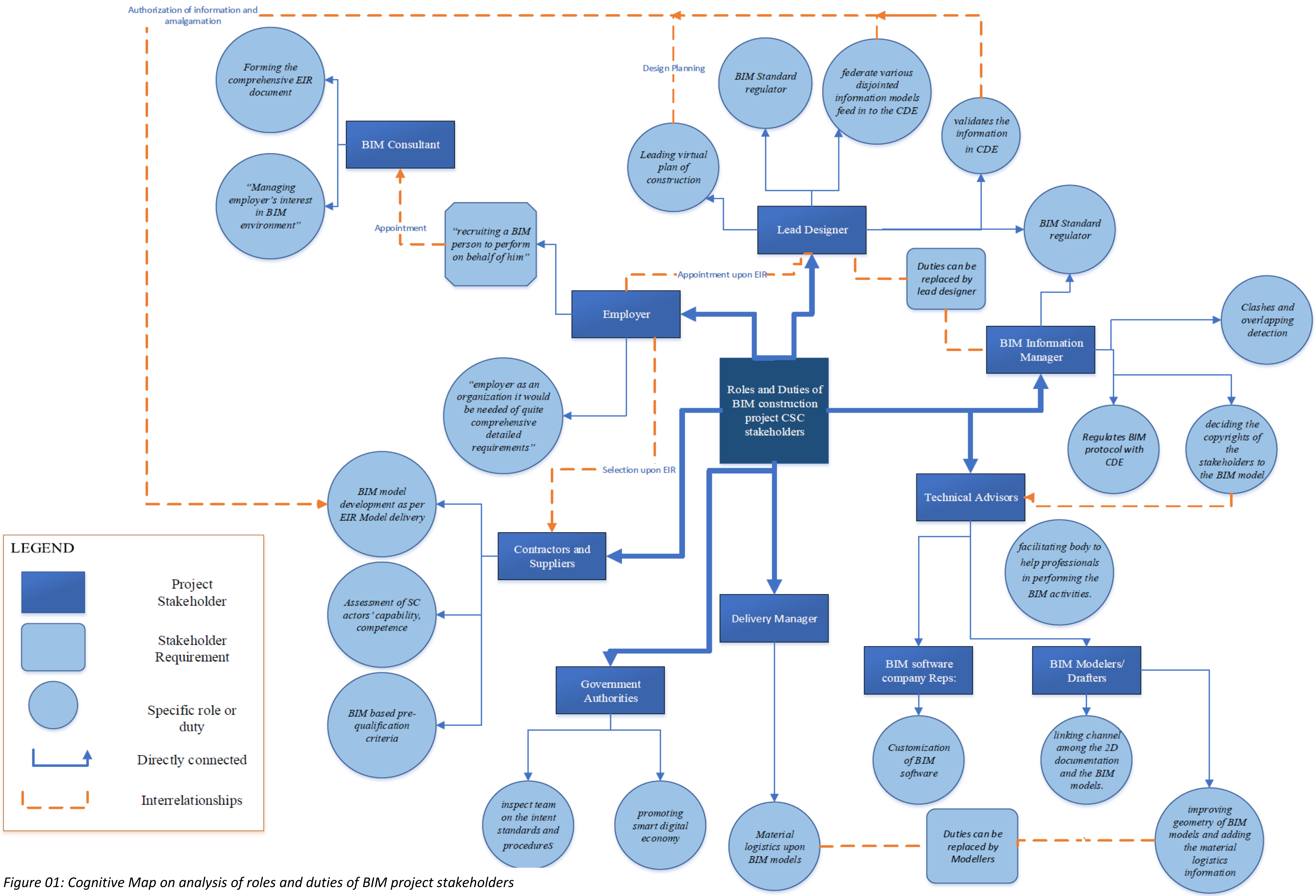

Figure 01: Cognitive Map on analysis of roles and duties of BIM project stakeholders

6.0 CONCLUSIONS

This paper aims to ascertain the deviations in traditional project stakeholders of a BIM project and to acknowledge the identified roles concerning their roles and duties performed during the BIM implementation. In line with this, six number of respondents with BIM actual implementation was questioned on the nature of stakeholders that they have been experienced in a BIM project and whether there were any transformations of traditional characters in such a project. As the final output of this paper, a cognitive map was produced as shown in Figure 01, to illustrate the roles and duties of BIM project stakeholders as a combination of both the literature findings and empirical data. The literature review discovered the standard roles and duties of BIM project stakeholders and the composition of the BIM project team as identified by the regulatory institutions. Accordingly, BIM-related literature exposed to BIM specific job profiles such as; lead architect, client's representative, delivery manager, and technical advisors. Henceforth, the key characteristics of project team members given by the various authors were identified while ascertaining the overlapping of administrative authorities. Accordingly, outcomes of the expert interviews revealed the practical context of BIM project stakeholders where the replacements were identified upon the scarcity of resources and BIM knowledge base. Further, primary data discovered the intervention of professionals that have not been mentioned in standards like ‘BIM consultant' as to assist the employer in BIM implementation. Additionally, empirical data revealed the participation of government authorities in countries like the UK where the regulations follow up and promoting the digital technologies to increase the productivity was aimed at. Further, findings of the empirical data highlighted that the conventional roles related to construction would be the same in this context. Moreover, there would be certain additions of duties and responsibilities related to information generation and management. Accordingly, respondents believed that the skilled project members are essential for implementation as the BIM is a high technical related phenomenon where the proper learning of it is needed.

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A LEVEL 2 BIM MATURITY-KPI RELATIONSHIP ASSESSMENT

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Abstract: Building Information Modelling (BIM) maturity was addressed as a measurement process on capabilities and performance in relation to BIM implementation. Key Performance Indicators (KPIs) presents a set of targets that aims to deliver overall improvements within construction industries. This study proposes an assessment that aims to bring concepts of BIM maturity and KPI assessments together, whereby BIM maturity provides a measure of the organisational/project BIM capability level (i.e. 'input') and KPIs measures impact of the BIM capabilities on organisation/project performance (i.e. 'output') to the UK client sector. A mixed method approach was attempted with an in-depth single case study (a UK Main Contractor-Procurement Platform) through focus group workshops to propose a BIM maturity assessment to the Client sector. The study established a set of BIM maturity metrics aligned with the UK Level 2 BIM requirements. Therefore, based on the data collection, the metrics were assessed at 3 organisational levels targeted to industry stakeholders involved in the Level 2 BIM adoption. Having developed the BIM maturity assessment and determined the linkage between BIM maturity and KPIs, this study aims to then examine strength of relationships between the proposed BIM maturity and KPIs to assess Level 2 BIM adoption in line with the UK construction strategy.

Keywords: BIM, KPI, maturity assessment, project performance, UK client sector

1. INTRODUCTION

Building Information Modelling (BIM) has been approached in various ways from academic publications, and governmental bodies. They all agreed that technological applications are essential drivers being operated within BIM. However, the UK industry has defined BIM as a modelling process to be facilitated for a building life-cycle through human interactions. The UK government imposed a mandate to their governmental projects across the UK to implement Level 2 BIM by 2016. Level 2 BIM has been defined by: "A series of domain and collaborative federated models." (BIM Level 2. 2016). The mandate was implied because recent published construction strategy report by the UK Government aims to cut off public sector assets cost to 20% by 2016 (HM government, 2013).

BIM maturity was introduced as a measurement process with a set of progressions on capabilities and performance in relation to BIM implementation based on levels of accomplishment. It is defined by: "the extent to which a specific process is explicitly defined, managed, measured, controlled, and effective" (Paulk, Curtis, Chrissis, and Weber, 1994). After identifying the main purpose of BIM and its application across the UK, BIM maturity models have emerged from various studies by different authors across the globe. There are a set of BIM maturity assessments that were conducted. The main purpose of BIM maturity is to measure effectiveness of BIM capabilities and adoptions across the construction industry, which may reflect on the UK governmental mandate and examine success of BIM projects across the UK (Aboumoemen, 2016). Figure (1) demonstrates a sample of the UK Level 2 BIM Guides and Processes used for their Level 2 approach (NBS, 2015).

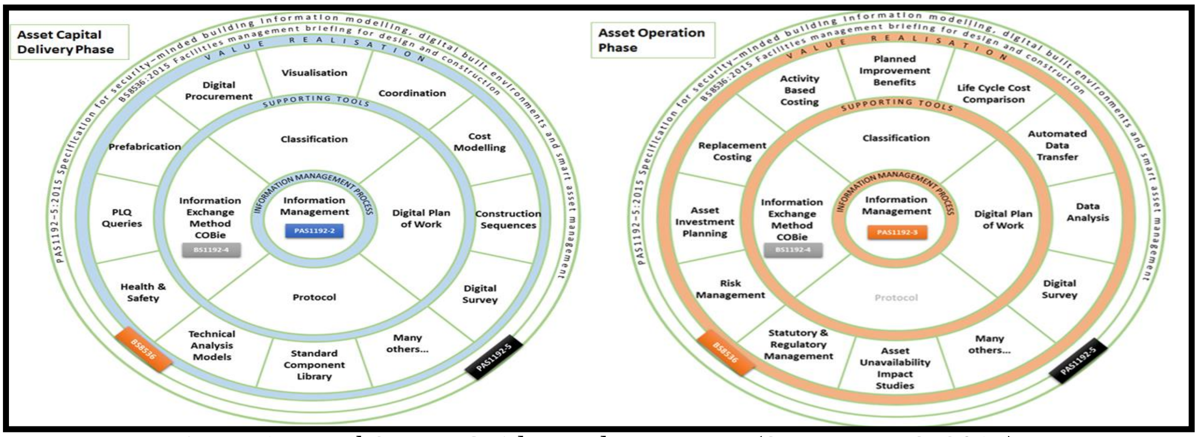

Figure 1: Level 2 BIM Guides and Processes (Source: NBS, 2015)

BIM Maturity assessments has delivered various benefits and its importance has been examined across the UK, and therefore the Key Performance Indicators (KPIs) shall be presented in a similar direction to outline its benefits. Target improvements were proposed which resulted in emergence of KPIs that aimed to deliver overall improvements within the UK construction industry (Wolstenholme, 2009). Project performance measures were specified on Cost, Time, and Quality, but other measures were introduced, such as safety and performance that differed from one study to another. They shall help recognise impacts that could occur on overall performance of projects and organisations through the usage of KPIs. An approach has existed in combining both parameters BIM and KPIs through outlining how they can operate together within construction organisations. A few sets of publications have been published that addresses possible links of BIM implementation on primarily used KPIs across construction projects through assessing project performance.

2. WHAT ARE MATURITY ASSESSMENTS?

The definition of maturity is the state of being fully developed, or the development having reached its optimum. It could be viewed that all models were driven from the Quality management maturity grid developed by Crosby (1979) that delivers a 5-maturity grid related to quality management and requirements that will be achieved in each maturity level. Examples to existing models are: NASCIO Enterprise Architecture maturity model (NASCIO. 2003) and Project management (PM2) model (Kwak and Ibbs, 2002). According to the Jugdev and Thomas (2002) maturity models identify project or organizational strengths and weaknesses and benchmarking information. Andersen and Jessen (2003) define maturity as the quality or state of being mature. They point out that concept of maturity to an organization it might refer to a state where the organization is in a perfect condition to achieve its objectives. The maturity models also have some limitations from a theoretical perspective. They are based on software maturity models that lack a theoretical basis (Jugdev and Thomas, 2002). The Capability Maturity Model Integration (CMMI) should be the adapted model that maturity models shall follow since most of the maturity models in relation to BIM in the literature has adopted the CMMI approach within their models (Chrissis et al., 2003; Paulk et al., 1994). BIM has been defined as a software process in some areas where BIM was used as software so the CMMI was used to assess maturity. The model has been used by organisations as a maturity model basis. The presented BIM maturity should follow the CMMI since it is more relevant and related to background of BIM than rest of the types and should follow developments of maturity that were presented previously. The capability maturity model that BIM maturity models should follow is presented in Figure (2).

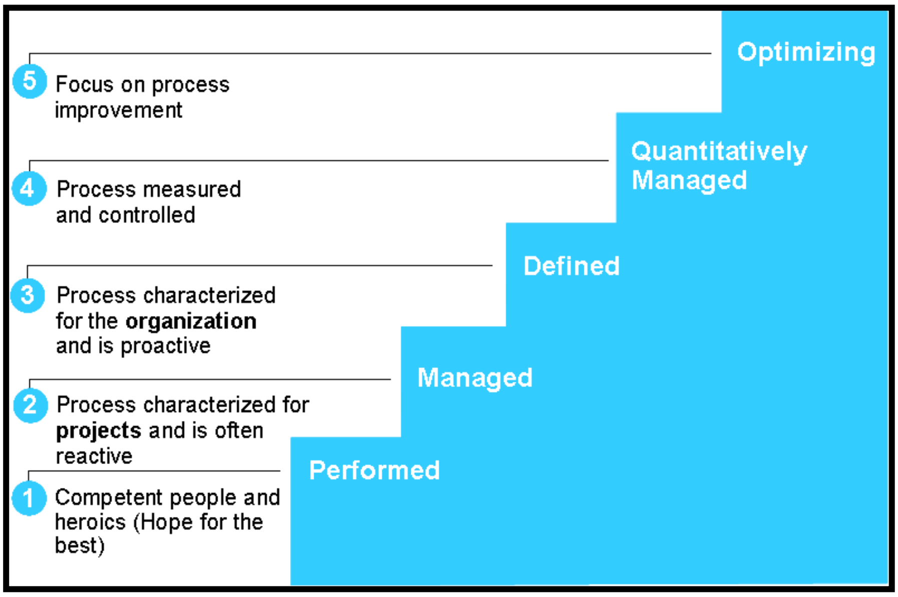

Figure 2: Capability Maturity Model Integration (CMMI) (Chrissis et al., 2003)

3. BIM MATURITY ASSESSMENTS

BIM maturity presents a measurement process introduced as a set of progressions on capabilities and performance related to BIM implementation based on accomplishment levels (Paulk et al., 2004). The assessments rely on a 5-level maturity to assess BIM capabilities and measure their adoption and effectiveness across the industry (Aboumoemen, 2016). A set of assessments were developed by industry practitioners and academics to evaluate BIM within the Architecture, Engineering, and Construction (AEC) industry (Giel & Issa, 2014).

4. KEY PERFORMANCE INDICATORS (KPIS)

KPIs are a measure of a process critical to the success of an organisation. According to the Constructing Excellence report in 2004, there are several performance measures that define the success of a project or organisation (Swan and Kyng, 2004). Lim argues that KPIs depend on a criterion for project success which was split into macros and micros. Project success should be viewed from the different perspectives of the individual owner, developer, contractor, user, the general public, and so on (Lim and Mohamed, 1999). KPIs are compilations of data measures used to assess performance of a construction operation. They are methods management uses to evaluate employee performance of a particular task. In order to review industries overall organisational performance and projects measurements, then KPIs include 8 main factors, which are known as follows: Time, Cost, Quality, Client satisfaction; Client changes, Business performance, Health and Safety, and Environmental. The UK construction industry in its latest report has outlined the KPIs used in their study, known as Economic Indicators, Client Satisfaction, Contractor Satisfaction, Profitability, Predictability, Respect for People, Environmental Indicators, Housing, Non-Housing, Consultants (UK industry performance report. 2017). Finally, to achieve current and future organisational projects significant performance improvements enabled measurements, then the KPIs could be summarised by a performance measurement process that includes the 9 following KPIs: Cost, Time, Quality, Satisfaction, Health and Safety, Performance, Profitability, Productivity and Sustainability (Aboumoemen and Underwood, 2017).

5. ESTABLISHING A RELATIONSHIP BETWEEN BIM AND KPIS

According to Aboumoemen and Underwood (2017), a few publications have been published that addresses the possible links of BIM implementation on used KPIs across construction projects. There have been previous attempts to link BIM and KPIs together. The main purpose of BIM maturity is to measure effectiveness of BIM capabilities and adoptions across construction industries, to reflect on the UK governmental mandate and examine the success of BIM projects across the UK. There are a number of performance measures (KPIs) that define the success of a project or organisation (Swan and Kyng, 2004), which were based on the development of the Latham (1994), Egan (1998), and Wolstenholme (2009) reports.

5.1 Existing BIM and KPIs Evaluations

A limited number of publications were available that presented relationships between BIM maturity and KPIs across projects (Smits et al., 2016). Having conducted an analysis on the existing combined BIM/KPI assessments across the globe, it was noted that currently there have been attempts to link BIM and KPIs together across 24 BIM / KPI assessments in total in the literature, where it can be concluded that 6 categories form the essentials of the BIM/KPI combination in previous studies. These are: 1) BIM implementation within Organisations (5); to outline the impacts of BIM with construction industries / firms / organisations (Ashworth and Tucker, 2018; Barlish & Sullivan, 2012; Poirier, Staub-French, & Forgues, 2015; Shin, Choi, & Kim, 2015; Sun & Zhou, 2010), 2) BIM impact on construction projects (KPIs) (5); to demonstrate the effect of BIM on KPIs and construction projects performance (Eadie, et al., 2013; Gyarteng, 2014; Hassan, 2012; Smits et al., 2016; Suermann, & Issa, 2007), 3) KPIs impact on BIM implementation (4); where the impacts of KPIs on the implementation of BIM existed and varied from one study to another (Coates et al., 2010; Manzione, et al., 2011; Ozorhon and Karahan, 2016; Sarkar, Raghavendra, & Ruparelia, 2015), 4) Assessment Framework (4); since an assessment framework have existed to combine BIM and KPIs together (Aboumoemen, 2016; Badrinath, ASCE, & Hsieh, 2019; Mom & Hsieh, 2012; Wong, Salleh, & Rahim, 2016), 5) Assessment method (4); Balanced scorecard being presented and used to be compared together (Khanzadi, Sheikhkhoshkar, & Banihashemi, 2019; Park et al., 2013; Shin and Choi, 2016; Won & Lee, 2016), and 6) Assessment tool; since an assessment tool was presented to demonstrate the relationships of BIM and KPIs together. (MoJ. 2016; Sebastian & Berlo, 2010). A sample of studies on existing BIM/KPIs is available in Figure (3).

Existing BIM / KPIs in literature

Legend (number of studies)		Country (number of studies that existed in the same country)	
1	BIM implementation within Organisations (5)	1	UK (6)
2	BIM impact on construction projects- KPIs (5)	2	Korea (4)
3	KPIs impact on BIM implementation (4)	3	Netherlands (2)
4	Assessment framework (4)	4	US (2)
5	Assessment method (4)	5	Taiwan (2)
6	Assessment tool (2)	6	Other countries (8) [China, Gulf countries, Canada, India, Brazil, Iran, Malaysia, Turkey]

Previous literature on combined BIM / KPI parameters

No. #	Publication	Country and Year
1	**US- BIM effects on construction KPIs. Doctoral thesis in University of Florida**. (Issa & Suermann, 2009; Suermann, 2009; Suermann & Issa, 2007).	Florida, US 2007-2009
2	**China- KPIs: Analysing the impact of BIM in construction industry in china.** (Sun & Zhou, 2010)	Beijing, China 2010
3	**The key performance indicators of the BIM implementation process.** (Coates et al. 2010)	UK 2010
4	**Doctoral thesis in Arizona University and How To Measure the Benefits of BIM: A Case Study Approach (US).** (Barlish, 2011; Barlish & Sullivan, 2012).	Arizona, US (2011 and 2012)

Previous literature on combined BIM / KPI parameters (driven from the BIM maturity table)

No. #	Publication	Country and Year
16	**BIM Tno Quickscan tool.** (Berlo, Dijkmans, Hendriks, Spekkink, & Pel, 2012; Sebastian & Berlo, 2010)	Netherlands 2010-2012
17	**Key Performance Indicators To Analyze And Improve Management Of Information Flow In The BIM Design Process** (Manzione, Wyse, Sacks, Van Berlo, & Melhado, 2011).	Brazil 2011

Figure 3: Sample of existing BIM / KPIs in literature (Aboumoemen and Underwood, 2017)

The purpose of classifications being set for the delivered combined BIM/KPIs in the studies are mainly due to their existence in the studies where some supported the overall delivery of the combined BIM/KPIs, however some of the presented classifications may not be suitable for the combined BIM/KPI assessment for this report. According to Aboumoemen and Underwood (2017), a set of variations existed; starting from 1) Variation of BIM implementation across organisations, causing an absence of standardised BIM elements across organisations, 2) Variation of KPIs set of numbers and implementation across projects, resulting in absence of standardised set of KPIs across projects, 3) BIM being approached in various ways, resulting in absence of standardised BIM, and 4) Different set of BIM and KPIs elements were used, resulting in a delivery of a framework that suits specific studies and not general. The literature on BIM/KPI has presented: 1) KPIs as main use in organisations and how will BIM be implemented within organisations, 2) KPIs as main use in projects and how will BIM be implemented within the projects, 3) BIM as a main driver and how KPIs tend to reflect on the BIM implementation within the industry, and 4) A framework that reflects on the combination of BIM and KPIs together. Summary of the overall strengths and weaknesses, and a highlighted set of selected categories are available in Figure (4).

Combined BIM-KPIs in Literature approaches purpose of usage, their strengths and weaknesses

ID	Nature of the category (number)	Summary of strengths	Summary of weaknesses
1	**BIM implementation within Organisations (5)**	KPIs as main use in organisations and how will BIM be implemented within organisations	Variation of BIM implementation across organisations, causing an absence of standardised BIM elements across organisations
2	**BIM impact on construction projects- KPIs (5)**	KPIs as main use in projects and how will BIM be implemented within the projects	Variation of KPIs set of numbers and implementation across projects, resulting in absence of standardised set of KPIs across projects
3	**KPIs impact on BIM implementation (4)**	BIM as a main driver and how KPIs tend to reflect on the BIM implementation within the industry	BIM being approached in various ways, resulting in absence of standardised BIM.
4	**Assessment framework (4)**	A framework that reflects on the combination of BIM and KPIs together	Different set of BIM and KPIs elements were used, resulting in a delivery of a framework that suits specific studies and not general
5	**Assessment method (4)**	Methods such as (balanced Scorecard) that assists the integration of BIM and KPIs together	Different methods also existed, which results in diversity of methods being operated in some organisations
6	**Assessment tool (2)**	A tool that combined BIM and KPIs together through delivered a set of KPI questions to reflect on the BIM elements	KPIs treated as a set of questions to meet BIM requirements of study, resulting in a different approach to KPIs for a single study

Figure 4: BIM-KPIs assessments strengths and weaknesses

Based on the literature review findings, all the publications outcomes on BIM maturity, KPIs, and combined BIM/KPIs shall help formulate the required assessment. A Level 2 BIM Maturity-KPI assessment framework for the UK client sector was developed to assess Level 2 BIM adoption in line with the UK construction strategy, available in Appendix (A) (Aboumoemen and Underwood, 2017). The framework addressed strengths that existed in some of the presented studies; (Aboumoemen, 2016; Smits et al., 2016) that were beneficial for the suggested framework, and aimed to overcome some of the weaknesses that existed in other studies; such as absence of a strong relationship between BIM and KPIs, and the overall strengths and weaknesses have been summarised. The initial list of BIM and KPIs in the framework was driven from previous studies, and some have been presented. The suggested BIM and KPIs relationships (weak, medium, strong) in the framework assisted in recognising the necessary relationships between BIM and KPIs qualitatively. The maturity assessment in the framework was attempted through simplifying the levels into 3 instead of 5 for users to utilise the assessment (i.e. by assigning 1-Awareness for level 1, 2-Occasional for level 3, and 3- Consistency for level 5, and therefore eliminating levels 2 and 4 to deliver necessary distinction between each level since 5 levels have delivered a similar relationship between levels (i.e. levels 2 and 4 being close to levels 1, 3, and 5). The anticipated benefits proposed in the framework demonstrated benefits expected to emerge from assessments done in the framework, and their possible impacts on the BIM-KPI relationships [No relationship, Non-significant (weak), Moderate (Medium), and Significant (Strong)] used to assess strengths of relationships between BIM and KPIs through correlations and regressions quantitative measures. As a result, the relationship assessment will be presented in the next section.

6. RESEARCH METHODOLOGY

The literature review aimed to identify various sources including journal articles, books, reports, and websites that investigated the usage of both BIM maturity assessments, and KPIs combined together in the construction industry, For this research, an extensive literature review was conducted that included the keywords of BIM maturity assessments, KPIs, and BIM KPIs using search engines of Google Scholar, Scopus, etc.... Literature that contained information regarding the stated keywords were included and classified into categories to meet the research needs. As a result, 24 previous attempts of linking BIM and KPIs together were identified (Aboumoemen and Underwood, 2017). For this paper, a summary of the strengths and weaknesses for the presented categories on BIM-KPIs were presented, and then a relationship assessment for Level 2 BIM maturity-KPIs that combines all the existing literature together was proposed. This research aims to explore requirements for Level 2 BIM maturity as well as KPIs on project performance. As a result, the Pragmatism philosophical stance was adopted, since the research starts with a problem; in relation to there being absence of combining BIM and KPIs together that is open to new knowledge based on findings and aims to solve these problems and improve future practice. The Abduction approach was adopted, since the research shall build upon existing literature on BIM maturity and KPIs, before then will develop a theory through a conceptual combined Level 2 BIM Maturity-KPI relationship assessment. The assessment will then be refined and examined across the UK construction industry. For the data collection procedures conducted, then the research followed a mixed method approach, which was attempted with an in-depth single case study by a UK Main contractor - Procurement Platform through a set of focus group workshops to propose a BIM maturity assessment to the Client sector. The study focused on establishing a comprehensive set of BIM maturity metrics that are aligned to the UK Level 2 BIM requirements. Therefore, based on the data collected through the workshops, the metrics were assessed at 3 organisational levels targeted to specific industry stakeholders involved in the Level 2 BIM adoption. The data collected from the workshops provides meaningful and related categories to what is the process required for development of the updated assessment. Development of the assessment in the workshops depends on the categorical issues related to Level 2 BIM maturity and KPIs that was presented and is supported by the proposed framework requirements.

6.1 Overview of the Single Case Study Selection

The selected case study is a main contractor-chain procurement platform for a UK public sector local authority client. There specialisation is to serve public sector clients across the north west, providing them with higher quality facilities that will include added values, which will be measured through their KPIs, discussed previously. For this research, the researcher will conduct focus group workshops within the platform based on the relationship assessment requirements. This research has been conducted with a digital construction working group that consisted of a homogenous group of 5 members including the researcher, all sharing a common background amongst themselves. A set of workshops were conducted with them to define requirements based on the Level 2 BIM maturity-KPI assessment framework (Aboumoemen and Underwood, 2017), and accordingly the researcher has developed the relationship assessment based on the framework. Outcomes related to Level 2 BIM maturity was outlined according to the group requirements along with the literature presented on BIM maturity, whereas outcomes related to the KPIs was provided from the researcher based on the literature and by the platform along with the literature presented on BIM maturity.

7. ORGANISATIONAL LEVEL DEVELOPMENT PROCESS

3 Organisational levels were assigned for the assessment of the Level 2 BIM maturity, which were known as: (1. Strategic- Organisational and project levels that are being managed by the organisation team. (2. Implementation- Implementing BIM across organisation, placing and setting up information in place. (3. Operational- Operating BIM across organisation, and how is collected information being achieved. Due to the existence of several BIM level 2 criteria, then a selection criterion was suggested to select the ones that could be measured and could achieve BIM level 2. Suggested users expected to be involved in the assessment of this framework are as follows: For the strategic level- Senior managers; the implementation level- Implementation and Information managers, and the operational level- Project managers.

The spreadsheet will operate based on the following procedures:

It is required that the user will stand on the cells as shown in step 1, where the description for each sub metric in terms of its maturity level will appear as hidden comments. 2) After the user was to decide on which current level they are at, the user is to click on a drop-down list cell, as shown in step 2, which will bring up the maturity levels 1-3. 3) Based on the colour coding given in "The how" stage for each maturity level, the selected number should automatically convert to that colour (i.e Awareness=Orange) as shown in step 3. 4) Since the comment is hidden, it will be required from the user to then right click on the coloured cell and select (show comment) as shown in step 4. 5) After the previous step is attempted, the description of each cell should then appear as shown in step 5. 6) Finally, all the previous steps are to then be repeated in the same sequence, and upon completion of the strategic level, the calculation of the Maturity level in total will appear as shown in step 6. The formula which the user has decided to choose was: 1) Average of all the numbers, and 2) The total will be a) 1-1.6= Awareness, 1.6-2.4= Occasional Application, and 2.4-3= Consistency. A summary of this is shown in Figure (5) below. An extract of the Strategic organisational Level is available in Figure (6).

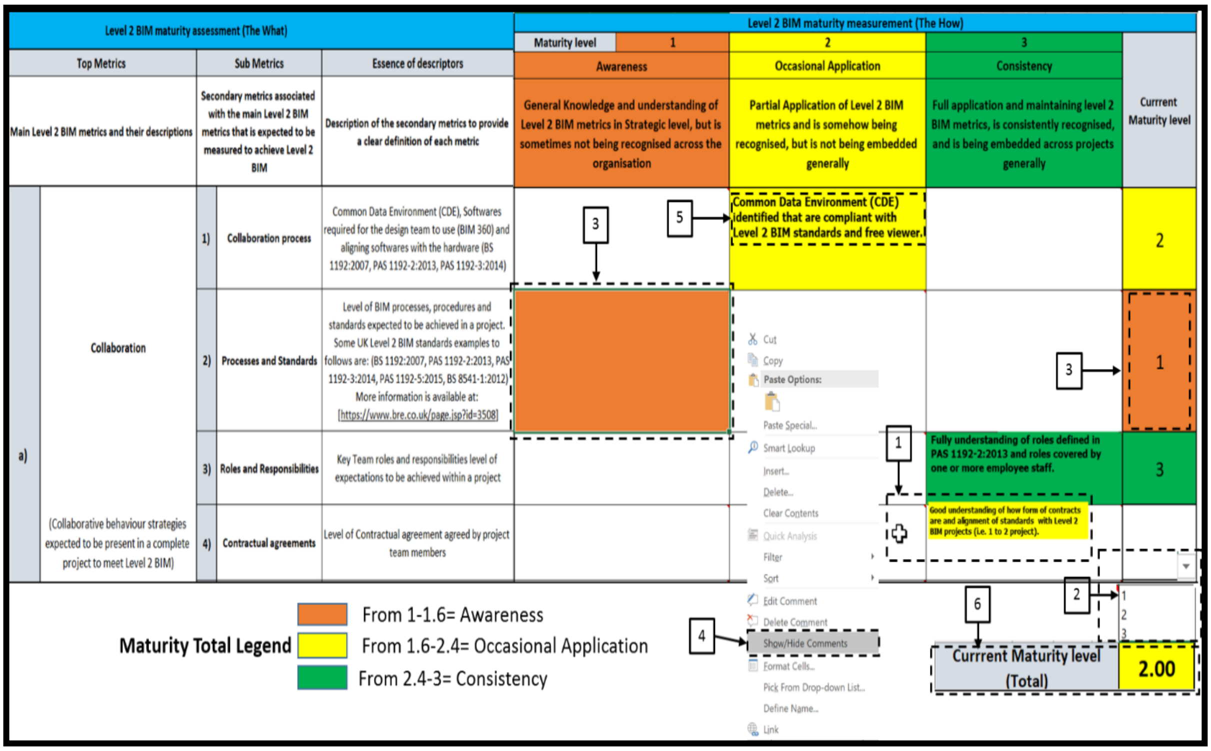

Figure 5: Sample of an organisational level development process

8. RESEARCH FINDINGS

Figure (6) presents an extract of the assessment within an organisational level.

Level 2 BIM maturity assessment (The What)					Level 2 BIM maturity measurement (The How)			
					Maturity level 1	2	3	
Top Metrics		Sub Metrics		Essence of descriptors	Awareness	Occasional Application	Consistency	
Main BIM maturity levels and their descriptions that are expected to be measured for achieving Level 2 BIM		Secondary levels within the main BIM maturity levels that is expected to be measured and to achieve Level 2 BIM		Full description of the Secondary levels within the main BIM maturity levels of to provide a clear definition of each level, which will then be expected to be measured and to achieve Level 2 BIM	General knowledge and understanding of Level 2 BIM strategic level across organisation	Partial Application of Level 2 BIM strategic level and is somehow recognised, but not embedded generally	Full application and maintaining level 2 BIM strategic level, embedded across projects generally, consistently recognised	Currrent Maturity level
a)	Collaboration	1)	Collaboration process	Common Data Environment (CDE), Softwares required for the design team to use (BIM 360) and aligning softwares with the hardware (BS 1192:2007, PAS 1192-2:2013, PAS 1192-3:2014)	No awareness of systems to be used	Common Data Environment (CDE) identified that are compliant with Level 2 BIM standards and free viewer	Systems that are able to integrate the BIM models (CDE) that are compliant with Level 2 BIM standards into operations.	1
		2)	Processes and Standards	Level of BIM processes, procedures and standards expected to be achieved in a project. Some UK Level 2 BIM standards examples to follows are: (BS 1192:2007, PAS 1192-2:2013, PAS 1192-3:2014, PAS 1192-5:2015, BS 8541-1:2012) More information is available at: [https://www.bre.co.uk/page.jsp?id=3508]	Aware and understand what the UK BIM Level 2 standards are, but not embedded. Minimal understanding of the CAPEX and OPEX	Understanding and partially implementing the UK BIM Level 2 standards. Partial understanding of the CAPEX and OPEX	Understanding and fully implementing the UK BIM Level 2 standards. Fully understanding and application of the CAPEX and OPEX	
		3)	Roles and Responsibilities	Key Team roles and responsibilities level of expectations to be achieved within a project	Minimal understanding of roles defined in PAS 1192-2:2013 and no internal resources	Partial understanding of roles defined in PAS 1192-2:2013 and have limited internal resources	Distribution of roles and responsibilities amongst team members that have been embedded across projects which are applied frequently in organisations.	
	(Collaborative behaviour strategies expected to be present in a complete project to meet Level 2 BIM)	4)	Contractual agreements	Level of Contractual agreement agreed by project team members	Minimal Understanding of how form of contracts are some awareness of alignment and no previous experience with Level 2 BIM.	Good understanding of how form of contracts are and alignment of standards with Level 2 BIM projects (i.e. 1 to 2 project).	Full understanding of how form of contracts are and alignment of standardised clauses to contract document (i.e 5+ projects).	

Figure 6: "The What and the How" = Level 2 BIM parameters and assessment sample

Due to existence of several level 2 BIM criteria, then a selection criterion was suggested to select the ones that could be measured and could achieve Level 2 BIM. Therefore, it is expected to collect a diverse list of BIM elements that will be more focused on the Level 2 BIM outcomes, and as a result, it is proposed to split them into 3 metrics that will fit into each organisational level; 1) Top Metrics, 2) Sub Metrics and 3) Essence of descriptors, which will then be expected to be measured and to achieve Level 2 BIM. The maturity level assessment was split into 3 levels: 1) Awareness 2) Occasional Application, and 3) Consistency. Some BIM maturity assessments delivered a 5 level maturity assessment based on the Software engineering institute (SEI. 1993). But according to Aboumoemen (2016), it was suggested to reduce the maturity level assessment from 5 to 3 levels, to provide the necessary distinction between the levels since similarities could be seen existing in some levels. Figure (7) presents the proposed BIM-KPI relationships used to assess strengths of relationships between BIM and KPIs.

The Evidence = Relationship of BIM and KPIs											Legend
Strategic Level		(The Strategic goals and gearing up of the delivery of BIM at the organisation / project Level, and Organisational and project levels that are being managed by the organisation team.)									No Relationship (None) 0
Sub Metrics	Maturity level and descriptor	Relationship with KPIs									Not Significant (Weak) 1
Secondary metrics associated with the main Level 2 BIM metrics that is expected to be measured to achieve Level 2 BIM	Awareness										Moderate (Medium) 2
	Occasional Application										Significant (Strong) 3
	Consistency	Cost	Time	Quality	Satisfaction	Health and Safety	Performance	Profitability	Productivity	Sustainability	Current KPI relationship total
Collaboration process	No awareness of systems to be used	1									1.00
Processes and Standards											
Roles and Responsibilities											
Contractual agreements											

Figure 7: "The Evidence" = Level 2 BIM and KPI relationship assessment sample

It has been agreed in the workshop discussions to have a 4-level relationship for the KPIs strength of relationship since this allows to determine the KPIs possible relationships with the Level 2 BIM sub metrics. It is expected that the users would fill out the Level 2 BIM maturity and KPI relationship assessment by first selecting the maturity level that they believe they fit in, followed by determining the KPIs strength of relationship with the Level 2 BIM sub metric selected maturity level, in order to see what would be the expected relationship between Level 2 BIM and KPIs. According to Aboumoemen (2016), the benefits that could emerge from linking both BIM maturity and KPIs are as follows: 1) Improved Collaboration, Communication and relationships, 2) Improved certainty and reduction of uncertainty, 3) Out turn cost certainty and reduced risk provision, 4) Programme Certainty, 5) Performance certainty, 6) Improved change implementation and management, 7) Improved safety, 8) Improved user satisfaction, 9) Reduced lifecycle cost.

9. CONCLUSION

From the previous presented chapters, it can be concluded that the BIM maturity assessments, KPIs, and combined BIM-KPIs available in literature could be used in the UK. BIM was presented in several ways but has led to slow uptake and low awareness to UK disciplines, and thus BIM maturity is developed to assess capabilities and measure their adoption. This shall help extract benefits that could be realised from usage of BIM maturity across organisations; however, those benefits could be meaningless. As a result, KPIs are presented through project and organisational types along with different accomplishment levels, where KPIs could be used to link them with BIM maturity; in order to demonstrate benefits that could be extracted from usage of BIM maturity amongst UK disciplines. An approach has existed to combine BIM and KPIs together and how both shall deliver direct impacts to the industry. Although the potential strength that could exist through linking both parameters, however, a limited set of publications has addressed such possible links. Since these publications have failed to deliver an approach on both parameters working together, it has been encountered as an existing knowledge gap and weakness resulting in a total absence of such link, and therefore how both parameters could work together shall be acknowledged. The workshops consisted of a group of 5 participants including the researcher, to collect main ideas on what is expected for the BIM maturity-KPI relationship assessment development required in their platform that aims to improve their current performance.

As part of the future work, it is expected to conduct semi-structured interviews, where a set of questions will be asked to collect the expected information on the possible linkages between the Level 2 BIM maturity and KPIs. The results obtained from the interviews shall deliver a benchmark on the possible relationships between the Level 2 BIM maturity and KPIs that will be used for the questionnaires. It is expected to conduct an online survey questionnaire to examine and visualise the strength of relationships between the Level 2 BIM maturity and KPIs through distributing a 5 Likert scale questionnaire on Level 2 BIM and KPIs based on the findings of the focus group workshops and the semi-structured interviews. The results obtained shall deliver a relationship between both variables that will assess how the relationships are through the correlation analysis, and this could be used to test and see what benefits are expected to emerge and examine it with the results of the correlation and the regression analysis. The relationship assessment is available to all potential users to use, since it is expected to test and validate the framework amongst the UK construction industry.

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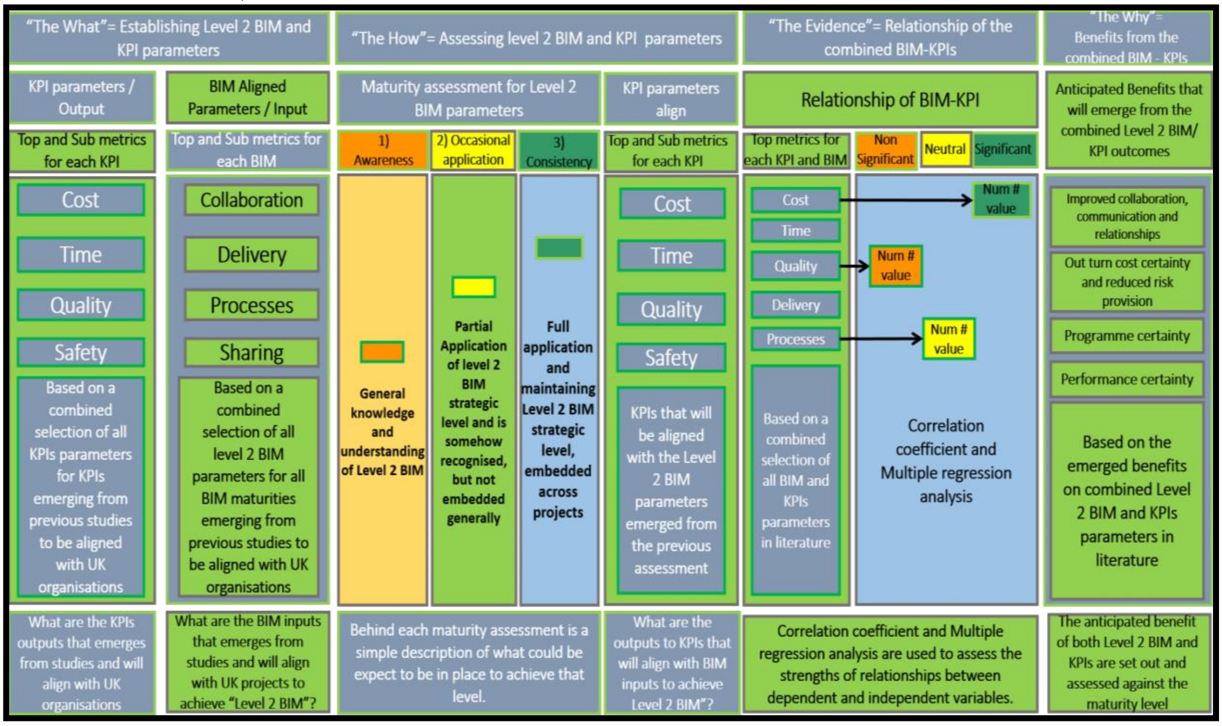
11. APPENDIX A

Level 2 BIM Maturity-KPI assessment suggested framework (Aboumoemen and Underwood, 2017)



IMPROVING THE CONSTRUCTION INDUSTRY IN THE STATE OF KUWAIT

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Abstract: After the Government of Kuwait launched the 2035 vision of Kuwait, the development of a sustainable built environment industry become one of the country's priority topics. Yet, the construction industry is confronting numerous challenges including time and cost overruns, waste, and low industry performance. Globally, delays in projects is the most common problem in this industry and specifically in Kuwait. However, several studies revealed that using advanced project management approaches such as Lean Construction and Building Information Modelling can improve the performance of the construction industry, therefore, overcoming these challenges. This paper aims to investigate the challenges facing construction projects in Kuwait, the implementation of Lean Construction and BIM approaches in this industry; in an attempt to find a suitable solution to address these issues. Thus, this study delivers a comprehensive awareness into the causes of delays in construction projects in Kuwait from reviewing the relevant literature and by examining the findings of the distributed online questionnaire. This questionnaire targeted 141 specialists in the construction industry who are involved in public-sector construction projects in Kuwait including clients, contractors, and consultants. The findings of the questionnaire revealed that delays in projects and a lack of collaboration and communication between stakeholders are the main challenges facing this industry.

Keywords: Construction industry, Kuwait, lean construction, Building Information Modelling, construction challenges, time overrun, cost overrun, information management, sustainability.

1. INTRODUCTION

The construction industry plays an important and vital role in enhancing the productivity of countries around the world (Othman & Ismail, 2014). On a global level, the construction industry has recently become a very competitive field, whilst increasing project complexities create enormous challenges. In order to keep up with this market, ensure a successful project, and build a good reputation, it is important to control the risks associated with time, budget, and quality. These are also indicators of work efficiency of project delivery within the industry (Al-Marri, Ibrahem, & Nassar, 2012; Shahhossein, Afshar, & Amiri, 2017). Although these goals are difficult to achieve immediately, the implementation of collaborative and integrated procurement delivery systems through the use of innovative tools, such as Building Information Modelling, could help to accomplish these targets (Abdulfattah, Khalafallah, & Kartam, 2017).

In the Middle East, construction problems are increasing and there is a significant need to develop this sector in order to keep pace with developed countries. Kuwait is one such developing country that is struggling to address its construction challenges. However, the construction industry is one of the country’s priorities, especially after the Government launched the new vision of Kuwait 2035 (Mahdi, 2017). Although Kuwait is an oil-rich country and its currency; the Kuwaiti Dinar (KWD); has the highest value in the world (BookMyForex, 2017), the construction industry faces many problems and lags behind in terms of its productivity and performance.

Globally, the construction industry is facing significant risks in accomplishing the completion of projects on time and within budget, achieving the desired quality, and improving its low productivity (Al-Hazim, Salem, & Ahmad, 2017; Farmer, 2016; Laskar & Murty, 2004; Venkateswaran & Murugasan, 2017). Hussin, Rahman, and Memon (2013) described the nature of this industry as fragmented, complicated and constantly facing challenges. For instance, 70% of projects suffer delays and cost overruns, which on average comprise 14% of the contract cost, whilst approximately 10% of the total costs of projects are waste. Furthermore, around 57% of time is wasted by poor productivity (Ansah, Sorooshian, & Mustafa, 2016). However, over the past 40 years, the productivity of the construction industry worldwide has trailed behind most other industries (Moud, 2013; Ningappa, 2011). It has remained static, whereas the manufacturing industry has approximately doubled, as shown in Figure 1.

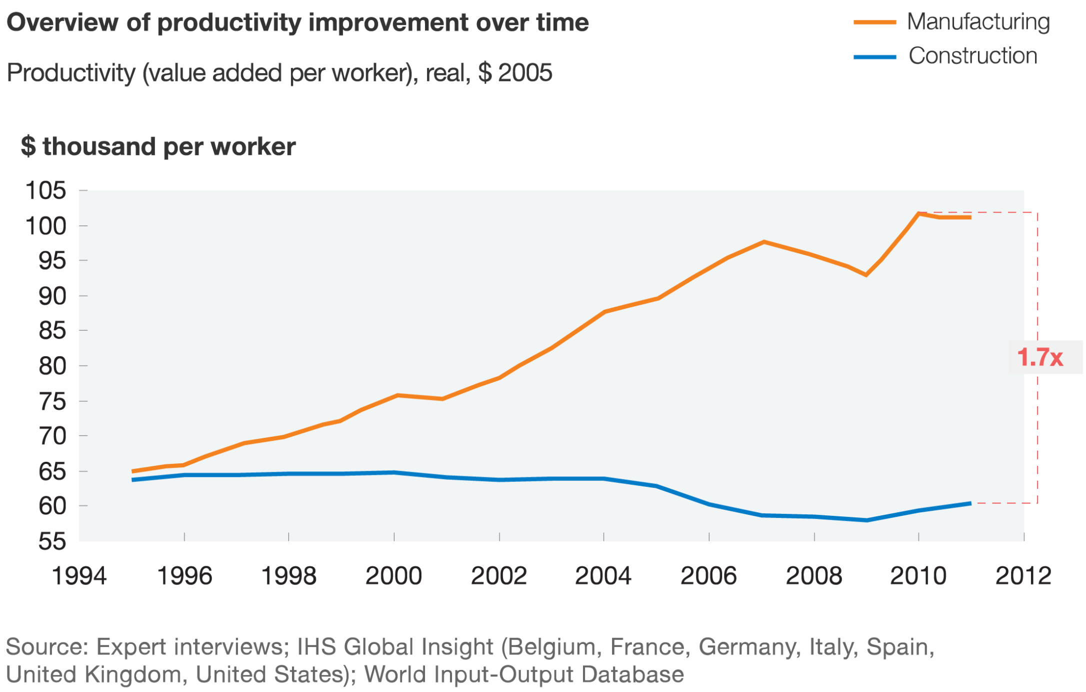

Figure 1: Overview of productivity improvements over time

Moud (2013) argued that the low productivity of the construction sector could be due to the absence of innovation in the industry. However, one reason for huge improvements in the productivity of the manufacturing industry (as shown in Figure 1) is the adoption of new management philosophies, such as Lean Production, which was developed by Toyota Manufacturing (Liker, 2004). According to Liker (2004) the Toyota Production System has proven its efficiency in terms of waste reduction and productivity enhancement. Thus, Gao (2014) and Aziz and Hafez (2013) have argued that the productivity of the construction industry could be improved by implementing Lean Construction.

In late 2008, the economic crisis had an adverse impact on the general economic development of Middle East construction companies. As a result, investors' trust in this sector has fallen sharply, whilst delays in projects represent one of the greatest barriers to success (Al-Kharashi & Skitmore, 2009). For example, Albogamy, Scott, Dawood, and Bekr (2013) said that 70% of all Governmental construction projects in the Middle East region suffered from delays. This issue is common due to the overlapping functions and benefits of the project stakeholders within a multicultural community (Motaleb & Kishk, 2011). Farmer's (2016) report noted that approximately 75% of total production was not in the government's direct control, and there is insufficient coordination between public and private stakeholders within the industry. As a result of such challenges in the UK, the government mandated the implementation of Building Information Modelling on their projects (HMGovernment, 2013). Moreover, Governments around the world have acknowledged the inefficiencies impacting the construction industry and have suggested, or requested, the implementation of Building Information Modelling (BIM) to overcome low productivity (Mehran, 2016).

1.1 Challenges in the Construction Industry in Kuwait

The Kuwaiti construction industry is expected to spend around KD 34 bn ($112.5bn) on an infrastructure development plan to provide construction facilities that can fulfil the Kuwait's 2035 vision (Mahdi, 2017). However, the construction industry in Kuwait has faced many challenges over the last five decades, including the necessity to reduce waste, eliminate inefficiency and improve productivity, whilst also considering the sustainability of construction projects (Koushki, Al-Rashid, & Kartam, 2005). Consequently, the need for infrastructure development is constrained by low productivity levels (Al-Zubaidi & Al-Otaibi, 2008) and cost overruns (Alaryan, 2014; Koushki et al., 2005), which are caused by factors such as delays in the delivery of projects (AlSanad, 2017).

The literature review revealed that 81% of the studies on the challenges and problems in the Kuwaiti construction industry concerned delays to projects. In 2017, the Ministry of Public Works to the Council of Ministers reported that 47 projects were delayed with a total value of more than $1.5 billion (Al-Zahi, 2019). Likewise, Alshahed (2017) revealed that 90% of the Ministry of Public Works' (MPW) projects suffer from delay, whilst the volume of waste materials in Kuwaiti construction is huge for such a small country, as shown in Figure 2. For instance, a comparison of the construction waste in Kuwait with that of Canada, as a large country, shows that construction and demolition waste in the Canadian industry amount to approximately 9 million tones per year, whilst in Kuwait, the figure was around 10 million tonnes per year (Yeheyis, Hewage, Alam, Eskicioglu, & Sadiq, 2013).

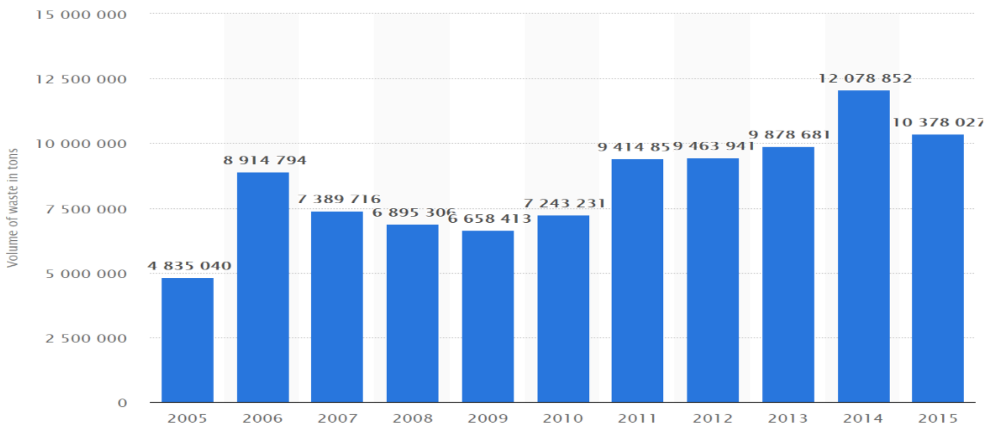

Figure 2: Volume of construction waste in Kuwait (Statista, 2018)

In addition, there is a lack of awareness and a limited adoption of advanced project management techniques and tool, such as BIM (Abdulfattah et al., 2017) and Lean Construction (Al-Adwani, Mollasalehi, & Fleming, 2018). Accordingly, there is a lack of local expertise in this area according to the literature.

1.2 Lean Construction (LC) and Building Information Modelling (BIM)

Lean Construction (LC) is now an established global method to improve the efficiency of construction by reducing waste, improving customer value and evolving management practices (Howell & Koskela, 2000). Research has shown that the adoption of Lean philosophy and its tools in the construction industry help to address the uncertainty and difficulty in this industry, consequently aiding it to become more efficient (Ahuja, Sawhney, & Arif, 2014).This adoption of Lean Principles aims to deliver the promised value to the customer without the normal waste that usually arises during the construction works in the project site (LCI, 2016). According to Bertelsen, Christoffersen, Bojsen Jensen, and Sander (2001), Danish contractors have implemented Lean principles in their projects. As a result, they have increased productivity by 20%, reduced the duration of projects by 10%, enhanced efficiency by 20%, and improved profitability by 20%-40% on projects where Lean thinking has been applied.

Building Information Modelling (BIM) has received considerable attention from both industry and academia sectors (C. Eastman, Teicholz, Sacks, & Liston, 2011). It is a revolutionary technology that is renovating the design process of the Architecture, Engineering and Construction (AEC) industry (Abdalla, 2016). Moreover, BIM supports project visualisation and improves collaboration among projects stakeholders which helps to achieve Lean principles (R. Sacks, L. Koskela, B. A. Dave, & R. Owen, 2010). The benefit of BIM not only covers the technical development process, it also provides an advanced and integrated functioning platform to enhance productivity and sustainability for the whole project life cycle (Elmualim & Gilder, 2014). The use of BIM data that is created during design throughout the entire project lifecycle allows for faster, more efficient, safer, less wasteful, more effective, less costly and more sustainable construction in operation, maintenance and decommissioning (Shaikh et al., 2017). Zuo and Zhao (2014) believed that with new information and communication technologies, especially Building Information Modelling (BIM), the development of green building has become more facilitated. Building Information Modelling changed the way of designing, engineering, building and managing construction projects through the diversity of software systems. For instance, BIM functions can facilitate sustainability by using energy analysis that helps reduce energy consumption. In addition, modelling and simulation in BIM leads to improved processes productivity (Eastman, 2011).

According to Sacks et al. (2010), Lean construction; which is a theoretical way to manage construction projects; and Building Information Modelling; which is the transformative information technology; are the most significant advances affecting the main revolution in the AEC industry. Therefore, instead of using one of the Lean construction tools, Building Information Modelling could be adopted to help achieve the purpose of using Lean thinking. BIM is an advanced system for coordination between all project stakeholders. Sacks et al. (2010) claim that there is a strong connection between Lean and Building Information Modelling. Thus, the way of managing the project and information management could be significantly improved after implementing BIM as a software system within the Lean framework of lean principles.

In fact, BIM has a potential impact to provide the required linkage between Lean and Green philosophies, it acts as a catalyst to do so (Ahuja et al., 2014). By collaboration, integrated analysis and information by specialists around the world, BIM has found to have the potential to analyse thoroughly, evaluate green buildings on different levels, and access to information required to make sustainable choices.

Lean Construction and Building Information Modelling have been used widely in many developed countries, such as the United Kingdom and the United States. Since BIM is a popular system that has exploited the use of software and technologies, it has been mandated in many developed countries. Therefore, the adoption of BIM has become a necessity for the evolution of the construction industry.

Correspondingly, Lean Construction and BIM have been found to be used in the Middle East region. The literature review has provided evidence that Lean Construction has been implemented in Saudi Arabia (Alsehaimi, 2011; Mohamed, 2016; Sarhan, Olanipekun, & Xia, 2016), Turkey (Tezel & Nielsen, 2012), Lebanon (Awada, Lakkis, Doughan, & Hamzeh, 2016), and the United Arab Emirates (Kanafani, 2015; Small, Al Hamouri, & Al Hamouri, 2017). Furthermore, the Municipality of Dubai in the UAE has mandated the adoption of BIM (Abdalla, 2016). However, there is no evidence of the implementation of Lean Construction and BIM in Kuwait.

2. RESEARCH METHODOLOGY

The authors have adopted the research onion model (Saunders, Lewis, & Thornhill, 2015) to design the research methodology. Starting with mentioning the research philosophies and selecting the appropriate one which is epistemology philosophy. Then, choosing a deductive approach based on the research objectives. The quantitative research was carried out for the research strategy while the online questionnaire has been selected as the survey method. Regarding the data collection for this research, the primary and secondary data collection was conducted through online survey, “Scopus”, journals, books, and reports.

A comprehensive literature review was carried out to find the main challenges facing the construction industry in Kuwait and its causes. Additionally, the researchers investigated the improvement methods to solve the addressed challenges. The primary data collection used in this study is based on an online questionnaire which is the most convenient way amongst other methods. The questionnaire was designed with a series of twenty-nine (29) questions including some qualitative elements (open-ended questions). The questionnaire was designed to investigate the main challenges facing this industry, the level of knowledge and awareness of Lean Construction and BIM and their applicability in Kuwait. Additionally, it includes some questions about Lean waste, and advantages and disadvantages of BIM implementation. The questionnaire was distributed to 383 practitioners working in the construction industry in Kuwait, including clients, contractors, and consultants; 141 of them completed the survey within two weeks.

2.1 Findings

The questionnaire results showed that delays in projects and the lack of communication and coordination between stakeholders are the main challenges facing the construction industry in Kuwait, as shown in Figure 3.

Challenges/ Problems	Strongly Disagree أعترض بشدة (1)		Disagree اعترض (2)		Neutral / not sure محايد/ لست متأكداً (3)		Agree أوافق (4)		Strongly Agree أوافق بشدة (5)			
	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Ø	±
1. Time overrun/ Delays	2x	1.65	3x	2.48	5x	4.13	64x	52.89	47x	38.84	4.25	0.79
2. Cost overrun	1x	0.84	6x	5.04	24x	20.17	59x	49.58	29x	24.37	3.92	0.85
3. Waste in Construction materials	2x	1.65	21x	17.36	34x	28.10	37x	30.58	27x	22.31	3.55	1.07
4. Lack of communication and coordination between project parties	2x	1.65	9x	7.44	15x	12.40	42x	34.71	53x	43.80	4.12	1.00
5. Low Productivity	-	-	22x	18.18	23x	19.01	53x	43.80	23x	19.01	3.64	0.99
6. Construction accidents	3x	2.48	38x	31.40	51x	42.15	27x	22.31	2x	1.65	2.89	0.83
7. Inadequate Project Management practice and poor site management	3x	2.48	21x	17.36	17x	14.05	51x	42.15	29x	23.97	3.68	1.10
8. Lack of experience and qualifications	4x	3.31	27x	22.31	26x	21.49	48x	39.67	16x	13.22	3.37	1.07
9. Lack of adopting new technologies	3x	2.48	16x	13.22	14x	11.57	55x	45.45	33x	27.27	3.82	1.06
10. Poor Planning and control	2x	1.65	11x	9.09	12x	9.92	48x	39.67	48x	39.67	4.07	1.01
11. Change in orders/ decisions initiated by clients	1x	0.83	8x	6.61	15x	12.40	57x	47.11	40x	33.06	4.05	0.89

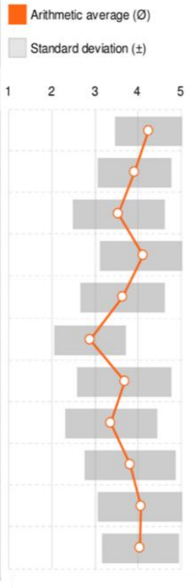

Figure 3: The challenges facing the construction industry in Kuwait

Moreover, the level of awareness of Lean Construction is low. In contrast, the level of knowledge and awareness of BIM is high in this industry. According to the participants answers, there are some public and private construction projects implementing BIM and Lean approaches such as Airport, residential projects, hospitals, and commercial projects (Figure 4 and 5).

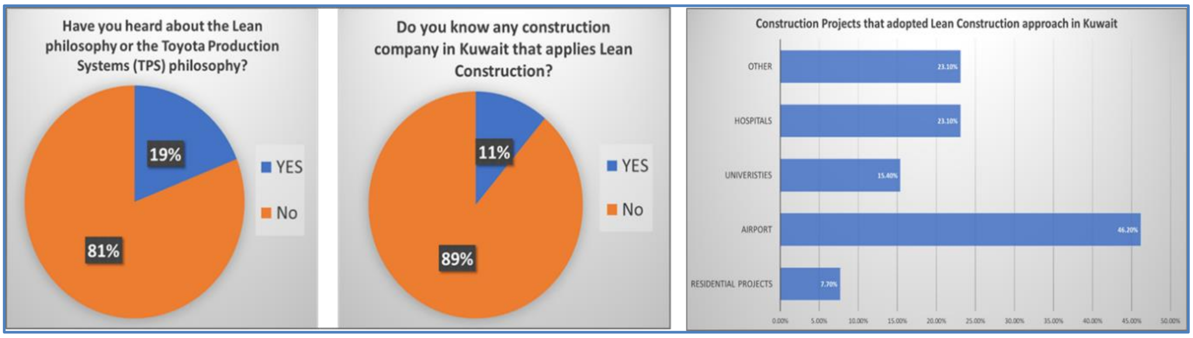

Figure 4: The level of awareness and knowledge of LC in Kuwait

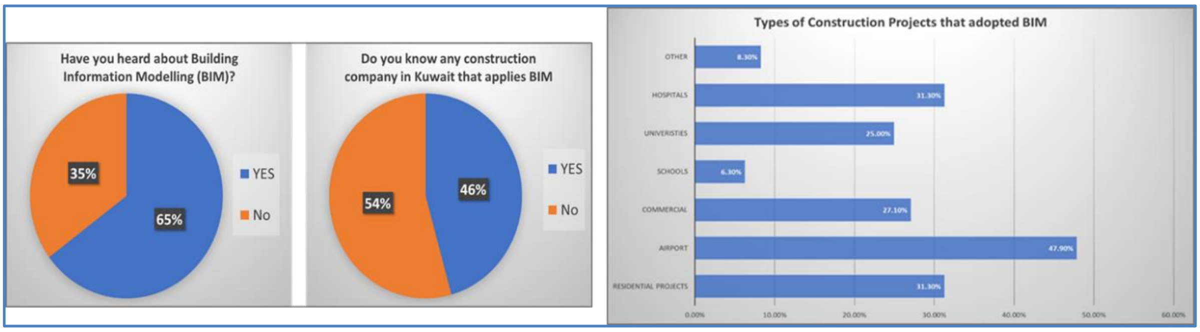

Figure 5: The level of awareness and knowledge of BIM in Kuwait

Participants were asked to assess the incidence of 8 Lean wastes in construction projects. The results showed that waiting, defects and non-utilised talents are the main Lean wastes generated in construction projects in Kuwait, as illustrated in Figure 6.

	Never لم يحدث ابداً (1)		Rarely نادراً (2)		Sometimes أحياناً (3)		Frequently كثير من الاحيان (4)		Always دائماً (5)			
Lean Waste in Construction	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Ø	±
1. Defects (e.g. Rework, Design error, Incorrect information, inconsistency between contract documents)	3x	2.65	7x	6.19	34x	30.09	53x	46.90	16x	14.16	3.64	0.90
2. Over Production	8x	7.08	33x	29.20	51x	45.13	19x	16.81	2x	1.77	2.77	0.88
3. Waiting	-	-	4x	3.67	28x	25.69	35x	32.11	42x	38.53	4.06	0.89
4. Non-utilized talents	1x	0.91	8x	7.27	37x	33.64	43x	39.09	21x	19.09	3.68	0.90
5. Transportation (Materials)	4x	3.60	20x	18.02	51x	45.95	27x	24.32	9x	8.11	3.15	0.94
6. Inventory (Excess products and materials being processed)	8x	7.14	31x	27.68	47x	41.96	22x	19.64	4x	3.57	2.85	0.94
7. Motion (people) (unnecessary movements by people "e.g. walking")	6x	5.41	18x	16.22	49x	44.14	29x	26.13	9x	8.11	3.15	0.97
8. Extra Processing (i.e. pouring concrete where pre-cast concrete would be more effective)	4x	3.57	12x	10.71	63x	56.25	25x	22.32	8x	7.14	3.19	0.85

Arithmetic average (Ø) Standard deviation (±)

Figure 6: Lean Wastes in the Construction Projects in Kuwait

Figure 7 shows the ranking of the benefits of BIM implementation in this industry. It revealed that accurate construction sequencing, improved design quality, and reduced errors and avoiding risks are the main advantages of BIM implementation.

	Strongly Disagree اعترض بشده (1)		Disagree اعترض (2)		Neutral محايد (3)		Agree اوافق (4)		Strongly Agree أوافق بشدة (5)			
BIM Drivers/ Benefits	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Ø	±
1. Cost savings through reduced re-work and RFI's (Requests for Information).	1x	1.14	2x	2.27	17x	19.32	43x	48.86	25x	28.41	4.01	0.82
2. Improve design quality.	-	-	1x	1.15	7x	8.05	44x	50.57	35x	40.23	4.30	0.67
3. Accurate construction sequencing	-	-	-	-	6x	6.82	47x	53.41	35x	39.77	4.33	0.60
4. Improve built output quality	-	-	1x	1.12	10x	11.24	54x	60.67	24x	26.97	4.13	0.64
5. Improve capacity to provide whole life value to client	-	-	2x	2.27	12x	13.64	49x	55.68	25x	28.41	4.10	0.71
6. Streamline design activities	-	-	3x	3.37	14x	15.73	54x	60.67	18x	20.22	3.98	0.71
7. Time savings	1x	1.14	-	-	11x	12.50	47x	53.41	29x	32.95	4.17	0.73
8. Improve communication to operative	1x	1.12	4x	4.49	11x	12.36	45x	50.56	28x	31.46	4.07	0.85
9. Facilitate increased pre-fabrication	-	-	3x	3.37	15x	16.85	47x	52.81	24x	26.97	4.03	0.76
10. Design health and safety into the construction process	2x	2.25	1x	1.12	13x	14.61	47x	52.81	26x	29.21	4.06	0.83
11. Facilitate facilities management activities	1x	1.14	-	-	15x	17.05	47x	53.41	25x	28.41	4.08	0.75
12. Reduce waste	-	-	1x	1.15	11x	12.64	48x	55.17	27x	31.03	4.16	0.68
13. Smooth and clear flow	1x	1.14	1x	1.14	11x	12.50	49x	55.68	26x	29.55	4.11	0.75
14. Reduce errors and avoid risks	1x	1.15	1x	1.15	7x	8.05	48x	55.17	30x	34.48	4.21	0.73
15. Collaborative environment	1x	1.14	-	-	13x	14.77	44x	50.00	30x	34.09	4.16	0.76
16. Increased productivity	1x	1.14	1x	1.14	13x	14.77	46x	52.27	27x	30.68	4.10	0.77
17. Reduced project costs	-	-	2x	2.27	25x	28.41	37x	42.05	24x	27.27	3.94	0.81
18. Better communication across stakeholders	-	-	1x	1.14	10x	11.36	50x	56.82	27x	30.68	4.17	0.66
19. Less defective work on site	-	-	3x	3.41	13x	14.77	44x	50.00	28x	31.82	4.10	0.77
20. Improved site layouts	-	-	5x	5.68	12x	13.64	45x	51.14	26x	29.55	4.05	0.82
21. Improved construction and procurement program	-	-	-	-	16x	18.18	46x	52.27	26x	29.55	4.11	0.69
22. Improved on site health and safety	2x	2.30	2x	2.30	24x	27.59	36x	41.38	23x	26.44	3.87	0.91

Arithmetic average (Ø) Standard deviation (±)

Figure 7: The benefits of BIM implementation in Kuwait

On the other hand, the questionnaire showed that organizational issues such as lack of skilled personnel, and lack of knowledge about BIM are the major barriers for adopting BIM in the construction industry in Kuwait.

3. CONCLUSIONS

Lean Construction (LC) and Building Information Modelling (BIM) have demonstrated their effectiveness in improving the construction industry in many countries around the world. LC is a management philosophy to minimise waste and add value for the customer, whereas BIM is a process that manages information through the project lifecycle, from planning and designing through to project completion. Since there is a lack of awareness of Lean Construction and misusing of Building Information Modelling, it is essential to consider these two resources when exploring ways to improve the efficiency of the construction industry. Although BIM is known as a collaborative system that manages information, it still does not provide a strategy to promote cooperative action (Al-Mohannadi, Arif, Aziz, & Richardson, 2013). Accordingly, integrating LC and BIM presents a positive alternative, because Lean Construction is a ‘thinking’ management approach that will help to create an improvement strategy and employ BIM to achieve its purpose. The integration of Lean Construction and BIM can be exploited to develop construction processes that exceed the degree of enhancement if applied individually (Sacks et al., 2010).

In the Kuwaiti construction industry, the level of awareness of BIM in the construction industry in Kuwait is high, as well as its implementation. However, the implementation of BIM in this industry is limited and slow. The maturity level of BIM in the construction industry in Kuwait is BIM Level 1, indicating that there is a low-partial level of collaboration between a project’s stakeholders in the industry. According to the research findings, the implementation of BIM and Lean Construction should be driven by the Government (Client) to ensure proper implementation of these approaches and benefit the industry.

The researchers believe that Lean Construction is a way of thinking and BIM is the future of construction. From this perspective, the adoption of both Lean construction and BIM will push the Kuwait' construction industry to its optimum performance. Because, there is a great need for an advanced system that enables the integration of projects’ stakeholders, their operations, and information in an organised way. As the Greek philosopher Heraclitus said: “Change is the only constant in life”, from this point, Kuwait’s construction industry needs to be modernised by adopting these new methods and exploiting intelligent technologies to keep pace with evolution.

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EXPLORING BEHAVIOURAL NEGATIVE FACTORS HINDERING THE PERFORMANCE OF STRATEGIC CONSTRUCTION ALLIANCES IN THE UK

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Abstract: The importance of strategic alliances as a collaboration strategy in the global markets in general and the UK markets, in particular, are obvious which can yield long-term survival and achieve success for companies working within a competitive environment. Many authors have emphasised the role of the alliances for adding value through knowledge development, improving skills and enhancing learning processes of firms aligned together. Over the past decades, many opportunities have been provided by the collaboration of firms for achieving targeted goals. Eventually, using strategic alliances strategy is one of fundamental mechanism able to develop skills of the participants of the construction industry and dealing with risks facing project delivering. The aim of this paper is to identify behavioural negative factors which affect the performance of strategic construction alliances in the UK. The methodology adopted to achieve the aim of this study is the qualitative exploratory technique for collecting data from the alliances in the UK construction industry. Interviews were conducted with project managers to identify the behavioural negative factors leading the performance of the UK construction alliances to failure. The main findings emerged as five behavioural barriers through semi-structured interviews are namely: distrust, opportunistic behaviour, coercive power, conflict and lack of commitment. The contribution of this paper is to help researchers to step forward in considering behavioural barriers and challenges in various typologies of alliances. Awareness of the presence of these barriers is another contribution that helps UK construction's practitioners to make sure regarding the effectivity of decisions are selected for alliance future and what its consequences.

Keywords: Strategic alliances, behavioural negative factors, the UK construction industry.

1. STRATEGIC CONSTRUCTION ALLIANCES IN THE UK

Several principles have been noted when reviewing the literature on construction alliances. For instance, Bennett and Jayes, (1998) demonstrate that partnerships within the construction industry have three testified stages, each of which is partially different in concept due to their evolution. While most researchers in construction have taken the principle of "partnering" to represent an alliance within the supply chain, the concepts of "strategic partnering", "alliance" and "strategic alliance" are also used when describing such relationships. Additionally, several researchers and empirical studies (Akintoye and Main, 2007, Chen et al., 2012, Meng, 2012) demonstrate that strategic alliances in construction can provide a lot of benefit to all stakeholders due to its ability to change adversarial behaviour among partners. It has emerged as an essential strategy to avoid opportunistic and conflict-based relations among partners, as well as enabling or guiding those who are seeking a strategy for long-term commitment and relationships.

However, the application of a strategy for strategic alliances is different from project partnering. The concentration on applying this strategy opening the scope for a consistent relationship between the partners involved while concludes that the achievement of alliance targets and partners, and project performances are the main goals. Aligned with these facts, most researchers in construction understand the term alliance to mean reciprocal relationships within the supply chain. In general, strategic alliances aim to empower the relationships between stakeholders through respect, commitment, trust, teamwork, knowledge sharing, communication and shared goals. These relationships are usually determined through good faith in alliance rules, rather than a formal contract. Cheng et al., (2004) state that alliances within construction usually create an informal climate rather than formal relations. The fundamental reason for using a strategic alliance is to fit the targets of engaged partners, which involve various incentives and benefits. There is an even more important belief that an alliance should lead to worthwhile jobs for partners, and quality and time completion for the owner. This represents the essential reason why involved partners consider its use. Cheng et al., (2004) illustrate that strategic alliances in construction should help engaged companies to earn actual benefits within the project, and at corporate levels. These benefits include decreased risks, quality development, reduced cost, decreased rework, confirmed market share, increased profits, improved competitive position, enhanced innovation opportunities, and developed labour productivity and efficiency.

Thus, to enhance these incentives and benefits within the alliance, partners should be involved in sharing experiences and skills. Meanwhile, top management should support these parties by enabling the smooth execution of an alliance. This means ensuring that all partners are willing to contribute to the alliance as the effort will not be worthwhile without the support of top management. Meanwhile, the main obstacles to alliances are known to be inappropriate technological knowledge, a lack of training programmes, conflict, and opportunism (Lu and Yan, 2007).

Egan (1998) focuses on some major clients for the British Airport Authority and the relationships among the organisational objectives, stating that capabilities are the main incentive for a successful alliance. Meanwhile, Cheng and Li (2002) provide a framework for management skills and contextual characteristics that can be used to identify critical success factors for a construction alliance. Thus, alliances can become more successful when using proper management mechanisms, which involve alliance tools and individual measures. Thus, to achieve a successful alliance, the owners of allied organisations should formulate a process of partner forming, which may include the following steps: (1) ensure partners are willing to participate within the alliance; (2) select a facilitator; (3) determine who will participate within alliance workshop; (4) schedule the alliance workshop; (5) choose and provide materials, and (6) prepare the agenda and hold the workshop.

The gap that is investigated in this paper emerged from increased voices of researchers that alliances in global businesses and in the construction industry are facing a high percentage of failure (Chen et al., 2012, Donato and Shee, 2015). Also, the efforts that have been conducted to explore the negative barriers confronting the successful of alliances still limited (Zhang et al., 2016, Russo and Cesarani, 2017). Furthermore, there are flame refers to that participants' behaviours during implementing strategic alliance process consider negatively as barriers facing any possible success in future (Koolwijk et al., 2018).
This paper aims to discover the phenomenon of presence behavioural negative factors that impact the march of the performance of the strategic construction alliances in the UK by conducting intensive exploratory interviews with experts in the construction industry. It is particularly concentrated to increase the awareness of partners related to these factors to encourage delivering strategic construction alliance in the UK successfully.

1.1 Rationale of Strategic Construction Alliances

The concept of an alliance in construction is described as a comprehensive management approach to gathering projects goals. The supply chain relationships and collaboration in the construction industry are diverse categorised into three main, distinct strategies: traditional adversarial, short-term collaboration, and long-term collaboration (Meng, 2012). Some authors have criticised these forms, Thomas and Thomas, (2005); Wood and Ellis, (2005), because they have seen these relationships focus on win-loss approaches, witnessed mutual suspicion amongst parties, noted ineffective problem solving, a lack of trust, poor communication and the transferral of information, and a lack of plans for continuous improvement. Thus, Egan (2002) asserted that ensuring successful supply chain relations in construction requires the shift in plan from traditional to contemporary relationship strategies. Therefore, a strategic alliance is recognised as a substantial strategy, where the essential goal is to enhance relationships between contracting partners, either in single relation partnerships or in long-term strategic alliances (Cheung et al., 2003). The Associated General Contractors of America (Contractors, 1991) defined strategic alliances as a way of fulfilling an optimum relationship between a client and a contractor. A strategic alliance provides massive benefits to contracting partners, including work efficiency, cost effectiveness, enhancing opportunities for innovation, and risk sharing, and decreases the level of confrontation. Notwithstanding, Bayliss (2002) and Cook & Hancher (1991) doubted that an alliance could be considered an opportunity to gain benefits through exploiting a partner. Nonetheless, an alliance is not a contract but establishes relationships between firms who are aligned based on mutual trust, commitment and open communication. It also serves to generate an environment that improves cooperation and teamwork.

A strategic alliance strategy is a high-risk, high-gain approach, and a successful strategic alliance cannot be obtained naturally. Black et al. (2000) stated that mutual trust and commitment, effective communication, the clear understanding of different partners, knowledge sharing, flexibility to change, and decision making are fundamental factors for a successful alliance. However, the non-compromising tendering process within a construction alliance, a lack communication and knowledge and skill transfer between partners, poor perceptions about the alliance process and a lack commitment amongst partners represent issues that mitigate against the concept of alliance. Moreover, Larson and Drexler (1997) point out that, for an alliance to be successful, it should include all actors in the supply chain. With regard to the project structure, knowledge, skills, and process, obstacles can be avoided by an appropriate process design and by the training of participants.

Furthermore, Haksever et al. (2001) and Scott (2001) identified several intangible benefits, including: a willingness to share risks, increasing confidence in success, decreasing exposure to project risks, encouraging a transfer of practices and processes to other projects, enhancing cooperation, encouraging team spirit, improving the mechanism of learning from the alliance in order to improve the firm’s overall competitiveness, enhancing customer satisfaction, developing employee skills and improving the motivation of employees within different levels of the firm. Moreover, Chuang and Thomson (2016) demonstrate that a strategic alliance can offer a number of benefits to the firms. This can include improving cost efficiencies, which are associated with the economies of scale of an alliance’s performance and enhancing a long-term competitive advantage. These economies of scale can be achieved through adding resources to a firm’s assets which might increase the firm’s capacity to enhance cooperation with rivals. Studies on competitive dynamics confirmed that the resources possessed by firms have a stronger impact on competitive interactions (Chen and Miller, 2012). The resources saved or generated from strategic alliances can help firms to overcome competitive pressure and improve a firm's performance (Wassmer, 2010). Even though a strategic alliance opens a firm's resources for opportunist behaviour, it can also provide resources which may enhance a firm's ability to align with competitors, thereby fulfilling potential advantages, such as knowledge sharing, exchanged resources, cost savings, and improved performances by firms.

2. RESEARCH METHOD

2.1 Exploratory Interviews

During an initial stage, the researcher conducted semi-structured interviews with eight top managers from there construction alliance realise the impact of negative behavioural factors on performance of strategic construction alliances. The results gained from the interview sessions assisted into formulate the constructs in the conceptual framework. The context of this paper is exploring behavioural negative factors impacting the performance of strategic construction alliances in the UK. according to this research context, it was hard to obtain number of specified persons from these companies because the researcher was seeking to gain critical knowledge from the experts which have long-term of experience. Thus, purposive probability sampling was selected to stand on the relevant knowledge which can be beneficial for the phenomenon under investigation. In order to present the interviewees' experience and their background, Table 1 shows interviewees information. Further, the researcher will use the letter (P) to refer to all interviewees in order to keep Their privacy safely.

Table 1: Interviewees Information

Participants Labels	Managerial Level	Years of Experience
P1	Alliance Commercial Manager	30 Years
P2	Alliance Project Director	35 Years
P3	Alliance Project Director	25 Years
P4	Alliance Planning and Controls Manager	15 Years
P5	Alliance Safety Manager	19 Years
P6	Alliance engineering Manager	22 Years
P7	Alliance Commercial Director	35 Years
P8	Alliance Programme Manager	48 Years

According to results gained from the interviewees, the conceptual framework of this study can be framed based on these pieces of fact. Figure 1 demonstrates the conceptual framework of this study.

Figure 1 The Conceptual Framework of Study

2.2 Data Collection

To determine sample size, this process was undertaken through contacting the main manager within the alliance selected, the researcher asked this manger to have an opportunity of a curried-out pilot study to ensure the questions all being suitable and able to gain appropriate information regarding the phenomenon under investigation. In order to ensure the representativeness of the informants and increase the response rate, this manager based on his responsibility inside the alliance, conducted connection with the managers of his team to reach a proper number of interviewees to determine these factors. With this regards, snowballing technique conducted to reach appropriate number of participants to given suitable information regarding this phenomenon. In parallel, the data were collected for one month using face-to-face interviews with key informants during visiting the alliance under study.

3. DATA RESULTS

3.1 Distrust

There are several behavioural aspects affected by the distrust as mentioned through the interview session by the participants, where 3 participants insisted that mistrust impact the level of the commitment in the alliance, where P7 responded that “ultimately, because it would not work unless you are committed, and you trust each other. I would like to think I cannot identify that would ever happen. The alliance manager needs to establish and identify that, if there is an issue, straightaway, where maybe one company is frustrated with another company, and it is escalating, that needs to moved up to alliance leadership team and raised there, because if you do not get it sorted, it is lose-lose for everybody, so I would not like to be in one of those alliances where that dose happen because it is lost”.

Aligned with that comment, P6 also mentioned that “if you lose trust and you lose commitment, either you have got a poor management team, you have got a model that does not work, then the alliance will just fall apart I think and it just would not work and, more to the point, we will lose money and my focus is deliver profit, that is my focus” and P5 added that “the openness and commitment it all kind of kinds back into the trust, so if there is none of that openness saying you know, we have got a problem here and we need you to help us fix it". So, trust and commitment are linked together, deceased one of it, would cause flaw in the alliance achievement. distrust as participants pointed view happen as a result of the inability of leaders to make the staff aligned together, the reason for that could be occur lack of experience of the leadership level, or the inability of them to read perfectly the participants cultures and perceptions regarding what they need to achieve in the alliance, participant's motivations in that time would change and seek to cover their self-interest and then negative side of distrust is shown.

3.2 Opportunistic Behaviour

Opportunistic behaviour is considered one of these freaks could be happened within the strategic alliances. The problem of this negative factor can be happened not just by stealing tangible and intangible things for example, tacit knowledge and resources, but it can be represented by hiding somethings without sharing it with other partners to cover the alliance requirement. In addition, relating to the conflict and how it is playing role in opportunistic behaviour, P6 responded that "conflict is one of the motivators leading opportunistic to be coming up" which thereby the relationships would be threatened as P2 commented that "well, the relationship would not be there because you are trying to build a relationship with someone who is told you lie and somebody you never trust and it will be the same both sides, so it is massive impact" which indicates that the main principal of building the strategic alliance is the trust, starting the relations within the alliance with behaviours that are inspired negative things, will lead to break down the alliance relationships from the beginning. P3 reflected his opinion regarding the commitment and opportunism behaviour, where responds "if you hide stuff away then it becomes an issue and we committed to no surprises, so you commit to no surprises then you have got to get things on the table, so I think they are the key ones for me".

3.3 Coercive Power

The main thing can be extracted from these comments that individual decisions does not work which mean using dictatorial authority to do something, that is wrong, because importance of working as a teamwork in the strategic alliance came from the origin of the word (aligning) means cooperation. Using this power within that organisation will lead to achieve goals of the person that has the power at the expense of others. Therefore, consensus decision-making is fundamental, where it can deal with persons who have experience and skills to be able exposure the challenges, and that what confirmed by P6 that "I think if you were showing the power as an individual and ignoring everything else, then I do not think that would work, but I think you have got to be shown to be powerful in terms of being forceful in terms of decision making. So, a team yes, as an individual no" and P5 pointed out that "so if we have got dictatorial in the alliance, then we are not unanimous in our decision-making because people have not been asked to buy into that".

3.4 Destructive Conflict

The negative conflict is a part of the behavioural negative factors of the strategic construction alliances. The human nature is attracted to the conflict when some of the behaviours are breaking down. The importance of this factor into failing the alliance is not isolated from other factors, where 7 out of 8 participants confirmed that there are several reasons which encourage the conflict to be appeared. 5 participants are linked of coming up the conflict back to decrease the level of trust between the participants, where P3 commented that "if you get that breakdown in trust you will get conflicts, you will get less performance” and P6 explained the importance of dependency and trust in delivering the alliance, so if they are lost he reflected “if the dependency is gone, yes, you lost that, you lost trust, and it will go to conflict, and it would not be a nice place to work quite simply”. To analyse these comments, the negative side of conflict can be occur not just by demolishing the trust and dependency, but sharing knowledge and strategy of selecting the right partners would be a reason for appearances the conflict, where P4 responded regarding that “if you not sharing knowledge from different organisations in terms of issues and problems, you will get the breakdown in the trust, which will lead to the conflicts, the disillusionment and people working in silos, friction, et cetera” and P8 pointed out to the importance of selection right partners to avoid the conflict in the alliance future, where said “if they do not have the principles being, if you like, trustworthy then the negative, the implications of that are huge, if I do not have the right behaviours, I am not the right person and not everyone can do it. So, the selection of your people is very important”.

3.5 Lack of Commitment

The most important behaviour factor in the strategic alliance success is commitment, lacking this factor indeed will affect other behaviours which should be working, and will lead to terminate the alliance in the end from another side. As a result, 7 out of 8 participants agreed that if the trust and commitment are lacked, huge of issues would be presence, P6 mentioned that if the weaknesses of leaders consistent with signs of lacking the commitment, alliance processes will breakdown “if you lose trust and you lose commitment, either you have got a poor management team, you have got a model that does not work, then the alliance will just fall apart I think and it just would not work and, more to the point, we will lose money and our focus is deliver a profit” also P8 gave his opinion regarding the lack of commitment, where focused on how the responds of leadership and management teams related to communicating with staff when the commitment is lacking “if there is a lack of commitment quite often the important thing is to see the response from the alliance management team and the alliance leadership team. So, you can have a problem”.

4. DISCUSSION OF FINDINGS

4.1 Distrust

Distrust as a behavioural factor in the interviews and how it negatively impacts on the destiny of alliance relationships and project delivery is that by losing trust, behaviour and tangible resources would be affected. This means that in terms of behavioural impact, conflict and opportunistic behaviour could appear, whilst associated commitment to the alliance charter could suffer and decline. Whereas, with regards to tangible resources, partners could limit supply of required assets if trust is lacking and the sharing of information and knowledge could be detrimentally affected if partners notice ambiguity in alliance relations. Meanwhile, Wong et al., (2008) explain that distrust in collaborative construction projects will likely result in integration dilemmas, insufficient outcomes and project failure. Notably, in projects that contain evidence of distrust, the leadership team will use extensive control mechanisms to monitor collaborative performance, which will enhance the leaders’ satisfaction regarding the outcomes but will generate a high level of disputes, a low level of commitment and poor or inadequate sharing of knowledge (Hasanzadeh et al., 2016).

4.2 Opportunistic Behaviour

Rationale risks can impact heavily on successful strategic alliances, based on analysis of the results, a lack of partner commitment can breed the emergence of opportunistic behaviour, thus undermining the prospects of alliance targets. According to the interviewees' opinions, alliance partners, not surprisingly, tend to pursue self-interest apart from being committed to the common interest of the alliance and this is a sign of commencing opportunistic behaviour, which could spark conflict. Based on the dangers of opportunism and how partner commitment can be affected by this behaviour, mutual trust is indeed damaged, which creates serious threats to embedding social alliance relationships. Furthermore, controlling this behavioural problem is demanding as it has a crucial impact on the sustainability of superior strategic alliance performance. The secondary data is aligned to support the reality of negative opportunistic behaviour and its impact on the level of trust and commitment within alliance relationships. According to the findings of (Afonso Vieira et al., 2011, Jena et al., 2011, Barroso-Méndez et al., 2016) the impact of opportunistic behaviour reduces the level of trust directly, while the effect on the level of commitment is indirect as it is mediated by the trust impact. Furthermore, Berger et al., (2004) confirm that reducing the level of opportunistic thinking and communication problems between alliance partners, will result in the trust, commitment and interaction being improved, and vice versa.

4.3 Coercive Power

Through exploration of the impact of coercive power, the alliance members noted that frequent use of coercive power can be damaging to the relational norms of trust and commitment and that the cooperation's essence could be affected due to increasing conflictive aspects and discouragement of participant willingness. The interviewees' opinions based on their experiences within construction alliances concentrated on the negative impact of using this type of behaviour for the goal of creating an alliance and achieving consensuses in the decision-making process. It is believed that using this type of power can generate hidden conditions of distrust in the collaboration norms, while traditional thinking by alliance leaders when giving orders will enhance conflict and opportunistic thoughts. In addition, according to Lu and Hao, (2012), using coercive power during established long-term cooperation will generate a negative effect on the relations between partners and cognition-based trust. While, Donato and Shee, (2015) assert that negative association will be accompanied by adopted coercive power and that direct implications include negative impacts on relationship trust, knowledge supply chains, cooperation, commitment, and conflict resolution, which in turn will critically impact on the effectiveness of construction supply chain collaboration. Finally, the findings of Akhtar et al., (2016) support the research findings by establishing the negative impact of coercive power when building innovative and cooperative relationships, and how innovative practices can be hindered by applying this traditional power.

4.4 Destructive Conflict

Through analysis of the results and interview opinions, concentration appears to act as a negative conflict, with different forms in relation to its impact on partner relationships in strategic alliances. It is believed that poor partner management, including exclusivity at the decision-making table, lacks understanding of partner ambition to gather mutual goals and connect with a common alliance target, which in turn sparks negative conflict. In addition, the effects of conflict on mutual trust are widely discussed in the interviews, as the managers stress that the existence of conflict can undermine the presence of trust, which will generate into distrust and ultimately damage alliance relationships. It will also impact on the effectiveness of knowledge sharing, organisational learning and developing skills. Whilst the findings of Malhotra and Lumineau, (2011) confirm that the degree of trust can be affected by conflict especially if the alliance charter is designed based on unbalanced priorities between the aspirations of partners and the main goal of the alliance. Similarly,Karlsson and Kindbom, (2018) reveal that the generation of conflict usually occurs through partner disagreement or misunderstanding and the significant negative impact of this behaviour is detrimental on collaborative performance, relationships and implementation costs.

4.5 Lack of Commitment

The fundamental reason for poor partner commitment, based on the opinions of the interviewees, is ambiguity of the alliance principles, distrust and fragmentation of the alliance partners, which results in the misunderstanding of alliance procedures and the creation of conflict between alliance partners. Eksoz et al., (2014) emphasise that a lack of trust and commitment represents a barrier for successful collaboration. Whereas, weakness of trust and commitment is the path towards conflict between alliance partners. Moreover, the findings of Jacobson and Ok Choi, (2008) assert that poor unification of an alliance vision and insufficient partner commitment negatively impacts on the success of a construction partnership project. Notably, what is not considered are the negative stages that can appear through shortage of important elements. As an absence of successful factors will enhance the feeding and thoughts of opportunistic self-interest, which will promote partner conflict, thus these negative effects will undermine the efforts of the resolution problems**.**

5. LIMITATION OF STUDY

In order to present the limitation of this study, this study focused purely on strategic alliances in the construction industry, which is represented the infrastructure sector. Similar research could apply the same behavioural factors and performance indicators in different field such as business field, the energy, medical or the housing sector.

6. CONCLUSION

This paper provides an intensive illustration of the behavioural negative factors that impact the performance of strategic construction alliances in the UK. In doing so, it presents the mechanism of construction alliances and the rationale of adopting this strategy and how it can be considered essential to delivering construction project smoothly and successfully. This paper reveals a group of behavioural negative factors via conducting detailed exploratory interviews with experts in the UK construction industry who have long been experiences within this sector. Noticeably, the findings refer that increasing tension between partners and lack presence of agreement upon the alliance charter during the initial stage and even via implementing alliance process will motivate destructive conflict to appear. Hence, relations between alliance members might be negatively affected, transferring essential information, problem-solving, knowledge sharing, and formal and informal mutual communication would be frustrated. Disappearing behavioural satisfaction during implementing alliance functions will encourage partners to start thinking opportunistically to feed-up their self-interests. Thus, it is important for managers to be aware of the role of the behaviours to deliver projects and cooperated crucially with other partners particularly during the stage of formation of the alliance goals. Determining partners’ targets and how it is being melted and achievable within the alliance goals is more essential. This matter cannot be fulfilled without establishing a proper mechanism for managing partners' communication in order to encourage parties to sharing information and knowledge required to deliver project timely. Solidify the idea of interdependency between partners to facilitate sharing resources via alliance boundaries and reduce costs of collecting from outside, as well as strengthen the principle of dependency improves the way of transferring the innovation and experiences between partners properly. further research efforts will focus on behaviours that stand behind appearance these negative factors that negatively impact on the performance of construction alliances. Therefore, suggested indicative actions through a concentrated strategic guideline will be developed to fundamentally test and validate the research findings.

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GIG ECONOMY AS A TOOL FOR SUSTAINABLE LIVELIHOOD STRATEGY FOR CONSTRUCTION WORKERS IN SOUTH AFRICA

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Abstract: The economic meltdown and recession experienced in the country have affected the construction industry negatively in numerous ways. Among them is the shortage of construction work that affects the livelihood of construction workers. Towards improving the livelihood of construction workers this study proposes the adoption of the gig economy as a tool for enhancing their sustainable livelihood strategy. The study's aim was achieved through administering a questionnaire to construction workers in Gauteng province in South Africa. Random sampling was adopted administering the questionnaire and a total of 60 was retrieved from the construction workers and used for the analysis. The data extracted from the questionnaire was analysed using SPSS V 24, adopting, mean score and frequencies. The study discovered that the workers have low awareness about the adoption of the gig economy as a tool for sustainable livelihood strategy. The adoption is hindered by the corrupt practices within the construction industry and poor collaboration among construction workers. The study contributes to practice through the provision of an effective means for improving the livelihood of workers. The study recommends that collaborative practices should be encouraged and awareness regarding the gig economy should be created in the industry.

Keywords: Construction workers, gig economy, independent contractor, sustainable livelihood.

1. INTRODUCTION

Ayessaki and Smallwood (2018) affirmed that the construction industry performs a significant role in the development of South Africa as the final product is regarded as capital or an investment good. Similarly, Mashwama et al. (2019) indicated that the construction industry contributes to the economy of South Africa through the provision of employment, housing delivery and other infrastructures. In support of the aforementioned opinion, Osunsanmi et al. (2019) stressed that the economy of every nation is significantly dependent on the activities of the construction sector, which has a momentous effect on national gross domestic profit and vice versa. It can be inferred from the above opinion that there is a correlation between national economic growth and construction industry development.

Windapo (2016) submitted that the construction industry develops through the activities of its workers that deploys their body coupled with their skills to work on site. Bowen et al. (2015) opined that the skill of construction workers is a crucial resource on the construction site. This is because their skill is needed to combine other construction resources such as equipment, finance and others towards achieving an optimum return on investment. Rasdorf et al. (2016) further noted that the skill of a construction worker is a crucial asset for the advancement of the sector. Similarly, Oesch (2010) avowed that workers in the construction industry could be regarded as the driver of the industry because without their efforts the industry will collapse. It can be inferred from the above opinions that construction workers perform a crucial function in the construction industry.

However, despite the construction workers crucial function in the construction industry they are prone to numerous problems ranging from occupational hazards, poor wages and many others (Govender et al., 2017). Windapo (2016) indicated that poor wages and salary are a major problem among semi-skilled workers in South Africa. Zannah et al. (2017) indicated that construction workers are among the lowest-paid workers in comparison to other workers in other sectors. The poor wages among construction workers has led to most of them seeking an alternative source of income through other means to achieve a sustainable livelihood. Owusu (2007) affirmed that sustainable livelihood is a strategy adopted by an individual with the intention for creating an additional income outside their traditional employment.

The sustainable livelihood of workers in other sectors has been improved through the adoption of the gig economy (Graham et al., 2017). Durlauf (2019) asserted that the gig economy is a labour market dominated with the use of short term contracts or freelance workers as opposed to permanent jobs. This opinion recognised gig work as a temporary job performed on a permanent project. Petriglieri et al. (2019) described gig economy from a work arrangement perspective. The author believed that gig economy is created when a contract is created between an individual and a company in consideration for the payment for a job performed on a temporary basis. It can be deduced from this opinion that the difference between a traditional worker and a gig worker is that gig worker has a temporary work relationship with the employer.

Durlauf (2019) proclaimed that the relationship between employers and some gig worker commence from online platforms as most of them are sourced from such platforms. Osunsanmi et al. (2018a) indicated that the advent of the fourth industrial revolution enabled the selection of workers from online platforms. The fourth industrial revolution also is known as industry 4.0 enabled this procedure because this revolution witnessed human-computer interaction (Osunsanmi et al., 2018a). The interaction allowed easy selection of labourers through online platforms powered by the internet. Kässi and Lehdonvirta (2018) revealed that large and small firms are adopting such platforms to access skills and flexible gig workers to increase the performance of their project.

Prestia (2019) and Kässi and Lehdonvirta (2018) opined that gig workers contribute to the performance of a project in the nursing sector. This was also discovered in other sectors like banking and policy formation (Abbas et al., 2018, Kässi and Lehdonvirta, 2018). Graham et al. (2017) affirmed that gig workers contribute to the performance of the sectors because they are always concerned about their individual performances. This is because their poor performance disturbs their reputation, therefore, enforcing them to do a better job. This suggests that gig workers contribute positively to the performance of numerous sectors. Unfortunately, in the construction industry little is known regarding the performance, awareness and challenges confronting gig economy as a tool for sustainable livelihood strategy.

2. WORKERS IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

Windapo (2016) stipulated that the construction industry in South Africa is confronted with numerous challenges with the major one been the shortage of skilled workers. The shortage is usually experienced among workers that require technical and formal training. The shortage originates from the compulsory requirement that a worker must be employed before been employed into the industry. Erasmus and Breier (2009) related the shortage of skilled construction worker in South Africa to the state of the economy, ageing workforce and poor basic education for construction workers.

CIDB (2015) indicated that poor education among construction workers has been a major stumbling block to the growth of the South African construction industry. Bowen et al. (2018) discovered that poor education among construction worker is responsible for the spread of HIV/AIDS within the construction industry. Earlier on Bowen et al. (2015) and Haupt et al. (2005) revealed that South African construction workers are classified as a high-risk group regarding HIV/AIDS. Similarly Govender et al. (2017) discovered that in comparison to other sectors the construction sector in South Africa is highly affected by HIV/AIDS pandemic. Bowen et al. (2014) avowed that HIV/AIDS is high in the construction industry because the testing of HIV which is described as the major form of control for the disease is hindered by the workers AIDS-related knowledge. This aforementioned opinion suggests that poor education has been the major hindrance to construction workers health in South Africa.

Mashwama et al. (2019) discovered that poor education among construction workers in South Africa also affects the occupational health and livelihood strategies within the industry. All over the world occupational health and workers, livelihood has been a major threat to the growth of the construction industry including South Africa (Ayessaki and Smallwood, 2018). Mushayi et al. (2018) asserted that occupational hazards are high within South Africa construction industry in comparison to other industries in the country. Smallwood (2015) stipulated that a construction worker within the industry have a higher likelihood of been injured on a construction site. Oesch (2010) affirmed that the injuries confronting construction workers affect their sustainable livelihood strategies.

2.1 Sustainable Livelihood Strategies and the Gig Economy

Katwal (2016) affirmed that livelihood strategies are plans that an individual adopts in meeting their basic needs such as food, shelter and many others. Ushie et al. (2010) and Chaudhuri (2018) on the other hand stipulated that livelihood strategies could be described as the material and social resources an individual use for making a living. Hyder (2016) perceived livelihood strategies are a function of the resources available to an individual or household and the decision taken by such household or individuals to use the resources. It can be inferred from the opinion that livelihood strategy is determined by an individual decision.

Owusu (2007) opined that the decision of an individual to embark on a livelihood strategy is determined by numerous factors. The factors range from taxation, economic condition, climate change, land use and many others. Chaudhuri (2018) avowed that sustainability is the crucial factor determining the livelihood strategy employed by a worker. Hyder (2016) asserted that a livelihood strategy that can cater to the present and future needs of a worker is referred to as a sustainable livelihood strategy. Achieving a sustainable livelihood strategy has been the major target of every worker. Graham et al. (2017) discovered that towards ensuring sustainable livelihood strategy workers in urban areas have embraced the gig economy.

Prestia (2019) affirmed that around the 1960s and 1970s the word gig referred to a performance carried out by an individual to augment their income. De Stefano (2015) declared that presently gig economy refers to adopting or using an independent worker of any parent organisation. Friedman (2014) further stated that gig workers are different from a consultant. The researcher believed that gig workers are freelancers careerists, self-employed specialists or members of a mobile workforce. Petriglieri et al. (2018) indicated that there is an estimate of over 150 million gig workers in North America and Western Europe with possibilities for more growth in that sector. Prestia (2019) gave a percentage rise in the sector over the decades. The study discovered that in 1995 there were only 7% of the workforce were considered as gig workers, it rose to 35% in 2017 and is expected to be 43% in 2020. It can be deduced from these findings that the millennial generations are the drivers of gig workers.

Kässi and Lehdonvirta (2018) asserted that gig workers are not specific to the millennial generations as some gig workers are over 50 years due to limited career opportunities. Abbas et al. (2018) provided other reasons for an individual on becoming a gig worker. The author affirmed that couples that need time to raise children sometimes join the gig worker, also workers that are victims of a company downsizing join the gig workers. Lehdonvirta (2018) opined that sometimes students join gig workers to enhance their resumes and escape the stress of full-time work to enable plan for their personal vacation. Therefore, it can be affirmed that there is a significant benefit for been a gig worker. Aside from the benefit of been gig worker firms and company also enjoy low cost from employing gig workers (Graham et al., 2017). Table 1 presents the advantages and disadvantage of the gig economy.

Table 1: Advantages and disadvantages of gig economy

Advantages	Disadvantage
They are concerned about company performance because it is crucial for their self-sustainment.	The gig economy workers have a high chance of being disloyal to the company
They take up jobs that fit their talents thereby making them perform the job better.	The culture of the company will be diluted.
The personnel overhead cost to the company is reduced.	Volatile income
The organisation talent pool is not burdened	It is difficult to determine their contribution to the economy

Source: Author's review of the literature

3.METHODOLOGY

The study area is focused on Johannesburg within Gauteng province South Africa. Johannesburg was perceived as the most appropriate area for the study for several reasons. The most significant among the reasons are attributed to the nature of Johannesburg city. The city is the centre of commercial and industrial activities and has absorbed population drift from a different part of the province over the years (Osunsanmi et al., 2018b). This continually prompts the need for construction activities within the city that in return attracts numerous workers. This, therefore, formed the basis for picking construction professionals located within Johannesburg.

The study adopts random sampling for selecting the respondents within the study area. This technique was chosen because of its capability to produce a smaller size from a larger population with the intent for making a generalization about the larger group (Kumar, 2019). Creswell and Creswell (2017) reported that random sampling works on the concept of obtaining a comprehensive list of a larger population and select random individuals to be adopted for the sample. The concept behind this sampling technique makes it suitable for this study because they are numerous construction professionals within Johannesburg. Therefore, professionals with close proximity to the researcher that are registered with their respective professional bodies are selected. A total of 70 construction professionals were selected with the selection based on their working conditions. Out of the selected construction professionals, 60 responded effectively and their response was analysed. The study utilized quantitative research method due to is capacity for analyzing data in number format through mathematical methods and generalizing the findings across a large group of specific peoples (Muijs, 2010). The quantitative data were analysed adopting statistical package for social science (SPSS) version 24 using frequency distributions.

4. DISCUSSION OF FINDINGS

4.1 Background Information

The background information of the respondents is summarized in table 2 below;

Table 2: Summary of Background Information

	Frequency	**Percent (%)**	**Cumulative percent**
Highest Academic Qualification			
ND/Diploma	17	28.3	28.3
B.Sc/ B.Tech	26	43.3	71.6
M.sc/ MBA/ MPM	10	16.7	88.3
Ph.D	7	11.7	100
Total	**60**	**100**	
Working Experience			
1-10 years	19	31.7	31.7
11-20 years	27	45.0	76.7
31-40 years	10	16.7	93.4
41-50 years	4	6.6	100
Total	**60**	**100**	

Table 2 presents the respondent's personal information such as their academic qualification and working experience. The table shows that all the respondents are educated thereby confirming their eligibility to answer the question posed by the research instrument. However, 43.3% of construction professionals are B.Sc/B. Tech degree holders, 28.3% of the respondents are ND/Diploma holders, while 16.7% have obtained MSc/MBA/MPM degree and few (11.7%) have studied up to PhD level. Regarding their working experience the table revealed that the respondents have a sufficient knowledge of the construction industry, therefore, confirming their eligibility to rate the gig economy. The table shows that 45% have a working experience between 11-20 years, 31.7% have worked for 10 years, 16.7% have an experience of 31-40 years and 6.6% have above 41 years working experience.

4.2 Awareness and Readiness to Adopt Gig Economy

Table 3 presents the respondent's awareness, readiness to adopt Gig economy and their level of agreement with the gig economy as a tool for ensuring sustainable livelihood for construction workers.

Table 3: Awareness and readiness to adopt the gig economy

	Frequency	Percent (%)	Cumulative Percent
Awareness with the gig economy			
Yes	38	63.3	63.3
No	22	36.7	100
Total	**60**	**100**	
Readiness to adopt Gig economy			
Neutral	15	25.0	25.0
Ready	37	61.7	86.7
Very ready	8	13.3	100
Total	**60**	**100**	
Agreement with gig economy as a tool for sustainable livelihood strategy			
Neutral	23	38.3	38.3
Agree	29	48.3	86.6
Strongly agree	8	13.4	100
Total	**60**	**100**	

Table 3 showed that more than half (63.3) of the respondents are aware of the possibilities for using the gig economy as a tool for sustainable livelihood of construction workers. The findings from this study further echo the discovery of (Wood et al., 2018) that revealed that there is a high level of awareness regarding the gig economy in Africa. According to Graham et al. (2017) workers are ready to embrace the gig economy with the intention of supplementing their income. This opinion was confirmed in this study as it discovered that a cumulative of 86.7% of the respondents are ready to adopt gig economy to further enhance their income. Table 3 presented the construction professionals level of agreement with gig economy as a sustainable livelihood strategy. It can be seen from the table that only 48.3% of the professionals agree that gig economy is a means of sustainable livelihood strategy. This percentage is smaller in comparison to other professions like nursing (Prestia, 2019).

4.3 Hinderance to the Adoption of the Gig Economy in the Construction Industry

The respondents were asked to rate their level of agreement to the factors that could hinder their adoption of the gig economy as a tool for sustainable livelihood strategy. Their response was acquired using a five-point Likert scale from not agree denoted by 1 to very agree represented by 5 and the outcome is presented by table 4.

Table 4: Hinderance to the adoption of a gig economy in the construction industry

	Mean score	Rank
Corrupt practice in the construction industry	4.82	1
Weak collaboration among workers	4.76	2
Dynamic nature of the industry	4.53	3
Education	4.36	4
Permanent workers are treated better	4.25	5
Trust	4.10	6
Volatile income	3.95	7
Lack of paid vacation for sick leave	3.76	8
Job uncertainty	3.62	9

Table 4 revealed that the major hindrance to the adoption of a gig economy in the construction industry is corrupt practice in the construction industry and weak collaboration among workers with a mean score of 4.76 above. Likewise Windapo (2016) discovered that corruption within the construction industry is responsible for loss in skills among workers. Other significant factors that hinder the adoption of the gig economy in the construction industry include dynamic nature of the construction industry, education, trust and discrimination among permanent workers been treated better. Whereas factors like volatile income, lack of paid vacation for sick leave and job uncertainty were rated as less significant factors affecting the adoption of gig economy in the construction industry.

5.CONCLUSION

The construction industry is a vital part of the economy contributing enormously to a country's GDP through the provision of infrastructures and job employment. The industry contributes to the economy through the activities performed by the construction workers both skilled and unskilled. Unfortunately, the workers in the construction industry are susceptible to poor wages and salary that in return affect their sustainable livelihood strategy. sustainable livelihood is a strategy adopted by an individual with the intention of creating an additional income outside their traditional employment. Workers livelihood strategy in other sectors has been improved through the adoption of the gig economy.

The gig economy is a labour market dominated with the use of short term contracts or freelance workers as opposed to permanent jobs. It can also be described as a temporary job performed on a permanent project. A worker in the gig economy is different from a consultant as they are often referred to as freelancer's careerists, self-employed specialists or members of a mobile workforce. The idea of gig workers has grown rapidly in other sectors like transportation, nursing, banking and many others. Due to the growth of the gig economy in these sectors, numerous research has been directed into the challenges, principles and benefits of gig economy as a means of sustainable livelihood. However, within the construction industry especially in South Africa little is known about gig economy as a tool for sustainable livelihood strategy.

Therefore, this study filled the gap in research has it examined the challenges, awareness and agreement with the gig economy as a tool for sustainable livelihood strategy. It was discovered that construction professionals are aware of the possibilities for using gig economy as a tool for sustainable livelihood of construction workers. Aside from the awareness with the gig economy the study also discovered that construction professionals are ready to adopt gig economy to further enhance their income. However, in comparison to other sectors and professionals like nursing and banking it was discovered that the readiness level of construction professionals for adopting gig economy is low. The factors responsible for the low readiness for adopting gig economy in the construction industry was due to corrupt practice in the construction industry and weak collaboration among workers. The study recommends that collaborative practices should be encouraged and awareness regarding the gig economy should be created in the industry.

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THE POTENTIAL OF INDUSTRY 4.0 TO ENHANCE CONSTRUCTION HEALTH AND SAFETY (H&S) PERFORMANCE

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Abstract: Construction health and safety (H&S) challenges have persisted despite a range of interventions over decades and include adequate hazard identification and risk assessments (HIRAs), real time monitoring of construction-related activities, workers handling heavy materials, plant, and equipment, and ultimately, the experience of injuries. Given the abovementioned, and the advent of Industry 4.0, a quantitative study, which entailed the completion of a self-administered questionnaire online, was conducted among registered professional (Pr) and candidate (Can) Construction H&S Agents, to determine the potential of Industry 4.0 to contribute to resolving the challenges cited. The findings indicate that Industry 4.0 technologies such as augmented reality (AR), drone technology, virtual reality (VR), VR based H&S training, and wearable technology / sensors have the potential to resolve the cited H&S challenges as experienced in construction. Conclusions include that Industry 4.0 technologies can finally address the persistent H&S challenges experienced in construction. Recommendations include: employer associations, professional associations, and statutory councils should raise the level of awareness relative to the potential implementation of Industry 4.0 relative to H&S in construction; case studies should be documented and shared; tertiary construction management education programmes should integrate Industry 4.0 into all possible modules, especially H&S-related modules, and continuing professional development (CPD) H&S should address Industry 4.0.

Keywords: Construction, health and safety, industry 4.0, performance, South Africa.

1. INTRODUCTION

The Construction Industry Development Board (cidb) (2009) highlighted the considerable number of accidents, fatalities, and other injuries that occur in the South African construction industry in their report 'Construction Health & Safety Status & Recommendations'. The report cited the high-level of non-compliance with H&S legislative requirements, which the cidb contends is indicative of a deficiency of effective management and supervision of H&S on construction sites as well as planning from the inception / conception of projects within the context of project management. The cidb (2009) adds that poor construction H&S performance at organisational and site level is attributable to a lack of management commitment, inadequate supervision, and inadequate or a lack of H&S training. Furthermore, a lack of worker involvement, personal risk appreciation, and work pressure also contribute to poor performance. Park and Kim (2013) in turn contend that most accidents associated with construction work were attributable to a lack of proactive and preventive measures such as H&S workforce training, HIRA, H&S awareness, and H&S education.

According to the Council for Scientific and Industrial Research (CSIR) (2018), the Fourth Industrial Revolution (FIR), also known as Industry 4.0, is being driven by the rapid rise and convergence of emerging technologies. Industry 4.0 is a collective term for technologies and value chain organisation which draw together cyber-physical systems, the Internet of Things

(IoT) and the Internet of Services (IoS), together with other emerging technologies such as cloud technology, big data, predictive analysis, artificial intelligence, augmented reality, agile and collaborative robots, and additive manufacturing. Considering the numerous challenges experienced in construction, H&S included, it is inevitable that Industry 4.0 is considered to overcome these. According to Autodesk & CIOB (2019), digital technologies are transforming every industry, and construction is no exception. Infinite computing, robotics, machine learning, drones, the IoT, augmented reality, gaming engines, and reality capture, to name just a few, are innovating the design, build, and operation of buildings and infrastructure.

The implementation of Industry 4.0 is gaining momentum, and entails a paradigm shift that will have a significant impact on the management of occupational H&S. The adoption of Industry 4.0 related technology offers the construction industry a chance to improve efficiency, productivity, and H&S. For example, construction H&S monitoring relies heavily on manual observation to identify and monitor any potential hazards that may expose workers to H&S risks. This can become challenging, as construction sites must be continuously monitored to detect unhealthy and unsafe working conditions in order to protect workers from potential injuries and fatal accidents. However, Industry 4.0 brings technology such as augmented reality (AR), drones, virtual reality (VR), and wearable sensors that can mitigate many of these challenges.

Given the continuing poor H&S performance in South African construction, the aim of the study was to evolve an Industry 4.0 response to H&S challenges encountered in construction to determine the:

- Importance of six parameters to respondents' organisations;
- Frequency at which ten H&S phenomena are experienced on projects;
- The degree of effectiveness of current on-site H&S management in terms of eighteen aspects;
- Extent of the need for H&S improvement on projects;
- Respondents' self-rating of their awareness of / exposure to four Industry 4.0 technologies;
- Potential of Industry 4.0 technologies to improve H&S-related interventions / goals, and
- Potential of Industry 4.0 technologies to reduce the occurrence of H&S phenomena.

In terms of the study reported on, the Industry 4.0 technologies considered, include augmented reality (AR), drones, virtual reality (VR), and wearable sensors.

2. REVIEW OF THE LITERATURE

2.1 Statistics

The disabling injury incidence rate (DIIR) in South African construction is 0.98 i.e. 0.98 disabling injuries per 100 workers, the all industry average being 0.78, and a fatality rate of 25.5 per 100 000 workers, which does not compare favourably with international rates (cidb, 2009). The Australian construction industry fatality rate per 100 000 for 2016 was 3.3 (Safe Work Australia, 2017) and for the United Kingdom, was 1.94 in 2015 / 2016 (Health & Safety Executive, 2016). The severity rate (SR) in turn indicates the number of days lost due to accidents for every 1 000 hours worked. The South African construction industry SR 1.14 is the fourth highest, after fishing, mining, and transport, the all industry average being 0.59. Given that the average worker works 2 000 hours per year, if the SR is multiplied by 2, the average number of days lost per worker per year can be computed – the construction industry lost 2.28 working days per worker. This is equivalent to 1.0% of working time.

2.2 Cost of Accidents

The cidb (2009) also refer to Smallwood's 2004 findings that the total cost of accidents (COA) could have been between 4.3% and 5.4%, based upon the value of construction work completed in South Africa. Therefore, the indirect motivation exists for CPMs to reduce project costs through improved H&S performance. Furthermore, the key issue relative to the COA is that ultimately, clients incur the COA as the COA is included in contractors' cost structures in the form of indirect costs, as contractors do not disaggregate costs when preparing tenders.

2.3 Drones

A study conducted by Gheisari and Esmaeili (2016) determined that using unmanned aerial vehicles (UAVs) commonly referred to as 'drones', to monitor construction activities could help identify potential on site hazards and therefore improve H&S management. They state that UASs provide an effective solution to carry out real-time monitoring and improve H&S monitoring and control practices on site. According to Alizadehsalehi et al. (2017), UAV technologies can easily monitor the entire construction site by flying around the construction area under a H&S manager's control and transmit real-time information for inspecting H&S purposes related to the project. UAV technology can enable H&S managers to identify hazards at different stages of the project and develop suitable mitigation strategies (Alizadehsalehi et al., 2017).

The Health & Safety Executive (HSE) (2019) states that recent advances in access technologies such as UAVs or drones, and Remotely Operated Vehicles (ROVs) coupled with imaging technology, have enabled increasing replacement of the human element in terms of visual inspection. This is beneficial in terms of avoidance of high-risk manned interventions such as in confined spaces, working at height, or in hazardous environments (HSE, 2019a).

2.4 Virtual Reality and Augmented Reality

In recent years visualisation technologies such as VR and AR have been developed and used to improve construction productivity, H&S, and quality (Le et al., 2015). Both AR and VR have the potential to improve on site construction processes (Le et al., 2015). According to Park et al. (2013), AR based applications and systems have been developed to improve on-site tasks such as data visualisation, work inspection, and checking for omissions. Furthermore, they have improved on-site H&S performance to some extent.

2.5 Virtual Reality Systems as Training Modules

Silliker (2018) states that VR is rapidly gaining traction as a training tool in occupational H&S. VR technology provides a virtual environment that allows users to immerse themselves in a virtual world that uses sight, sound, and sometimes motion to provide a realistic experience (Silliker, 2018). Wang et al. (2018) state that construction is a high-risk industry where accident rates remain high; reasons leading to the high level of risk include limited H&S knowledge of on-site workers, and lack of H&S awareness and training of these individuals. Furthermore, construction H&S training has traditionally been presented in a classroom setting with slide presentations or videos, however, the H&S information provided in the presentations and videos often do not represent real construction site conditions (Wang et al., 2018).

A study conducted by Sacks et al. (2013) determined that VR-based training was more effective than traditional H&S training methods, which made use of classrooms and slide presentations. The study determined that workers had better recall in identifying and assessing construction H&S risks, than they would have using traditional conventional methods. According to Wang et al. (2018), there are currently a few VR-related technologies that have been developed to improve the current construction H&S training practices. VR is becoming more popular in the occupational H&S space as it provides a method of training workers relative to their actual job tasks in a safe environment (Silliker, 2018).

2.6 Wearable Technology in H&S Management

Seo et al. (2015) state that due to the hazardous working environments on construction sites, workers are frequently faced with potential H&S risks throughout the entire construction process. Nath et al. (2017) state that "construction works are labour-intensive and often stipulate the workers to go beyond their natural physical limits to cope with the increasing complexities and challenges of their assigned tasks".

Traditional approaches of measuring H&S performance indicators are largely manual in nature (Awolusi et al., 2018). To overcome these limitations of manual efforts, automated H&S monitoring is considered one of the most promising methods for accurate and continuous monitoring of H&S performance on construction sites (Awolusi et al., 2018). According to the HSE (2019b), there is growing evidence that wearable devices can significantly benefit H&S in the workplace through positioning and sensor technologies. To this end, the priority areas for a pending research project are monitoring occupational personal exposure to hazardous substances and physical hazards on construction sites, and musculoskeletal disorders (MSDs) in workers identified at greater risk.

Wearable technologies can enable the continuous monitoring of a wide range of vital signals which can provide early warning systems for workers with high-risk health issues (Ananthanarayan and Siek, 2010). Cousins (2018) in turn highlights that wearable devices can detect fatigue risk, high heart rates, and stress.

A study conducted by Nath et al. (2017) found that wearable technology was able to prevent work related injuries and fatalities by ergonomically designing the work environment based on previous data collected. The use of this technology was able to identify and eliminate the ergonomic risks at the source to prevent similar incident from re-occurring (Nath et al., 2017).

3. RESEARCH

3.1 Research Method and Sample Strata

The exploratory study entailed the completion of a self-administered online questionnaire survey. The sample strata for the research study included 92 Pr Construction Health and Safety Agents (CHSAs), and 139 Can CHSAs registered with the South African Council for the Project and Construction Management Professions (SACPCMP). The questionnaire consisted of eighteen questions – seventeen closed ended, and one open-ended. Twelve of the close ended questions were Likert scale type questions, and five were demographics related. 63 Responses were included in the analysis of the data, which entailed the computation of frequencies, and a measure of central tendency in the form of a mean score (MS), to enable the interpretation of percentage responses to Likert point scale type questions, and the ranking of variables. The 63 responses equate to a response rate of 31.2%.

As stated in the 'Introduction' above, in terms of the study reported on, the following Industry 4.0 technologies were considered: AR; drones; VR, and wearable sensors.

3.2 Research Findings

Table 1 indicates the importance of six project parameters to respondents' organisations in terms of MSs ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (not important) to 5 (very important). It is notable that all the mean MSs are above the midpoint of 3.00, which indicates that in general the respondents can be deemed to perceive the parameters as important. It is notable that 5 / 6 (83.3%) of the parameters have mean MSs > 4.20 ≤ 5.00, which indicates they are between more than important to very / very important. It is notable that H&S, the study subject, is ranked fifth after productivity, cost, time, and quality.

Notable differences between the sample strata includes H&S achieved a ranking of 1st relative to the Can CHSAs, but 5th relative to the Pr CHSAs, although the MSs are 4.30 and 4.33 respectively. Furthermore, five of the Pr CHSAs' MS are higher than the highest Can CHSA MS.

Table 1: Importance of six project parameters to respondents' organisations

Parameter	Can CHSAs		Pr CHSAs		Mean	
	MS	Rank	MS	Rank	MS	Rank
Productivity	4.23	3	4.61	2	4.43	1
Cost	4.20	4	4.61	1	4.41	2
Time	4.27	2	4.48	4	4.38	3
Quality	4.13	5	4.48	3	4.32	4
Health and safety	4.30	1	4.33	5	4.32	5
Environment	4.00	6	4.06	6	4.03	6

Table 2 indicates the frequency at which ten H&S phenomena are experienced on projects in terms of MSs between 1.00 and 5.00, based upon percentage responses to a scale of never to constantly. It is notable that 7 / 10 (70.0%) mean MSs are above the midpoint of 3.00, which indicates that in general the respondents can be deemed to perceive the phenomena to be experienced on projects. The mean MS of the phenomenon 'similar incidents reoccur' falls on the cut point. It is notable that no phenomena are experienced between often to constantly / constantly (MSs > 4.20 ≤ 5.00). 4 / 10 (40.0%) mean MSs are > 3.40 ≤ 4.20, which indicates the frequency is between sometimes too often / often - workers handle heavy materials, plant, and equipment, delays, on site hazards, and difficulty is experienced in terms of real time monitoring of construction-related activities. The remaining 6 / 10 (60.0%) mean MSs are > 2.60 ≤ 3.40, which indicates the phenomena are experienced betwee rarely to sometimes / sometimes - activities are commenced on site without adequate HIRAs, workers are unaware of the hazards and risks related to the construction process and its activities, design process-related hazards are encountered on site, similar incidents reoccur, accidents, and injuries.

A notable difference between the sample strata is that six of the Pr CHSAs' MS are higher than the highest Can CHSA MS. There are no major differences between the two in terms of the ranks achieved by the phenomena.

Table 2: Frequency at which ten H&S phenomena are experienced on projects

Phenomenon	**Can CHSAs**		**Pr CHSAs**		**Mean**	
	MS	**Rank**	**MS**	**Rank**	**MS**	**Rank**
Workers handle heavy materials, plant, and equipment	3.50	1	3.70	2	3.60	1
Delays	3.20	3	3.85	1	3.54	2
On site hazards	3.28	2	3.70	3	3.50	3
Difficulty is experienced in terms of real time monitoring of construction-related activities	3.17	4	3.66	4	3.42	4
Activities are commenced on site without adequate HIRAs	3.11	6	3.64	5	3.39	5
Workers are unaware of the hazards and risks related to the construction process and its activities	3.00	8	3.53	6	3.27	6
Design process-related hazards are encountered on site	3.14	5	3.27	7	3.21	7
Similar incidents reoccur	3.03	7	2.97	8	3.00	8
Accidents	2.86	9	2.88	9	2.87	9
Injuries	2.73	10	2.88	10	2.81	10

Table 3 indicates the effectiveness of current on-site H&S management in terms of eighteen aspects in terms of MSs between 1.00 and 5.00, based upon percentage responses to a scale of 1 (hardly), and 5 (highly). It is notable that 14 / 18 (77.7%) mean MSs are above the midpoint of 3.00, which indicates that in general the respondents can be deemed to perceive the H&S management of these aspects to be more than effective. It is notable that no aspects have mean MSs $> 4.20 \leq 5.00$ – more than effective to highly / highly effective. 6 / 18 (33.3%) of the mean MSs are $> 3.40 \leq 4.20$, which indicates the current on-site H&S management is between effective to more than effective / more than effective. Thereafter, 11 / 18 (61.1%) mean MSs are $> 3.40 \leq 4.20$, which indicates the current on-site H&S management is between less than effective to effective / effective. The last ranked aspect has a mean MS $> 1.80 \leq 2.60$, albeit 2.58, marginally below the upper point of the range, which indicates the current on-site H&S management is between hardly effective to less than effective / less than effective.

Notable differences between the sample strata includes three of the Can CHSAs' MS are higher than the highest Pr CHSA MS, and the rankings achieved by preventing delays, and incident reporting relative to the Can CHSAs (13^{th} & 6^{th} respectively), and Pr CHSAs (4^{th} & 11^{th} respectively).

Table 3: The degree of effectiveness of current on-site H&S management in terms of eighteen aspects

Aspect	**Can CHSAs**		**Pr CHSAs**		**Combined**	
	MS	**Rank**	**MS**	**Rank**	**MS**	**Rank**
H&S induction	3.97	1	3.64	3	3.79	1
H&S toolbox talks	3.87	2	3.69	1	3.77	2
Preventing injuries	3.77	3	3.66	2	3.71	3
Preventing accidents	3.67	4	3.56	5	3.61	4
Mitigating risks on site	3.63	5	3.45	6	3.54	5
Preventing delays	3.33	13	3.63	4	3.48	6
Incident reporting	3.63	6	3.18	11	3.40	7
Carrying out adequate HIRAs	3.53	7	3.25	8	3.39	8
H&S workforce training	3.50	9	3.21	9	3.35	9
Protecting workers in general	3.53	8	3.16	12	3.34	10
Monitoring the construction process and its activities	3.40	11	3.27	7	3.33	11
Supervision	3.37	12	3.21	10	3.29	12
Preventing similar incidents from reoccurring	3.30	14	3.06	13	3.18	13
Identifying potential construction process-related hazards	3.43	10	2.88	15	3.14	14
Observation	3.03	16	2.94	14	2.98	15
Identifying potential design process-related hazards during design	3.10	15	2.82	16	2.95	16
Real time monitoring	3.03	17	2.72	17	2.87	17
Preventing workers from handling heavy materials, plant, and equipment	2.90	18	2.28	18	2.58	18

Table 4 indicates the extent of the need for H&S improvement on projects in terms of MSs ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (minor) to 5 (major). It is notable that all the mean MSs are above the midpoint of 3.00, which indicates that in general the respondents can be deemed to perceive the need for improvement to be major as opposed to minor. It is notable that 9 / 11 (81.8%) mean MSs are > 4.20 ≤ 5.00, which indicates the respondents perceive the need for improvement to be between near major to major / major - improved supervision, improved observation, improved HIRAs, healthier working conditions, safer working conditions, improved H&S training, reduced occurrence of H&S incidents / accidents, improved monitoring of worker health, and improved monitoring of worker activities. Real time monitoring, ranked tenth, and automation of activities on site, ranked eleventh, have mean MSs > 3.40 ≤ 4.20, which indicates the respondents perceive the need to be between some improvement to a near major / major improvement. Many of these needs are frequently referred to in the literature and can be responded to by Industry 4.0 technologies.

A notable difference between the sample strata is that nine of the Pr CHSAs' MS are higher than the highest Can CHSA MS. There are no major differences between the two in terms of the ranks achieved by the first five phenomena.

Table 4: Extent of the need for H&S improvement on projects

Need	Can CHSAs		Pr CHSAs		Mean	
	MS	**Rank**	**MS**	**Rank**	**MS**	**Rank**
Improved supervision	4.23	4	4.61	1	4.43	1
Improved observation	4.23	3	4.61	2	4.43	2
Improved HIRAs	4.30	1	4.55	3	4.43	3
Healthier working conditions	4.27	2	4.45	5	4.37	4
Safer working conditions	4.23	5	4.45	6	4.35	5
Improved H&S training	4.20	8	4.48	4	4.35	6
Reduced occurrence of H&S incidents / accidents	4.17	9	4.39	7	4.29	7
Improved monitoring of worker health	4.20	6	4.36	8	4.29	8
Improved monitoring of worker activities	4.20	7	4.33	9	4.27	9
Real time monitoring	4.10	10	4.18	10	4.15	10
Automation of activities on site	3.70	11	3.73	11	3.71	11

Table 5 indicates the respondents' self-rating of their awareness of / exposure to four Industry 4.0 technologies in terms of MSs ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (limited) to 5 (extensive). It is notable that none of the mean MSs are above the midpoint of 3.00, which indicates that in general the respondents can be deemed to rate themselves below average. Only 1 / 4 (25.0%) mean MSs are > 2.60 ≤ 3.40, which indicates a rating of below average to average / average -drones. The remaining 3 / 4 (75.0%) mean MSs are > 1.80 ≤ 2.60, which indicates a rating of limited to below average / below average - virtual reality, wearable technology / sensors and augmented reality. The findings indicate that the respondents have generally a low level of awareness / had limited exposure to the four technologies to date.

A notable difference between the sample strata is that three of the Can CHSAs' MS are higher than the corresponding Pr CHSA MSs. It is notable that the ranks are identical for the two sample strata and the mean.

Table 5: Respondents' self-rating of their awareness of / exposure to four Industry 4.0 technologies

Aspect	Can CHSAs		Pr CHSAs		Combined	
	MS	**Rank**	**MS**	**Rank**	**MS**	**Rank**
Drones	2.64	1	2.69	1	2.67	1
Virtual Reality	2.52	2	2.13	2	2.31	2
Wearable technology / sensors	2.39	3	2.03	3	2.20	3
Augmented Reality	2.13	4	2.03	4	2.07	4

Table 6 indicates the potential of four Industry 4.0 technologies to improve H&S-related interventions / goals in terms of MSs ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (minor) to 5 (major). It is notable that all the MSs (100.0%) are above the midpoint of 3.00, which indicates that in general the respondents can be deemed to perceive the potential to be above average. It is notable that only one mean MS is > 4.20 ≤ 5.00, which indicates near major to major / major potential – observation. The remaining 10 / 11 (90.9%)

mean MSs are > 3.40 ≤ 4.20, which indicates between potential to near major / near major potential. 7 / 11 (63.6%) of these phenomena fall in the upper half of the range, namely > 3.80 ≤ 4.20 – supervision, real time monitoring, monitoring of worker activities, HIRAs, monitoring of worker safety, H&S training, and improvement of working conditions. The remaining 3 / 11 (27.3%) mean MSs are > 3.40 ≤ 3.80, which indicates between potential to near major / near major potential - reduced occurrence of H&S incidents / accidents, monitoring of worker health and automation of activities on site. Despite the respondents' generally low self-rating of their awareness of / exposure to the identified four Industry 4.0 technologies, they recognise the potential of Industry 4.0 technologies to improve the stated H&S-related interventions / goals. A notable difference between the sample strata is that six of the Pr CHSAs' MS are higher than the highest Can CHSA MS. There are no major differences between the two in terms of the ranks achieved by the first six phenomena.

Table 6: Potential of Industry 4.0 technologies to improve H&S-related interventions / goals

Intervention / Goal	**Can CHSAs**		**Pr CHSAs**		**Mean**	
	MS	**Rank**	**MS**	**Rank**	**MS**	**Rank**
Observation	4.07	1	4.39	2	4.25	1
Supervision	3.93	4	4.41	1	4.18	2
Real time monitoring	4.04	2	4.10	6	4.07	3
Monitoring of worker activities	3.93	6	4.18	3	4.07	4
HIRAs	4.04	3	4.06	7	4.05	5
Monitoring of worker safety	3.93	5	4.16	5	4.05	6
H&S training	3.85	8	4.16	4	4.02	7
Improvement of working conditions	3.89	7	3.93	8	3.91	8
Reduced occurrence of H&S incidents / accidents	3.59	10	3.88	9	3.75	9
Monitoring of worker health	3.64	9	3.77	10	3.71	10
Automation of activities on site	3.41	11	3.77	11	3.60	11

Table 7 indicates the potential of four Industry 4.0 technologies to reduce the occurrence of H&S phenomena in terms of MSs ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (minor) to 5 (major). It is notable that all the MSs (100.0%) are above the midpoint of 3.00, which indicates that in general the respondents can be deemed to perceive the potential to be above average. It is notable that no mean MSs are > 4.20 ≤ 5.00 - between near major to major / major potential – observation. 12 / 13 (92.3%) mean MSs are > 3.40 ≤ 4.20, which indicates between potential to near major / near major potential. 3 / 12 (25.0%) of these phenomena fall in the upper half of the range, namely > 3.80 ≤ 4.20 – risks, hazards, and accidents. The remaining 9 / 12 (75.0%) mean MSs are > 3.40 ≤ 3.80, two of which have mean MSs of 3.79, 0.01 below 3.80 – injuries, and unsafe acts. Despite the respondents' generally low self-rating of their awareness of / exposure to the identified four Industry 4.0 technologies, they recognise the potential of Industry 4.0 technologies to improve the stated H&S-related interventions / goals.

A notable difference between the sample strata is that eight of the Pr CHSAs' MS are higher than the highest Can CHSA MS. There are no major differences between the two in terms of the ranks achieved by the first six phenomena.

Table 7: Potential of Industry 4.0 technologies to reduce the occurrence of H&S phenomena

Phenomenon	Can CHSAs		Pr CHSAs		Mean	
	MS	Rank	MS	Rank	MS	Rank
Risks	3.79	2	4.13	1	3.97	1
Hazards	3.79	3	4.06	2	3.93	2
Accidents	3.85	1	4.00	4	3.93	3
Injuries	3.63	4	3.94	7	3.79	4
Unsafe acts	3.62	5	3.94	6	3.79	5
Unsafe working conditions	3.46	8	3.97	5	3.74	6
Difficulty in terms of monitoring workers	3.43	10	4.00	3	3.73	7
Difficulty in terms of monitoring on-site activities	3.52	7	3.88	8	3.72	8
Similar incidents reoccurring	3.54	6	3.77	9	3.66	9
Sprains and strains among workers	3.39	11	3.71	10	3.56	10
Unhealthy working conditions	3.29	12	3.60	12	3.45	11
A shortage of workers with the necessary skills	3.44	9	3.43	13	3.44	12
Delays	3.11	13	3.62	11	3.37	13

4. CONCLUSIONS

Given that productivity, and the traditional project parameters of cost, time, and quality are more important than H&S, it can be concluded that despite the respondents being construction H&S practitioners, the importance of parameters to their organisations reflects the prevailing paradigm in South African construction.

Given the frequency that ten H&S phenomena are experienced on projects by respondents, it can be concluded that the respondents' experience reflects the general research findings relative to H&S performance in South African construction, and that there is a need for improvement, potential to improve, and a need for the implementation of Industry 4.0. This conclusion is reinforced by the findings relative to the extent of the need for H&S improvement on projects, and the potential of Industry 4.0 technologies to improve H&S-related interventions / goals.

Given the degree of effectiveness of current on-site H&S management in terms of eighteen aspects, it can be concluded that the respondents' experience reflects the general research findings relative to H&S performance in South African construction, and that there is a need for improvement, potential to improve, and a need for the implementation of Industry 4.0.

Given the extent of the need for H&S improvement on projects, it can be concluded that the respondents' experience reflects the general research findings relative to H&S performance in South African construction, and that there is a need for the implementation of Industry 4.0.

Given the respondents' below average self-rating of their awareness of / exposure to four Industry 4.0 technologies, it can be concluded that there is a need for interventions to raise the level of awareness, and to integrate such technologies into built environment / construction education and training. However, this should be expedited in a contextual manner.

Given the potential of Industry 4.0 technologies to reduce the occurrence of H&S phenomena, the need for the implementation of Industry 4.0 in construction is amplified.

5. RECOMMENDATIONS

Built environment-related tertiary education must include, or rather embed Industry 4.0 in their programmes, and H&S-related modules should address the role of Industry 4.0 technologies.

Construction employer associations, and built environment associations and statutory councils must promote, and preferably provide H&S-Industry 4.0 continuing professional development (CPD) and evolve related guidelines and practice notes.

The Construction Industry Development Board (cidb) should evolve a position paper relative to Industry 4.0 in construction and deliberate the development of a related industry standard.

Researchers should actively conduct and document H&S-related Industry 4.0 case studies to record the benefits of implementing Industry 4.0 technologies.

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CONSULTATIVE APPROACH TO BIM IMPLEMENTATION

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Abstract: Building Information Modeling is transforming AECOO industry, it introduces new approaches and new technology as well as collaborative working environment amongst different stakeholders. BIM requires new method of management adapted to the new concept. As a result, a managerial gap within construction industry is created. New skills, expertise and standards have been developed to fulfil the gap. One of the reasons of the shortage of professionals adapted to the new era is the lack of investment in R&D in organizations. One option to bridge the gap in organizations is to involve an external BIM consultancy firm. The role of external BIM consultancy in bridging the gap in Architectural firms is the subject of the research. The objective is to identify the challenges faced by architecture firms in lack of internal R&D and how an external BIM consultancy can bridge the gap. An overview of the literature is discussed, interviews with industry experts verify the concept. The findings approve that lack of R&D in organizations results in lack of skilled professionals which is one of the key reasons of the gap. Other factors such as resistance to change was mentioned as well through the interviews. Recommendations on how to approach the managerial gap are discussed. As well future research related to the subject is proposed.

Keywords: building information management (BIM) implementation, research & development (R&D), external BIM consultancy, resistance to change.

1. INTRODUCTION

According to Coates, Arayici, Koskela (2010) "*BIM is not just another CAD, it is the shift from presenting information about the building to representing this information*". BIM technology allows the users to explore the old method in a new way and it prototypes the design process. BIM provide a new platform that enables interoperability between different stakeholders as well as it supports an integrated project delivery approach.

Based on Eastman, Teicholz, Sacks and Liston (2008) Building Information Modeling (BIM) has its roots in computer-aided design (CAD) research. Transferring from a 2D environment to BIM (3D) requires more than just acquiring different softwares and upgrading hardware. Improving the process of the whole phase of design and construction will reduce problems related to the traditional process in construction industry. There are general steps to be considered when implementing BIM, however each firm has its specific needs and requirements based on its sector. Although the AECOO (architecture, engineering, construction and owner-operated) is in the early years of BIM implementation, Building Information Modeling has supported and improved many business practices and facilitated a more integrated process that results in better quality buildings.

Autodesk Whitepaper (2008) defines BIM as "*An integrated process built on coordinated reliable information about a project from the design through construction and operations".* Based on McGraw Hill-Construction (2009, 2010) BIM adaption and implementation among major stakeholders across the globe have increased over the past years. Arayici, Kiviniemi, Coates, Koskela, Usher, and O'Reilly (2011) discuss that architectural profession is under pressure to adapt BIM. Since the owners became aware of the benefits of BIM, they started to request BIM on their projects. BIM is an innovative concept in AECOO industry, however, its implementation is not an easy process and usually the firms in different sectors are unaware of the challenges that they can face during its implementation at the level of project or organization (Criminale & Langar, 2017).

2. LITERATURE

The new ideas emerge in construction industry. Crotty (2012) believes that low level of investment in research and development (R&D) is one of the problems within organizations. The digital revolution is changing the nature of not only the construction industry but also other industries, however manufacturing went through those changes sooner than construction industry. Crotty (2012) asks a few questions, such as "what is the nature of the innovation? How rapid is the adaption? What are the benefits? Over the last 60 years of digital revolution, the changes transformed all the sectors, however what Crotty (2012) found interesting is that none of the firms embarked on the adaption consciously. All the sectors first started by resisting to new technology and innovation, however finally they took the innovative step. CAD/CAM (computer-aided design/computer-aided manufacturing) transformed the firms. Innovative process involves the development of technical standards and their adaption by the industry. The process of transformation in the majority of the cases is a progressive one. The firms started to automate one function, the next step was to link the systems, next was integration the groups of functions and then linking the operations and system. The aim of each of those steps was to reduce costs, better efficiency, through innovation and process management. The same steps are happening in construction industry globally and the firms are going through the BIM journey due to the pressure to provide a better service.

Bessant (1995) mentions that technology competence refers to the technological resources, skill and experience. This total package (technological resources, skill and experience) give the firms their distinctive competitive edge. There are various way to built-up those skills, it could be internally, through R&D or other sources. However, the firms need to look at external sources to fulfil the gap in their organizations. Technology transfer is the process through which the technology inter an organization. The transformation of the technology can be in many forms. It could be in form of a hardware, software or knowledge. The multi-dimensional nature of knowledge transfer requires wide ranges of process, policies implication. It is not just through a software training that the transfer will happen. The second point to consider is that it is time consuming process as it requires several stages. Each stage requires involvement of different parties (participants) as well as different activities to be performed. Bessant (1995) recognize different consultancy players in AMT (Advanced Manufacturing Technology). In the early days of AMT consultancy was dominated by technical and engineering-based consultancies and similar organisations. Below is a list of consultancy agencies:

- Major league management consultancies
- Software and systems houses,
- Hardware and systems suppliers
- Human resource management consultancies
- Universities and colleges
- Training consultancies
- Contract and industry research organizations

According to Bessant (1995) BIM requires a new way of management due to emergence of new technology and new processes. The managerial gap within the AECOO is created and it requires new competencies which can be built-up internally through R&D and/or through external sources; such as professional associations or private external consultancy /external 3rd parties. Technology transfer may be in a physical form or intellectual (knowledge) capabilities. However, technology transfer is a time-based process involving sequences of stages. Many organizations hire external consultancy firms as an intermediary to bridge the gap between the current state and the future state of the organization. The external consultancy input varies from offering of specific technological competencies to skill-specific subjects. However, their involvement goes further than that and it covers the managerial gap as well and the development of internal capabilities (Bessant, 1995). The external consultancy has an important role in bridging the gap in terms of technology and knowledge for the AECOO industry and their input has an impact on the overall advancement of the construction industries.

There are two approaches to consulting that are considered complementary rather than conflicting. First approach presents rather a broad definition of consulting. Fritz Steele defines consulting in this way" *any form of providing help on the content, process, or structure of a task or series of tasks, where the consultant is not actually responsible for doing the task itself but is helping those who are.*". The second approach defines consulting as a professional service and considers a number of characteristics that such a service must possess. According to Larry Greiner and Robert Metzger, "*management consulting is an advisory service contracted for and provided to organizations by specially trained and qualified persons who assist, in an objective and independent manner, the client organization to identify management problems, analyse such problems, and recommend solutions to these people.* (Kubr, 2002). In the research the second definition is considered, however as it mentioned above the two approaches are complementary.

The management consulting, the term used by Kubr (2002) is a method of assisting organizations to improve management and business practices, as well as individual and organization performance. Management consulting can be described as "transferring to clients knowledge required for managing and operating business". The nature of consulting is to create, transfer and apply business knowledge. The term knowledge in addition to theoretical knowledge encompasses experience, expertise, skills, and competencies. As a result the knowledge transfer is concerned both understanding and capabilities for the effective application of knowledge in organizational environment.

Kensek and Peng (2012) in Practical BIM 2012 provide a list of common services by BIM consultants throughout BIM implementation in an organization, some of them are mentioned below:

- Assess the current state of the firm in terms of processes, workflow and setup from actual production work, PD, SD, DD, CDs to internal and external collaboration efforts
- Identify a pilot project provide recommendations based on project deadlines, budget, timeframe and level of complexity
- Define staffing needs
- Provide custom and tailored training based on the project needs
- Develop / Update BIM Standards for the firm
- Develop a Company (BIM software) template

- Pre-Build (BIM Software) project specific content or companywide standard content (walls, doors, windows, schedules, etc.)
- Provide Project Optimization and Evaluation

However, the above list covers the tasks related to the projects and mostly technology oriented.

Azhar, Khalfan, Maqsood (2012) in "Now and beyond" mentions the barriers of BIM implementation relating to different stakeholders in the construction industry. These barriers and risks are categorized into two broad categories; technology-related risks and process related ones. Azhar et al. (2012) summarize the issue related to BIM implementation as;

- Management challenges by the use of BIM
- Lack of guidance on how to implement BIM
- Challenges related to contract documents
- Software firms do not treat the BIM process as a whole, they address certain quantitative aspects of it
- There is a need to standardize the BIM process and guidelines for its implementation
- Challenges related to the ownership of model
- Challenges related to development and operational costs of the model

Eastman (2008) argues that one of the challenges of the firms is how to engage the senior staff and the partners in the new intellectual transition, however when it comes to resistance to change as a barrier, there is no definition or any detail. According to Hammer and Champy (1993, as cited in Coates 2013) the fundamental error made by most organizations is that the technology is seen through the lens of the existing process. Rather than asking '*How can we use technology to allow us to do things that we are not already doing?*' they ask '*How can we use these new technological capabilities to enhance or streamline or improve what we are already doing*? Hiatt (2006, as cited in Coates 2013) developed Prosci ADKAR model, Prosci stands for **Pro**fessional + **Sci**ence and ADKAR means;

A **Awareness** of the need for change
D **Desire** to support and participate in change
K **Knowledge** of how to change
A **Ability** to implement the change
R **Reinforcement** to sustain the change

In this model in fact it is not the organization that changes but rather the individual behaviour changes, people within organizations change. The change in collective behaviour results in different outcomes for the organization. Based on the ADKAR model there is a link between process change and the associated business results. This link is called collection of individual changes and it occurs one person at a time. To manage change both individual change management and organization change management must be used together (The Prosci ADKAR model: Why it works, n.d.). The ADKAR model, does not consider organization management sufficient for change. In fact, it calls it change management and to achieve change management both individual change management and organization change management is necessary and one without the other one does not give result.

As the world changes, organizations need to adapt to the new requirements of the new era. It starts with an uncertainly situation for the organizations and the adaptation requires new-skilled people. The new challenges created by new technology and new approaches push the academic institutions and researchers to undertake actions and exploit the new situation. The construction industry is facing new challenges since a decade ago. There is an unprecedented need for professionals to bridge the gap between the Educational Institutions and different sectors of construction industry. External BIM consultancy is one of the ways to help organizations and provide skills and competences that will enable the Architectural firms to apply new digital transformation and create value through digital design and integrated project delivery approaches (Haron, Marshall-Ponting & Aouad, 2010)

To synthesize, Building Information Modeling is transforming the AECOO industry, it introduces new approaches and new technology as well as collaborative working environment amongst different stakeholders. BIM requires a new method of management adapted to the new concepts. As a result, a managerial gap within construction industry is created. New skills, expertise and standards are created to fulfil the gap. One of the reasons of the shortage of professionals adapted to the new era is the lack of investment in R&D in organizations. One option to bridge the gap in organizations is to involve an external BIM consultancy firm to fulfil the gap. The role of external BIM consultancy in bridging the gap in Architecture firms is the subject of the research, as per the literature.

3. METHODOLOGY

According to Crotty (as cited in Gray, 2004) there is an interrelationship between different layers of research from epistemology to theoretical perspectives and choice of methodology as well as the selection of methods. Saunders, Lewis and Thornhill (2009) has the same opinion and agrees that prior to data collection and analysis procedures, there are other issues to be consider. Guba and Lincoln (1994, as cited in Saunders et al., 2009) share the same perspective. What is significant to the researchers is to understand the interpretation of ontology and epistemology. Ontology is the study of being or the nature of existence/reality. Epistemology describe a philosophical background, in other words it provides the answer to “what it means to me” or what kind of knowledge are adequate, whereas ontology searches to understand “What is” (Gray, 2004). As Easterby-Smith *et al.* (1991, as cited in Gray, 2004) emphasis, an epistemological perspective has a significant impact on the whole research, first it helps to interpret the issues of research design, rather than just the design of research tools, and secondly a philosophy approach helps the researcher to be able to interpret the situation.

Prior to undertaking research it is necessary to understand the nature of the research (deductive, inductive) and its relation to the practice. Inductive approach is particularly concerned with the context in which the events are taken place, it means the study of a small sample of subjects rather than a large number one, whereas deductive approach is hypotheses testing and describes what is happening. The choice of deductive/inductive has an impact on the research choice of qualitative/quantitative data analysis (Easterby-Smith *et al.,* 2008 as cited in Saunders et al., 2009)**.**

Once the research approach is chosen, the next step is the choice of methodology followed by the choice of research data collection method. Different methodology could be chosen such as survey, case study, etc. Survey option is particularly used to gather the data from the industry experts. For data collection method different options can be chosen, however one of the choice that can be apply to different research approach is interview. The nature of the interviews needs to be consistent with research objectives and the research strategy. Semi-structured interviews is a list of questions or questions and themes, the subject may vary from interview to interview

(Saunders et al., 2009). In a research qualitative analysis, the data will be analysed based on the meanings expressed through the words. Requiring classification into categories and the analysis needs to be conducted through the creation of a conceptual frame (Saunders et al., 2009). According to Robson and McCartan (2016) in a qualitative data analysis, findings are presented verbally, and inductive approach is used. The purpose is to understand phenomena in their context and the situation is described from the perspective of the participants, and usually a small scale in terms of number of participants is selected.

The aim of the research is to explore the consultative approach to BIM implementation in Architectural firms. As the research's objective is seeking to interpret how "*humans are in a continuous process of social world"*. The authors decided to choose inductive approach. As inductive approach is particularly concerned with the context in which the events are taken place and it requires the study of a small sample of subjects. Four BIM manager/Design technology managers participated in the interview survey, interviewee A from a global architecture engineering and planning firm with more than 1000 employees around the world. Interviewee B from a Canadian architecture, interior designer firm with 100-500 employees with offices in Canada and outside of Canada. Interviewees C and D from two different Canadian architecture, interior design and master planning firms with 100-500 employees. Interviewee's C firm has offices in Canada and outside of Canada. Interviewee's D firm has offices in Canada. Interviewee's A firm has a R&D department at the headquarters outside of Canada as a result the requirements of the Canadian office were covered by headquarters via videos, webinars etc. The three other firms do not have a R&D department.

4. RESULT AND FINDINGS

The aim of the research is to explore the consultative approach to BIM implementation in Architectural firms. The objective is to identify the challenges faced by architectural firms in lack of internal R&D and how an external BIM consultancy can bridge the gap. The result of the survey can be summarized in three categories;

- Lack of skilled professionals
- External BIM consultancy
- Resistance to change

According to the result of the survey, the main challenge to BIM implementation is the lack of skilled professionals at the level of the project as well at organizational level. At the level of the project, interviewee D mentioned due to the lack of skilled professionals the BIM manager acted as BIM coordinator. At the organizational level the senior project managers did not consider BIM execution plan beneficial to the projects, according to interviewee D. Lack of skills of the new employees was mentioned by interviewee A, which was covered through internal training. Interviewee C mentioned internal online training had been organized regularly by the firm, as well the as existence of an internal BIM community of the employees in the office helped to fulfil a part of the gap.

Due to the lack of skilled professionals in three offices, BIM managers had a wider range of responsibilities than the one with R&D, The BIM managers had to involve as a BIM coordinator, conducting researches, involving in all the aspects of BIM implementation from technology to resistance to change. Interviewees B and D mentioned due to the high cost, their firms did not consider hiring an external BIM consultancy, in addition both demonstrated concern about the fact that the external BIM consultancies are heavily focus on the technology. According to interviewee B "*many of external consultancies are software reseller, as a result the training offered is technology oriented rather than BIM process*". Interviewee B proposed *lunch and learn* events as one way to approach the issue.

As it was cited by Criminale and Langar (2017), BIM implementation is not an easy process and usually the firms are unaware of the challenges that they encounter during its implementation at the level of project and organizational level. The observation that can be done is that organizations in lack of R&D, do not have a clear view of BIM implementation and all the responsibilities needs to be handle by BIM manager. Practically this is the BIM manager that based on experience and expertise needs to find a solution. Crotty (2012) believes that low level of investment in R&D is one of the problems within organizations.

As per literature review, Bessant (1995) believes that external consultancy can cover the lack of R&D. and gives the example of AMT (Advanced Manufacturing Technology). that in the early days, the consultancy was dominated by technical solutions. That's what is approved through the survey that external BIM consultancy's training is technology oriented, As well it was cited by Bessant (1995) that external consultancies cover both technical and managerial gap, whereas based on the result of the survey, it is only technical part which is covered, which is similar to the early days of AMT. Even considering the list of common services provided by external BIM consultancy in Practical BIM 2012 by Kensek and Peng (2012), it represents a list of technical tasks.

Another subject that came to the surface, was resistance to change. As for decades the work was executed in a certain way, forwarding towards a new process requires time and understanding. Resistance to change by senior project managers, internal interior designers, consultants such as mechanical, structural or landscape architects was a challenge that was cited by all the interviewees. Both interviewees C and D used the word of 'trust' on how to approach the challenge. As it was mentioned through the literature review, Eastman (2008) refers to resistance to change of senior staff and the partners in the new intellectual transition. Coates (2013) propose ADKAR model, as with this model the individual changes is essential to manage change within an organization.

5. CONCLUSION

The research aimed to identify the role of external BIM consultancy in bridging the gap in Architectural firms. BIM requires new method of management adapted to the new concept. As a result, a managerial gap within construction industry is created. New skills, expertise and standards have been developed to fulfil the gap. One of the major reasons of the shortage of professionals adapted to the new era is the lack of investment in R&D in organizations. One option to bridge the gap in organizations is to involve an external consultancy firm.

The study demonstrated the lack of R&D in the organizations as per literature as well as the interviews approved it. Due to the high cost, the firms do not consider investing on external BIM consultancy. In addition, BIM managers are more concerned about the contents of training, these factors confirm that external BIM consultancy need to review the training program proposed to firms. A BIM client in 2019 is different from a BIM client in 2007, the external BIM consultancy needs to answer the particular needs of a client rather than proposing the same training to all clients, this concept in fact is the foundation of the Lean construction, which is not the subject of this study.

It is recommended that the external BIM consultants broaden their training contents rather than offering the technical solution, which is just a part of BIM implementation. Client's requirements have been widened as they advance in their BIM implementation and external BIM consultancy needs to cover all aspects of information management. As well to reduce the cost of training the external consultant can offer skill-specific training or run *lunch and learn* events.

The new era created by BIM emergence has a direct impact on the organization's management. The BIM manager responsibilities have been amplified and they are not pre-defined tasks, on the contrary it is a cross-section of defined and un-defined tasks. As one BIM manager alone in long-term cannot undertake all the responsibilities and challenges, the organizations need to reflect on how to approach this challenge. In lack of R&D as well as not willing to hire an external consultancy due to the cost or due to the unappropriated training, other approaches need to be considered. One solution as it was mentioned by one of the interviewees is to create an internal BIM community of the employees as an option to fulfil at least a part of the gap.

Resistance to change was another challenge which came to the surface, at the organizational level as well as amongst architectural firms and their consultants. Creating trust between different stakeholders as well as the members of the project team is fundamental for initiating to approach this challenge. The ADKAR model, is one way to approach this challenge. The external BIM consultancy or other type of external management consultancy need to think on how to approach resistance to change.

Future researches need to be conducted on how to bridge the managerial gap by developing an internal R&D or through an external BIM consultancy or other type of external management consultancy. The ADKAR model can be one way to approach the challenge, however other models can be considered as well. Another subject such as the impact of internal R&D in business development is recommended as well.

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AN APPROACH TO "NATIONAL ANNEX TO ISO 19650-2"

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Abstract: In the UK the objective of BIM mandate in 2011 was to develop a strategy for introducing and implementing BIM Level 2. PAS 1192-2:2013 was published by BSI and came into effect from February 2013, focused specifically on project delivery and provided specifications for the information management requirements and digital transformation of the built environment. The ISO 19650-1 and ISO 19650-2 were published in January 2019 based on BS 1192 + A2 2016 and PAS 1192-2:2013, providing the international standards and supporting information management process. For certain requirements detailed in ISO 19650-2, each region/country can define and add its own recommendations in the form of National Annex. The aim of the research is to explore the ISO national mirror committee's interpretation of the "National Annex to ISO 19650-2" content. An overview of the literature is discussed and a survey was conducted to verify the concept. The results of the survey ARE analysed and recommendation is given. Future researches need to be conducted to approach this concern.

Keywords: BIM, ISO 19650-2, ISO 19650 series, PAS 1192 series.

1. INTRODUCTION

The initiative of the UK government in 2011 by publishing *construction strategy* is now considerably advanced. An international working group with the leading role of the UK has created ISO 19650-1 and ISO 19650-2. The ISO 19650-1 outlines the concepts and principles for information management according to BIM and ISO 19650-2 defines the requirements and standards for information management within the context of the delivery phase of assets. As the international working group was not able to agree on certain items such as container naming and classification system, the National Annex was added to ISO 19650-2 to define the standards, which enables each region/country to use standards that are already in place. The construction industry is going through a significant change by implementing the new standards. The aim of the research is to explore the ISO national mirror committee's interpretation of the "National Annex to ISO 19650-2" content.

2. LITERATURE

In 2011, the Construction Strategy was published by the UK Government with the aim of reducing the cost of public sector assets by up to 20% by 2016. To achieve this strategy, BIM level 2 was required for all centrally-procured government projects in the UK. The strategy was an initiative for adoption of BIM Level 2 for government projects (BIM Level 2, 2019a) Hence the initial aim was to drive the public sector to work at BIM Level 2, it had an impact on private sector as well, due to its benefits which including:

- Reduction in CAPEX, delivery and operational costs
- Reduced risk
- Improved carbon performance

- Predictable planning

2.1 BIM Level 2

BIM Level 2 maturity is a series of domain and collaborative federated models. The models, consisting of both 3D geometrical and non-graphical data, are prepared by different parties during the project life-cycle within the context of a common data environment. Using proprietary information exchanges between various systems, project participants will have the means necessary to provide defined and validated outputs via digital transactions in a structured and reusable form.

BIM Level 2 requires all project and asset information, documentation and data to be electronic, which supports efficient delivery at the design and construction phases of the project. At the design stage, designers, clients and end users can work together to develop the most suited design and test it on the computer before it is built. During construction BIM enables the supply chain to efficiently share precise information about components which reduces the risk of errors and wastes (BIM Level 2, 2016).

2.2 PAS 1192

In 2011, the UK Government's BIM Level 2 initiative resulted in publication of a series of national standards and publicly available specifications, became known as the UK 1192 series and define BIM Level 2 in the UK (Shillcock, 2019). PAS stands for *Publically Available Specification*. PAS 1192-2:2013 was developed to support BIM adoption in the UK. It was developed from British Standard BS 1192, published on 2007. BS 1192:2007 is part 1 of PAS 1192-2:2013. It provides a uniform framework for collaborative working and information in a BIM Level 2 environment. The PAS 1192-2:2013 describes requirement for attaining building information modelling (BIM) Level 2 during the project delivery phase (BIM Task Group, 2016).

PAS 1192 framework sets out the requirements for the level of model detail (the graphical content), model information (non-graphical content, such as specification data), model definition (its meaning) and model information exchanges (McPartland, 2017).

BIM Level 2 suite of documents according to BIM Level 2 (2019b):

BS 1192: 2007 + A2: 2016	(withdrawn, superseded by BS EN ISO 19650, in 2018)
PAS 1192-2: 2013	(withdrawn, superseded by BS EN ISO 19650, in 2018)
PAS 1192-3: 2014	
PAS 1192-4: 2014	
PAS 1192-5: 2015	
PAS 1192-6: 2018	
BS 1192-4: 2014	
BS 8536-1: 2015	
BS 8536-2: 2016	

2.3 Transitioning from PAS 1192 series to ISO 19650 series

According to Shillcock (2019) as the benefits of PAS 1192 series was recognized internationally by owners and clients, the requirement for an international standard became evident. The international organizations from different countries demanded from *International Organization for Standardization* (ISO) to elevate the UK 1192 series at an international level. That was the start of ISO 19650 series, “*forming an international series of standards creates a level playing field for organizations and suppliers from around the world to compete, innovate and collaborate, regardless of where those companies are located”.*

The ISO 19650 series has benefits for large multinational organizations as for years these organizations have struggled to accommodate the various requirements from their partners and stakeholders. ISO 19650 series helps these organization to create a unified approach across each of their regions, “w*ith dozens of countries involved in the process, each with varying cultural and legal constraints, producing a common way of working at an international level isn’t a quick or easy task” (Shillcock, 2019).*

In the UK, BS-1192:2007 + A2: 2016 and PAS 1192-2:2013 are withdrawn and are superseded by BS EN ISO 19650-1 and BS EN ISO 19650-2. CEN, the European Committee for Standardization also would adopt the ISO 19650 series as European Standards *(Shillcock, 2019).*

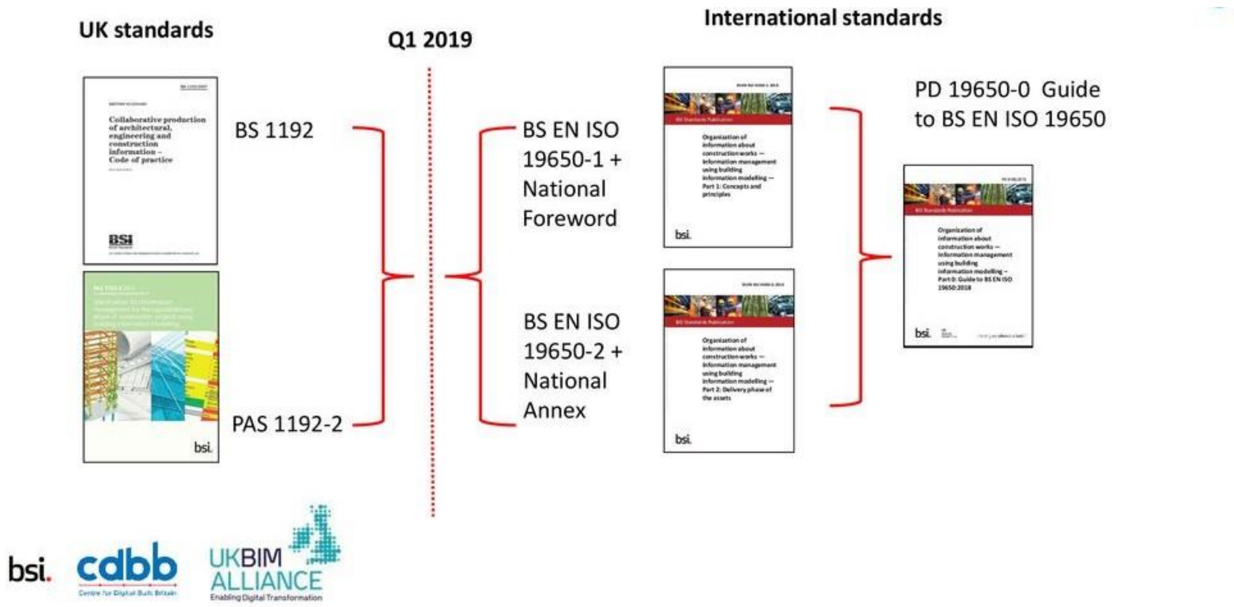

Figure 1: Transition and Associated Suites of documents Afterwards Q1 2019 in the UK (Source: cdbb, Center for Digital Built Britain, 2018a)

Figure 1 illustrates the standards replacing BS 1192:2007 and PAS 1192-2:2013 in the UK. PD 19650-0:2019 is the transition guidance for the existing BS 1192 and PAS 1192-2 users to understand the changes made between the UK’s existing standards and the ISO documents which are to replace them.

The initial draft of ISO 19650-1 is based on the concepts and principles of three documents. The concept of principles behind the collaborative production of information and the CDE (Common Data Environment) from BS 1192:2007, the concepts and principles of the effective management of information from PAS 1192-2 and PAS 1192-3. Figure 2, illustrates all the standards in use in the UK afterwards Q1 2019.
The initial draft of ISO 19650-2 is based on the activities and tasks within the information management process for the delivery phase of assets from both BS 1192:2007 and PAS 1192-

2:2013. "*With ISO 19650-1 and ISO 19650-2 now published, the focus has moved on to the management of information during the operational phase of assets, and the adoption of a security-minded approach to the management of information relating to sensitive assets*" (Shillcock, 2019).

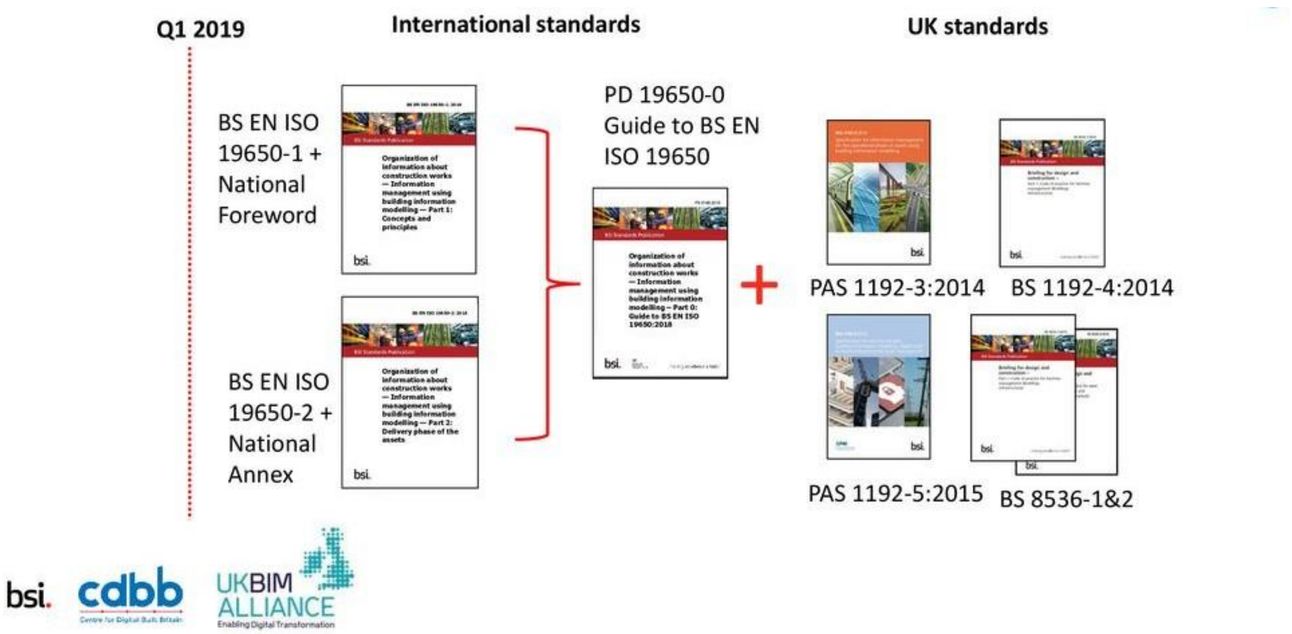

Figure 2: The UK BIM Standards, afterwards Q1 2019 (Source: cdbb, Center for Digital Built Britain, 2019)

"*Using PAS 1192-3 and PAS 1192-5 as a baseline, the international working group is currently drafting ISO 19650-3 and ISO 19650-5. We hope that they will be published in early 2020, at which point PAS 1192-3 and PAS 1192-5 will be withdrawn*" (Shillcock, 2019).

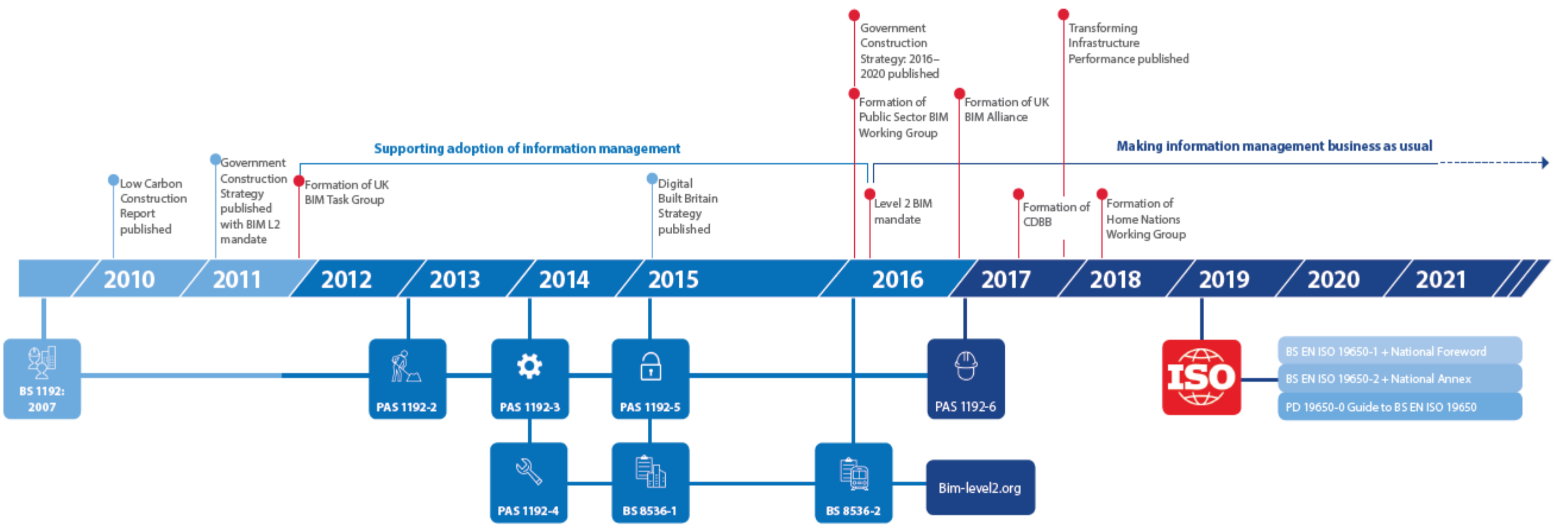

Figure 3: Timeline of Information Management (Source: cdbb, Centre for Digital Built Britain, 2018b)

2.4 National Annex

The ISO national mirror committee related to BIM is ISO/TC 59 / SC 13, which is the committee for "*Organization and digitization of information about buildings and civil engineering works, including building information modelling* (*BIM*)". ISO definition for committee (International Organization for Standards, n.d.):

- a Technical Committee (TC), which develops standards in a certain sector or industry;
- a Subcommittee (SC), which addresses a specialized area within a TC;
- a Project Committee (PC), which is created to develop one standard, after which it is disbanded

To get international consensus on the standardized conventions and codification, a National Annex was established to include region/country specific requirements. In fact, the ISO 19650-2 defines the requirement and the National Annexe define the standards to be used to meet the requirements specific to a region. For instance, within ISO 19650-2 there is a requirement for information management to be classified, for the UK National Annex the classification system is Uniclass 2015 however for the US National Annex is supposed to state the classification system as Ominclass. This allows flexibility for each region/country to use the standards that are already in place (Shillcock, 2019).

Another issue was naming conventions, ISO 19650-2 requires each information container to have a unique ID, and the international working group (the group who developed ISO 19650-series) did not accept the convention defined by BS 1192:2007 which is a UK standard. "*The addition of a National Annex enabled the standards to be completed so that they meet the needs of different regions. But in doing so, I believe we failed as a working group to create a truly common approach. This is because organizations who work in different regions will still need to comply with local standards, which adds unnecessary overheads, such as continuously educating teams and maintaining multiple configurations in the common data environments, for example*" (Shillcock, 2019; Operam, 2019).

The National Annex in fact in the case of the multi-national projects can create concerns, for instance when a company is working on an international project, instead of using a common naming convention, the project would have different naming convention depending on the region/country. That results an administration overhead. Another complication is the information shared between teams in different countries using the national Annex of each country needs their containers ID to be mapped (Operam, 2019).

According to Operam (2019) with naming conventions the biggest challenge are the people and everybody thinks their way and their convention is the best. "*The preference would be to adopt a serialized number approach. Either at an asset level, a national level, or ideally, an international level. This approach would mean that any additional information, such as project, originator and location would still be available. But instead added as metadata attributed to each information container*".

Ford (2019) mentions the differences to container naming (container maybe models, drawings, etc. in the ISO 1650-2) and classification of the BS EN ISO 19650-2 and National Annex which is the UK country-specific. Ford in the article explores the concern about metadata and container which is worth to read it, however that level of detail is not the subject of the paper.

3. METHODOLOGY

Prior to undertake a research it is significant to understand the nature (approach) of the research (deductive, inductive) and its relation to the practice (Gray, 2004). Easterby-smith *et al.* (2008 as cited in Saunders *et al.,* 2009) defines the importance of research approach:

- It enables to take more informed decision about the research methodology, which is not just the techniques by which data are collected and analysed,
- It enables to think about the research methodologies and research choices in continuation and relation with the research approach, whether the researcher is interested to understand why something is happening (inductive), rather than being able to describe what is happening (deductive)
- It enables to adapt the research design to cater for constraints.

The aim of the research is to explore the ISO national mirror committee's interpretation of the "National Annex to ISO 19650-2" content. The deductive approach was chosen as the aim of the research was to describe what is happening and moves towards hypothesis testing (Gray, 2004). To achieve the aim of the research, the survey methodology was chosen as the heart of survey is to attempt to identify something about a population. Due to the difficulty of arranging interviews with the participants, the questionnaire data collection method via email was chosen. The questions of the survey were designed with both closed-ended and open-ended questions. For the interpretation of the result of the survey, qualitative method of analysis was the most suitable method, as the aim of the research is to explore how the ISO national mirror committees interpret the new situation and what is their approach to "National Annex to ISO 19650-2" content.

The first objective of the questionnaire aimed to collect data in relation to lack/existence of any official document(s) prior to ISO 19650 series publication in the countries. The second objective was to explore the content of National Annex. The rational for these two objectives is based on the aim of the research. As the aim of the research is to explore the ISO national mirror committee's interpretation of the "National Annex to ISO 19650-2" content, there is a need to know if the countries have been already familiar with the PAS 1192 series which is the foundation of ISO 19650-2 series. Then move forward to second objective which is how the mirror committees in each country interprets the "National Annex to ISO 19650-2". The survey was sent to twenty members of ISO national mirror committees around the globe and the result will be discussed in detail in the next section.

4. RESULT AND FINDINGS:

4.1 Result

The questionnaires were sent via email to twenty ISO national mirror committees, a total of eleven responses were received. It means more than 55% responses to the survey. There were two types of questions; closed-ended and open-ended, mostly the closed-ended questions were answered. The countries who participated in the survey; Belgium, Canada, Denmark, Germany, Israel, New Zeeland, Norway, Philippine, Poland, Portugal and Singapore. The result can be divided into two categories as per literature, the first category absence/existence of official document prior to ISO 19650 series publication, and the second one was to explore the content of National Annex.

Denmark was the only country that had a Danish legislation prior to ISO 19650 series. However, for the rest of the countries it means 90% of respondents, ISO 19650 series is the first official document related to information management. Two countries mentioned that certain organizations in their country used PAS 1192 series as the reference document for BIM implementation.

Among eleven countries replied to the questions, only four countries will write a National Annex, it means only 35% of participants. Three countries have not yet decided to write a National Annex (30%) and four others will not develop one (35%). It means a total of 65% of participants had not decided to write a National Annex by September 2019 or would not write a National Annex. The countries that had not decided or will not write a National Annex, did not give any explanation of the reason of their decision.

Two European countries were look forward to publishing the document CEN/TR (European Committee for Standardization) Guidance for ISO 19650-1 and ISO 19650-2 which is currently being developed, and then based on the Guidance they will decide on further action.

4.2 Findings

As it was mentioned previously the aim of the research is to explore the ISO national mirror committee's interpretation of the "National Annex to ISO 19650-2" content. The objective of the survey was to collect data for two categories, the first one was absence/existence of official document in relation to BIM implementation prior to ISO 19650, and the second one was to explore the content of National Annex.

In relation to the first objective, the result of the survey demonstrated that for 90% of the participants, ISO 19650 series is the first official document for BIM implementation. Only Denmark had a Danish legislation prior to ISO 19650 series. PAS 1192 series was used by different organizations around the globe, however it was not a standard. ISO 19650 series have become an international standard since January 21, 2019 and it will be used as the official and legal document around the globe. .

In the UK, PAS 1192 series was developed by the industry and through the years the professionals became familiar with the concept and especially how to interpret it. In the UK, in relation to BS EN ISO 19650 series, two guidance were published by the UK BIM Alliance to help individuals and organisations to understand the fundamental principles of BIM according to BS EN ISO 19650 Part 1 and 2 (BIM Level 2, n.d.). The two guidance are:

- Information management according to BS EN ISO 19650, Guidance part 1: Concept
- Information management according to BS EN ISO 19650, Guidance part 2: Process for Project Delivery

Furthermore, the European Committee for Standardization is going to develop a Guidance for ISO 19650-1 and ISO 19650-2 which will be used by the European Union (EU) countries. However, the countries out of the EU do not have a guidance. The ISO 19650-1 and ISO 19650-2 as standards are the same for all the countries, only National Annex, is specific to a region/country. A guidance covering the common part can be used by all the countries. This concern can be the subject of the future research, as at present it is not clear which organization's responsibility is to develop a guidance for all the countries around the globe.

The second objective of the survey was to explore the approach of the mirror committees regarding the content of National Annex. The result of the survey shows that 65% (seven countries) of participants had not decided to write a National Annex by September 2019 or would not write a National Annex. Among the remaining 35% (four countries) who will develop a National Annex, only two countries defined the content of their National Annex, which was similar to the UK National Annex and the two others did not give information about it. Two European countries are look forward to publishing the European Committee for Standardization (CEN/TR) guidance for ISO 19650-1 and ISO 19650-2 which is currently being developed, and then based on the Guidance they will decide on further action in relation to the National Annex. As the result of the survey demonstrates the percentage of the countries develop a National Annex is low (35%) and two European countries are look forward the guidance by European Committee for Standardization. Similar to the first objective of the survey, the need for a guidance came to the surface. The objective of the second category was to discuss the content of National Annex, however the result proved that to write the content, there is a need for guidance, even if each region/country can write its own National Annex.

Although there were no direct questions concerning the guidance, the result of the survey demonstrated a need for guidance by countries participating in the survey. As in the future the remaining ISOs of ISO 19650 series will be published, the need for guidance can become to the surface. As it was mentioned above, there is no organization responsible for developing guidance for the countries around the globe, however the future researches need to be conducted and approach this subject.

5. CONCLUSION

The introduction of the ISO 19650 series is going to have a significant impact on the whole construction industry globally. If until now PAS 1192 series was the reference for BIM Level 2 especially in the UK, now ISO 19650 series creates a new era in the construction industry. The global construction community now refers to these series for the digital transformation of the built environment.

The aim of the research was to explore the ISO national mirror committee’s interpretation of the “National Annex to ISO 19650-2” content. The research started by an overview of the literature which covered BIM Level 2 and PAS 1192 series impact on construction industry in the UK and globally, followed by the transitioning from PAS 1192 to ISO 19650 series. The ISO 19650-1 and ISO 19650-2 were published in January 2019 based on BS 1192 + A2 2016 and PAS 1192-2:2013, providing the international standards and supporting information management process. For certain requirements detailed in ISO 19650-2, each region/country can define and add its own recommendations in the form of National Annex. The publication of ISO 19650-1 and ISO 19650-2 means the adaptation of the first official document for managing information over the whole life cycle of a built asset using BIM. However, the series needs to be interpreted by the ISO national mirror committees around the globe. To verify the new concept of managing information using BIM, a survey was conducted. The result of the survey demonstrated that to better interpret ISO 19650-1 and ISO 19650-2, a guidance is needed. As for the 90% of participant the series is the first official document in relation to information management. Furthermore, the remaining of ISO 19650 series will be published and the lack of guidance can slow down the integration of the series by construction industry around the world.

The subject of the research is new for the industry and in the future there will be more information concerning this subject. However, the research about the subject is recommended as the construction industry is going through the fundamental transformation. The research regarding the challenges that ISO international mirror committees and international community went through during the adaptation of the ISO series as well as the need for guidance is recommended.

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DRIVERS FOR USING OFFSITE CONSTRUCTION IN IRAQ

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Abstract: The advancement in design and technology, and increasing demand for housing, infrastructure and other facilities in the construction sector to address technical, social, economic and sustainability issues have proven the role of offsite construction (OSC), which can offer a more viable solution than traditional construction. Although most developed countries have already adopted OSC and are benefitting from its advantages, the uptake of this method is low in the Iraqi context. A literature review was conducted to study the adoption of this technology in Iraq, and the drivers for using OSC were identified. A questionnaire survey was subsequently carried out amongst construction companies to examine the relative drivers for using OSC in Iraq. The findings show that drivers like the speed of construction, low costs, high quality, increased productivity, improvements to environmental issues, revision-legislation, labour reduction and improved working conditions were strongly agreed by participants as drivers for using OSC in Iraq. Also, the research investigated the relationships between the identified drivers by using the Spearman rho test. The highest correlation was found between the time and quality factor, while the lowest correlation was found between environmental issues and the legislation factor. Further research will involve the conduct of an interview method with stakeholders from the construction industry in Iraq in order to further develop knowledge about the identified drivers and their relationships. Consequently, a strategy will be created to enhance the use of OSC in Iraq and to assist construction companies to achieve the best application of OSC.

Keywords: Offsite construction, Iraq.

1. INTRODUCTION

Iraq is currently facing problems of great magnitude: massive destruction in the areas of some cities; devastation of the basic infrastructure, such as water supply, sewers, roads, bridges and electrical grids; an increasing number of homeless people, and the phenomenon of immigrants and refugees causing a population explosion in the cities (Abdulrazak & Mori, 2012). This background shows the importance of the construction industry in Iraq, as the country is in urgent need of fast reconstruction, especially in the housing sector, in order to minimise housing shortages and assist the reintegration of internally displaced persons, to rebuild infrastructure, and set up advanced industrial projects to support the Iraqi economy (United nations Iraq, 2018; Shadhar, 2017; Abdulrazak & Mori, 2012).

Currently, studies show the increasing problem of housing shortages in Iraq. Al-Taai (2015) stated that the problem of housing in all parts of the country is exacerbated by the lack of solutions in the foreseeable future. He added that, according to senior economists, the country needs 20 years to solve the housing crisis. Indeed, Iraq is currently in need for 4-5 million housing units illustrated by Al-Metwali (2019) and Teen and Gramescu (2018).

Iraq is in a post war era, so it is necessary for the government to establish a clear strategic vision and to adopt more innovative approaches to rapidly and effectively address the trade-offs between the short and long term purposes of the reconstruction process (Abdulrazak & Mori, 2012). Construction industry stakeholders in many countries have started to think about innovative construction methods by incorporating off-site construction with on-site activities (Ansari, Thaheem, & Khalfan, 2016). Offsite construction (OSC) was introduced under the comprehensive umbrella of the 'modern method of construction' as a means for both improving and changing the construction industry’s thinking and practices (Akintoye, Goulding, & Zawdie, 2012). Also, Taylor (2010) indicated that OSC is presented as an important contributor to the continuous development of construction processes and site procedures. OSC is defined as “the manufacture and pre-assembly of building components, elements or modules before installation into their final locations” (Goodier & Gibb, 2007). Much has been written about the advantages of off-site construction in terms of quality, time and lower cost, which in turn suggests it offers a fundamental solution for the growing demand for buildings. Akintoye et al. (2012) clarified that offsite construction has been identified as one means of enhancing the construction industry to overcome skill shortages and meet market demands.

However, its adoption still varies in different countries, as Goulding and Arif (2013) stated, that the uptake and implementation of off-site manufacturing varies from country to country. The researchers stated that some markets of developed countries, such as the UK, Japan and Australia, have continued to demonstrate steady growth in the use of off-site construction. However, in some developing countries, the use of this method of construction is considered low (Wong & Lau, 2015; Kolo, Pour Rahimian, & Goulding, 2014; Mostafa, Dumrak, Chileshe, & Zuo, 2014; Goulding & Arif, 2013). Iraq is one of these developing countries that still falls behind most equivalent economies in terms of the adoption of OSC. A recent study by Abbood, Al-Obaidi, Awang, and Rahman (2015) stated that off-site construction in Iraq is rare. The researchers also mentioned that there is a lack of knowledge in many aspects of offsite construction, especially in its application. Moreover, Afif (2013) believed that offsite companies are rare in Iraq despite the fact that, in 2013, the Iraqi Ministry of Housing and Construction declared that pre-fabricated systems would be the main construction method in Iraq.

The highlight of this proposed research is a study of the key drivers and barriers for the use of off-site construction in order to develop a strategy to enhance the use of off-site construction in this country. Notwithstanding, the focus of this report will be a study of the drivers for using off-site construction in Iraq.

2. LITERATURE REVIEW: DRIVERS FOR OFFSITE CONTSTRUTION

The offsite construction method has apparent advantages that drive its adoption by industry stakeholders in their projects, and these benefits lead to cost savings (Kamar, 2011). Bendi (2017) added that the term ‘driver’ is known as the factor that positively affects the adoption of offsite techniques in construction activities. Goulding and Arif (2013) indicated that the drivers behind global interest in the use of offsite construction are generally similar in terms of the benefits that it can deliver, including faster, safer, better-quality and cheaper construction that is capable of being delivered at scale. Other common interests include the eradication of project commercial risk, meeting the needs of the local market, and the availability of an integrated supply chains capable of working in ways that eradicate wasteful practices. This helps to get the best outcomes from the use of offsite components of various complexities scaled through the requirement for appropriate skills and competences (Goulding & Arif, 2013).

Pan, Gibb, and Dainty (2008) examined a list of drivers and highlighted the most important in using OSC from housebuilders' perspectives, which are quality, time, cost, productivity and health and safety. Furthermore, one of the factors that will drive the move towards OSC will be the need to achieve higher environmental standards (Goodier & Pan, 2010). Moreover, the researchers believed that the UK government's sustainability and 'zero carbon' homes agenda undeniably provides incentives for the UK housebuilding business to consider adopting innovative technologies, which offer an important driver for offsite construction. Also, Pan and Goodier (2011) indicated that government-funded social housing has traditionally been the main driver for offsite technologies. Moreover, Elnaas, Gidado, and Philip (2014) divided drivers to the uptake of OSC in UK housebuilding under: technical, economic, environmental, organisational and social.

In the Australian construction industry, Blismas and Wakefield (2009) identified the drivers and sub-drivers for using OSC, which are: process and programme, cost/productivity, people and OHS, skills and knowledge, logistics and site operation, quality, and environmental/ sustainability. Similar benefits or drivers were found in the US construction industry, as Lu (2009) found that both the architects/engineers and general contractors perceived that the use of offsite construction techniques provided the following benefits: 1) reducing the overall project schedule, 2) increasing product quality, 3) increasing overall labour productivity, 4) increasing onsite safety performance, 5) reducing onsite disruption of other adjacent operations, and 6) reducing negative environmental impact of construction operations.

However, Lawson, Ogden, Goodier, and Goodier (2014) identified that a good understanding of the decision-making parameters of cost, time, and quality, which in turn can be quantified in financial terms and present the drivers for modular construction. Moreover, the researchers added that, in modern building projects, there have to be further extensions to the range of decision-making parameters, including planning and legal requirements which prove sustainability in terms of its economic, environmental, and social impacts (Lawson et al., 2014).

Furthermore, Al-Mutairi (2015) identified drivers for using OSC in Saudi Arabia, which are: increasing overall labour productivity; reducing project's overall timetable; minimising the total project cost; to recompense for the constrained working space on-site; construction & design duration reduction; compensating the shortage of skilled workers; the quality of product increasing; to reduce the incurring impact of the local weather conditions; company's reputation enhancing; improving the project's safety performance, and decreasing the environment impact. Moreover, Bendi (2017) mentioned that some of the drivers associated with offsite construction implementation in India are demand for affordable housing, cost and time certainty.

Indeed, Teen and Gramescu (2018) found that there is a need to invest in the housing sector in Iraq to address the housing shortage; therefore, this modern method of construction offers a significant opportunity to achieving this because of the advantages of this construction in reducing time and cost, achieving a high quality, and reducing impacts on the environment.

3. METHODOLOGY

The research reported in this paper represents part of a broader study. A questionnaire survey was used as a primary data collection tool while a literature review was adopted for the secondary data collection. The research started with an extensive literature review to identify the drivers and barriers of using OCS in the construction industry worldwide. The primary objective of this questionnaire was to determine the nature and extent of current OSC practices in Iraqi construction organisations. The second objective of this survey was to identify the key factors influencing the adoption of OSC in the Iraqi construction industry.

Therefore, the survey targeted two large governmental construction companies and one large private company. The first section of the questionnaire asked respondents to provide information concerning their current position, educational background and experience in the offsite construction implementation. The second section contained questions relating to the drivers for using OSC in Iraq, for which respondents were requested to indicate their agreement level towards the drivers on a five-point Likert scale, where 1 refers to *strongly disagree* and 5 refers to *strongly agree*. The third section concerns the barriers for using OSC in Iraq with response of using 5-likert scale as well. A total of 200 copies of the questionnaire were distributed, whilst 100 valid questionnaires were used in the analysis, representing a response rate of 51%. A descriptive analysis has been conducted for the drivers of using OSC in order to explore the most important within the Iraqi construction industry. Also, SPSS software was used to apply the spearman rho test to determine whether there are significant relationships between the drivers.

4. FINDINGS AND DISCUSSION

4.1 Descriptive Analysis/Sub-theme Drivers of Using OSC in Iraq

Figure 1 shows the construction companies' participants' responses regarding the factors that encourage the use of OSC in Iraq. In general, most of the drivers scored a high level of agreement. In total, 96 participants strongly agreed that the following represent drivers to the adoption of OSC in Iraq: reducing the overall project time, addressing the problem of housing shortages in Iraq, enabling a high volume production of mass units over a short period of time, and the provision of affordable housing. The speed of construction was also positively rated by 95 of respondents. In contrast, respondents agreed less with the following as drivers for the use of offsite construction in Iraq: reduction of labour required for onsite construction (19), and the availability of legal, standards and codes framework to cover all stages of the project (15). However, their agreement on the aforementioned factors was still positive demonstrated by high percentages in which 73 positive responses were received to the use of OSC requiring fewer workers (73), and (68) positive responses for the availability of legal, codes and a framework to cover all stages of the project. Moreover, (37) respondents neither agreed nor disagreed if the OSC reduced accidents onsite. Drivers, such as high quality and low construction cost and reduced environmental impact were strongly confirmed within the literature (Fenner, Razkenari, Shojaei, Hakim, & Kibert, 2018) as well as time reduction. These findings are in line with those by Krishnanunny and Anoop (2018); Rahimian, Goulding, Akintoye, and Kolo (2017).

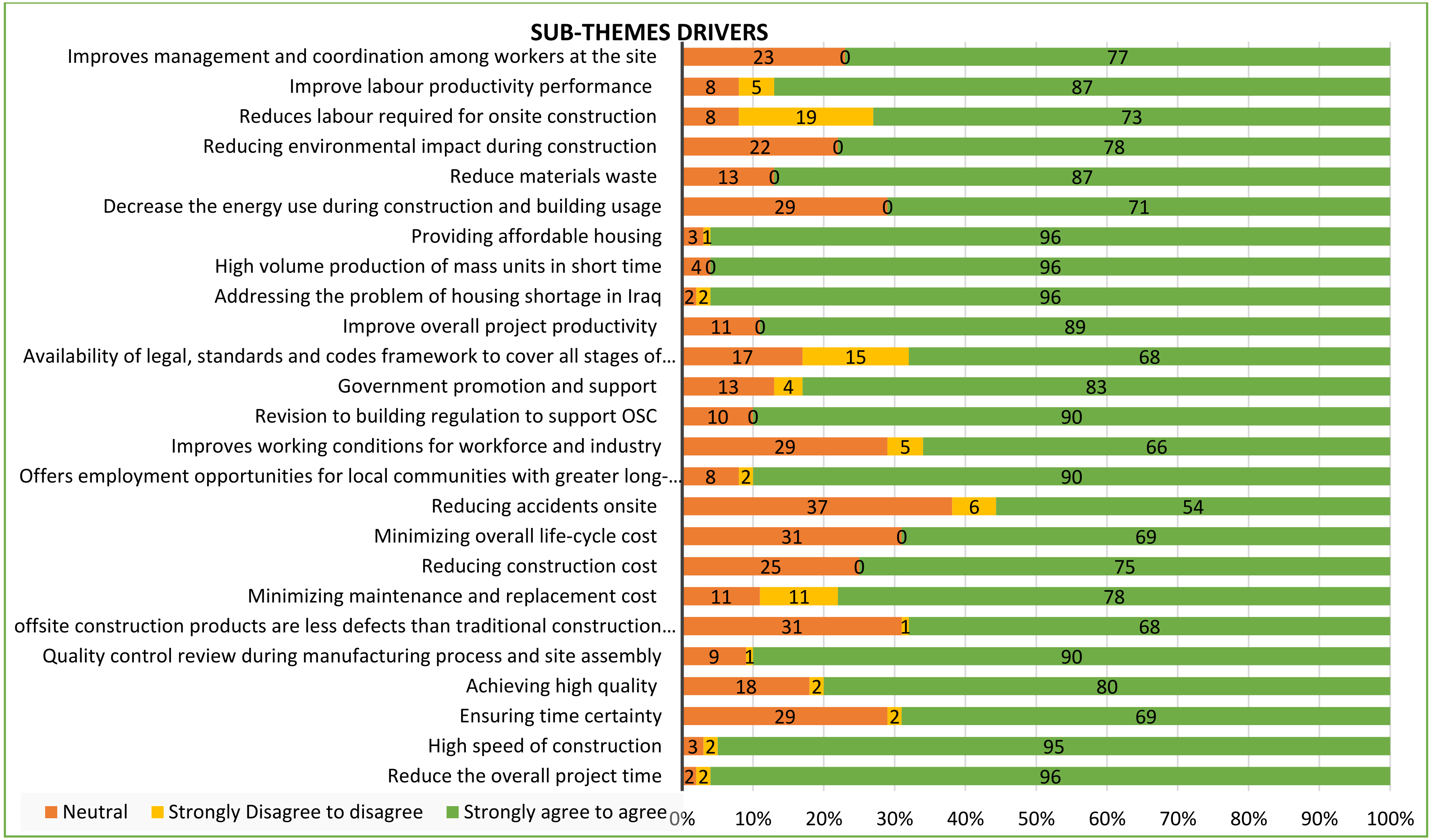

Figure 1: Sub-theme drivers for using OSC in Iraq

4.2 Correlation between the Drivers for using OSC in Iraq

The researcher used a Likert scale to summarise the responses to several key questions. Thus, the researcher computed several variables into one by using the mean; for example, the time factor has three Likert scale elements for analysis, which means these three items are computed into one variable by applying the mean ranking response. For example, the Mean is used for responses of ‘reduce of overall project time’, ‘high speed of construction’ and ‘ensuring time certainty’ to provide one mean value for time factor.

The spearman rho test was applied to describe the strength and direction of the linear relationship between the two variables, such as time with cost, in order to understand the interaction between each other. Table 1 shows the correlation between the drivers investigated within this study. The highest correlation was found between the time and quality factors, for which spearman rho=0.693. In comparison, the lowest correlation was found between the environmental issues and legislation factor, at rho=0.-0.051.

Table 1: Spearman rho test for the drivers for using OSC in Iraq

Correlation

			Time	Quality	Cost	Health & Safety	Legislation	Labour	Productivity& Market	Environmental issues
Spearman's rho	Time	Correlation Coefficient	1.000	.693**	.626**	.666**	.387**	.553**	.319**	.429**
		Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.001	.000
		N	100	100	100	100	100	100	100	100
	Quality	Correlation Coefficient	.693**	1.000	.515**	.583**	.540**	.391**	.400**	.385**
		Sig. (2-tailed)	.000	.	.000	.000	.000	.000	.000	.000
		N	100	100	100	100	100	100	100	100
	Cost	Correlation Coefficient	.626**	.515**	1.000	.547**	.475**	.593**	.303**	.422**
		Sig. (2-tailed)	.000	.000	.	.000	.000	.000	.002	.000
		N	100	100	100	100	100	100	100	100
	Health & Safety	Correlation Coefficient	.666**	.583**	.547**	1.000	.344**	.595**	.311**	.384**
		Sig. (2-tailed)	.000	.000	.000	.	.000	.000	.002	.000
		N	100	100	100	100	100	100	100	100
	Legislation	Correlation Coefficient	.387**	.540**	.475**	.344**	1.000	.215*	.227*	-.051
		Sig. (2-tailed)	.000	.000	.000	.000	.	.032	.023	.613
		N	100	100	100	100	100	100	100	100
	Labour	Correlation Coefficient	.553**	.391**	.593**	.595**	.215*	1.000	.573**	.489**
		Sig. (2-tailed)	.000	.000	.000	.000	.032	.	.000	.000
		N	100	100	100	100	100	100	100	100
	Productivity	Correlation Coefficient	.319**	.400**	.303**	.311**	.227*	.573**	1.000	.337**
		Sig. (2-tailed)	.001	.000	.002	.002	.023	.000	.	.001
		N	100	100	100	100	100	100	100	100
	Environmental issues	Correlation Coefficient	.429**	.385**	.422**	.384**	-.051	.489**	.337**	1.000
		Sig. (2-tailed)	.000	.000	.000	.000	.613	.000	.001	.
		N	100	100	100	100	100	100	100	100

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

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

For example, of these relationships, time has a high significant relationship with quality, rho=0.693. Indeed, the high quality of products and repetitive process and operation activities leads to improvements in the time performance creating greater certainty about the project completion when using OSC. This finding reflects those of Fenner, Razkenari, Hakim, and Kibert (2017); Alazzaz and Whyte (2014), confirming that the certainty of achieving construction deadlines when using offsite construction is greater than the certainty in classic construction. It is also indicated in the literature (Gan et al. (2017) that the imposition of inadequate time for construction, design and production by clients affects the quality of the offsite construction projects. Figure 2 illustrates this relationship.

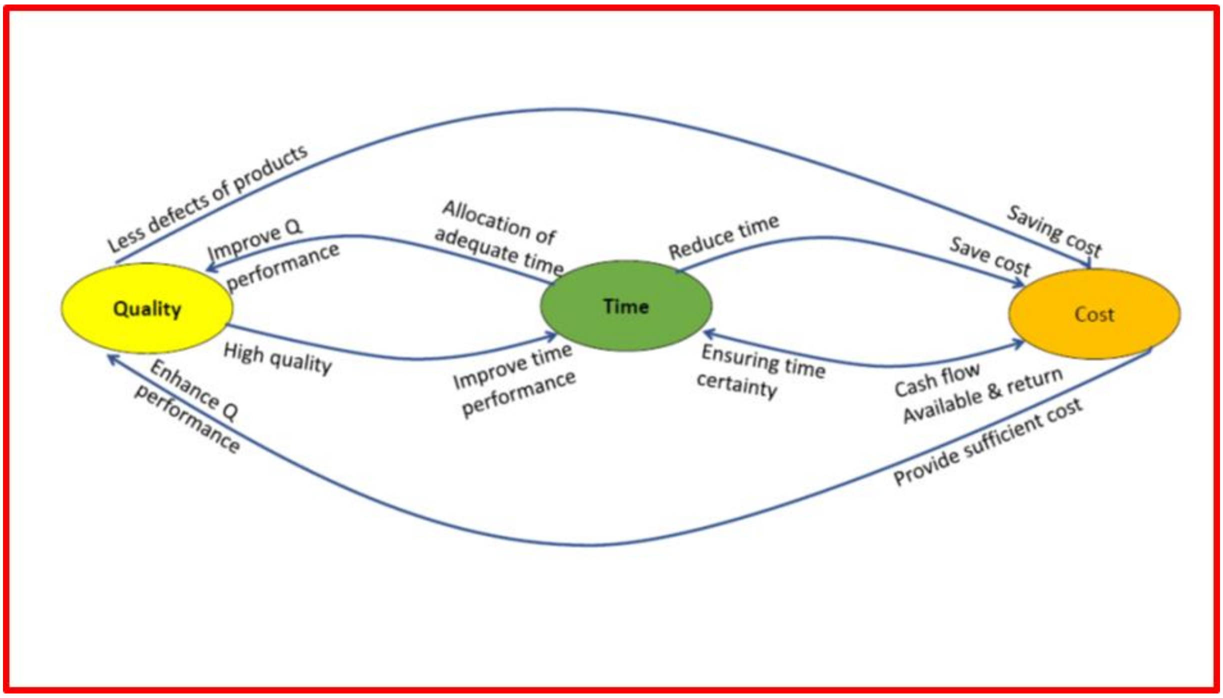

Figure 2: Schematic representation of high significant relationships between drivers of time, cost and quality

Another high significant relationship is found between time and cost (rho=0.626). This relationship can be justified that a short construction time when using OSC leads to reduced costs. This relationship was also highlighted in the literature review (Fraser, Race, Kelly, and Winstanley (2015). In addition, a cash flow return is faster when using OSC as a result of the advantages it offers associated with greater time certainty, whilst the availability of a cash flow increases certainty in the time performance. Figure 2 illustrates this relationship.

Furthermore, there is high significant relationship between the quality and cost factors, rho= 0.515. Indeed, high-quality products can be achieved when using OSC due to more stringent quality controls in the factory. This, in turn, means less defects and maintenance, and the products are less likely to be rejected; moreover, this subsequently leads to cost savings. The literature also supports these findings (Fraser, Race, Kelly, Winstanley, & Hancock, 2015; Alistair, 1999). Nevertheless, insufficient costs allocated for the design, production or construction stages affects the quality of offsite construction projects (Gan et al., 2017). Therefore, providing sufficient funding for all stages of a project leads to enhanced quality performances. Figure 2 illustrates this relationship.

It is worth to mentioning that the time and health & safety factors have a high significant interacting relationship, at rho=0.666, and this correlation is the second-highest relationship amongst the other correlations. This can be justified that, when using OSC, labourers are less exposed to bad weather conditions as a result of less time required onsite. This is supported by findings in the literature (Lawson et al., 2014).

Moreover, quality has a high significant relationship with the health & safety factors, as rho=0.583. This is can be justified as most of the work occurs in a factory environment under quality control with health and safety standards, and this protect workers from bad weather conditions. The relationship between quality and health & safety is also recognised in the literature (Wanberg, Harper, Hallowell, and Rajendran (2013), therefore, it is evident that there is a correlation between construction safety performance and construction quality.

5. CONCLUSION

Iraq is in a post war era; the literature review showed that more than two million housing units are needed as well as the work on its infrastructure. Hence, the government needs to establish more innovative approaches to overcome the reconstruction process, which off-site construction has the potential to offer. Therefore, the aim of the research was to develop a strategy to increase the use of off-site construction in the Iraqi construction industry. Before achieving this aim, it was important to examine perceptions about offsite construction in Iraq, by evaluating the drivers and barriers of using such a method of construction. A questionnaire survey method has been conducted for this purpose targeting the construction companies in Iraq.

Moreover, the descriptive analysis illustrated that most respondents agreed that the following factors encourage the use of OSC in Iraq: reducing the overall project time, producing a high volume of mass units in short time, and ensuring a faster rate of construction. Indeed, most participants agreed on the benefits of using OSC including cost, time, quality and environmental issues. Moreover, the spearman rho test was applied and revealed that the highest correlation was found between the time and quality factors. Meanwhile, the lowest correlation was noted between the environment issues and legislation factors.

The next stage will illustrate other drivers' relationships to use OSC in Iraq. Also, the researcher will conduct an interview method with stakeholders of the construction industry in Iraq to expand the knowledge about the identified drivers and their relationships in order to develop a strategy to enhance the use of OSC in Iraq.

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People, Skills and Education

DEVELOPING PROFESSIONAL CAPACITY IN THE CONSTRUCTION INDUSTRY THROUGH THE SINO-AFRICAN RELATIONS: A LITERATURE REVIEW

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Abstract: Over the years, China has taken a decisive lead in partnering with Africa. This partnership is fuelled by China's need for energy and Africa's need for infrastructural development. The partnership is perceived as a definitive means to fund numerous projects and access more advanced technology in the African construction industry. Numerous infrastructural projects have been executed since the advent of the Sino-African relations which has drastically decreased the cost of construction for African governments. Chinese firms have made this possible through the importation of capital, skills, equipment, and technologies. Based on this, the current study is aimed at understudying China's efforts towards skills development in Africa with specific emphasis on the construction industry. The study reviewed archived literature on Chinese presence in Africa and how it has influenced the transfer of modern technology and skills. Findings from this study revealed that strategies have been taken within the framework of the Sino African relations to enhance capacity building in the construction industry. However, there are still voids to be filled as the partnership have not distinctively contributed to skills development and technology transfer in the construction industries in Africa. Decisive actions must be taken to ensure that while projects are being executed within the continent, peculiar skills are transferred to the indigenous construction professionals. This will improve the professional capacity within construction industries in Africa.

Keywords: Sino-African relations, China-African relations, construction industry, skills transfer, technology transfer, capacity development.

1. INTRODUCTION

For a long time, developing countries have always relied on foreign direct investment for the growth of the national economy which is mostly achieved through the operations of transnational firms (Moran et al. 2005). Foreign direct investment is a means to develop the capacity of labour in a recipient country. Transnational firms will gladly invest in the training of their staffs, both indigenous and foreign. When these trained workers move from transnational to local firms, they take the vast knowledge they have accrued over the years with them and use it to the benefit of the local construction firm they are joining which will have a ripple effect on the local construction industry (Farole and Winkler, 2014). Bashir (2015) further explained that individual national government can use regulatory policies to fortify knowledge transfer and skill development. This can be done through establishing, managing, and enforcing a comprehensive regulatory framework that will encourage transnational firms to employ, train, and develop local skills.

By design, developing countries can solve most of their major problems through knowledge spill-overs. These spill-overs can directly improve national productivity, enhance economic development and ultimately improve the welfare of citizens by alleviating poverty (United

Nations, 2015). By the estimation of the International Labour Organization (2014), Africa is characterized as having the lowest rate of employment in the world and has forecasted that this low employment rate will continue to hinder progress in future. A study conducted by the world bank in Ethiopia suggests that Chinese construction firms prefer to hire expatriates from China, but it was gathered that the reason for this is the inadequate supply of indigenous skilled Ethiopian labour to handle the kind of tasks required. Since the firms need experts in different fields to carry out their day to day operations, they bring in people who can get the job done (Trang Tran, 2014). While some researchers have argued that in rapidly developing African nations like Morocco and South Africa, the problem is not a lack of jobs rather it is the lack of adequate training and education. Although other researchers have disputed this submission, still, there is a need for the development of the China-African partnership to effectively extend towards training and education of the local workforce in Africa in a bid to mitigate this problem (Benjelloun, 2015).

The twenty-first century came with a shift to a knowledge-based system of economy, this significant shift has transformed local construction industries to shift their demands for skills to technology and management which are the strengths transnational construction firms possess and can use as an advantage over local construction firms (Powell and Snellman, 2004). For foreign direct investments to be profitable to transnational firms, they must have an edge over indigenous players in the market. For instance, the edge that Chinese construction firms investing in Africa have over local firms includes easy access to funds, better skills and modern technologies (Auffraya and Fu, 2015). Based on the foregoing, the current study is aimed at understudying China’s efforts towards skills development in Africa with specific emphasis on the construction industry. This is with a view to ascertain if the existing strategies are adequately building the local construction capacity in African countries.

2. STRUCTURE OF THE PAPER

This study was conducted using systematic reviews from relevant literature published on China’s presence in Africa and how it has influenced the transfer of skills to the African construction industry. The paper is structured as follows; Section 1 constructed a background to the study which developed to highlight the aim of the study. Section 2 discussed the structure which the study followed. Section 3 discussed the role of China in the African construction industry. Section 4 extensively reviewed how the skills and technology have been transferred within the framework of the Sino-African relations. Section 4 further covered how skills and technology transfer has aided the capacity building within the African construction industry. Section 5 exposed briefly the measures that have been taken by Chinese firms to localise their operation in Africa in order to facilitate the capacity of indigenous professionals. Section 6 summarized the lessons learnt from this study. Section 7 concluded the study, highlighting the responsibilities of Africa to ensure that the capacity of the indigenous construction professionals is developed within the framework of Sino African relations.

3. CHINA’S ROLE IN THE AFRICAN CONSTRUCTION INDUSTRY

Over the years, the Chinese construction industry has grown to become one of the major drivers of the economy of China. The areas of improvement include infrastructure, tourism, as well as rural and urban housing. In recent times, the construction industry has been very pivotal to the fast-developing economy of China (Chen, 1997). The Chinese construction industry has grown to be one of the biggest and most competitive across the globe. It is characterised with adept skills in civil engineering activities which is essential for the development of infrastructures. (Foster, Butterfield, Chen, and Pushak, 2008). However, compared to global standards, the technology deployed within the African construction industry is outdated and inferior (Sundaram et al., 2011). Klosters (2014) pointed out that there is a significant problem in the construction industry around Africa owing to the inadequacy of construction and engineering skills. This is evident by submissions made by Hafez et al. (2014) in Egypt, Okuntade (2014) in Nigeria, Trang Tran (2014) in Ethiopia, as well as Benjelloun (2015) in Morocco and South Africa. One of the most controversial issues on the operations of China in Africa is that it does not adequately transfer knowledge and skills to the local society. This can be attributed to the importation of labour, equipment, and materials to be used in Africa from China (Chen, Dollar, and Tang, 2015).

Out of all the criticism China has faced as a result of its presence in Africa, the most celebrated one is that Chinese firms prefer to use Chinese labour instead of the citizens of the host country where they are executing projects. Dollar (2016) regarded this as a ‘mixed blessing’ in such a way that the heavy presence of Chinese workers provides missing skills in excess and makes the construction process faster. However, it also reduces the job opportunities for African labour and does not improve their technical ability. Construction firms are not supposed to bring in a huge number of people for an overseas project because countries, where the projects are to be executed, would like to create jobs for its citizens. The China Africa Research Initiative (2018) pointed out that by the end of 2017, over 200,000 recorded Chinese nationals are working within the African construction industry. This estimation includes Chinese nationals working with both indigenous and multinational construction firms. Furthermore, Farrell (2016) pointed out that most Chinese firms bring in employees illegally. Individual governments must devise means to checkmate this problem in order to create more jobs for its citizens and create an effective avenue for local skill improvement.

4. CHINA’S EFFORTS TOWARDS CAPACITY BUILDING IN AFRICA

About a quarter of Chinese aid to Africa can be classified as a means of assisting human capacity improvement (Bashir, 2015). The Chinese Ministry of Commerce (MOFCOM) is the central regulating department for all Chinese foreign aids. However, capacity development programmes are executed through different agencies, ministries, enterprises and academic institutions. These individual entities all work within a strategic framework with the sole aim of improving human capacity and skills in foreign countries (MOFCOM, 2011). Over the years, China has provided assistance to Africa in education, training and research which has been mainly in the science and technology field. This has been made possible by bilateral trade agreements which have recently been incorporated into the framework of the Forum on China African Cooperation (FOCAC) (King, 2014).

One of the most effective ways indigenous firms acquire new knowledge is by observing and studying the alien techniques, processes and practices by which transnational firms carry out their day to day activities and replicate them as at when necessary. This is referred to as the ‘demonstration effect’ (Crespo and Fontoura, 2007). Indigenous firms who frequently have dealings with transnational firms are in suitable positions to take advantage of demonstration effects (Cheung and Lin, 2004). Another effective way by which knowledge spill-overs can occur is through 'labour mobility'. This often happens when indigenous firms hire former employees of transnational firms. These workers would most definitely have learnt new ways of doing things and acquire foreign skills which will be beneficial to domestic firms (Cheung and Lin, 2004). Also, Inkpen and Tsang (2005); and Fu (2012b) acknowledged that social media and grapevine communication are unofficial ways knowledge can be transmitted to domestic firms.

Furthermore, China has really made a lot of wave in enhancing skills all around Africa at the higher institution level, ranging through different kind of partnerships at the university level. For instance, the Chinese Ministry of Education launched a 20+20 Cooperation Plan in 2009. This plan matched 20 universities in 17 African countries to 20 universities in China. This scheme was aimed at collaborating researches and exchange students among these institutions. Although, during stalk taking in 2013, this scheme was reported as being inefficient as only 2 universities were carrying out a student exchange program (Hartig, 2013). Another skills development program at the higher institution level is the Chinese Confucius Institutes located of different universities campuses around the world. These institutes are aimed at training interested students in the Chinese language, culture, and way of life. There are over 35 of such institutes around Africa. Understanding the Chinese culture and language will facilitate easy communication among indigenous African workers and their Chinese colleagues. This will in-turn expedite the learning and mentorship process within companies (King, 2014).

Outside the university, China has also contributed to capacity development in a number of ways. For instance, in 2009, the Chinese Ministry of Science and Technology established the China-Africa Science and Technology Partnership Program which is aimed at enhancing science and technology capacity in Africa through experience sharing and mentorships (Benjelloun, 2015). As a result of numerous channels through which Chinese education aid come into Africa, it is extremely difficult to estimate the exact value of the aid provided to date.

Studies carried out by Auffraya and Fu (2015) established five channels through which knowledge spill-overs can occur. The five channels are employees, subcontractors, suppliers, competitors and construction consultancies. Firstly, employees acquire knowledge from transnational firms through experience gained over a long period, formal training tailored for development in line with their jobs and mentorship from experts within the firm. Secondly, suppliers may gain some insights from foreign nationals as a result of continuous interactions which creates impressions and encourages upgrades in the supply chain to ensure that clients are satisfied. Similarly, Subcontractors will also gain from the vast knowledge of transnational firms through continuous long-term relations just like the suppliers which will improve their professional capabilities. On the other hand, competitors are forced to improve their processes by any means necessary especially through labour mobility in order to keep up with transnational firms. Lastly, construction consultancies benefit from the knowledge of transnational firms through labour mobility of technical experts within the construction industry (Auffraya and Fu, 2015).

As part of the agreement within the FOCAC framework, there are five major channels through which Chinese education aid to Africa is achieved. The first is through state scholarships for African students seeking to study in China. Secondly, training programmes for African technicians and artisans in a variety of fields including construction. Thirdly, providing competent professionals for experts training in Africa. The fourth is constructing various educational facilities in Africa to enhance teaching and learning process. And lastly, engaging in partnership programmes with different departments and agencies of African countries (King, 2014).

China Development Bank (CBD) which is the largest financial institution for Chinese foreign investments also assist in developing human resources through four main channels. The first is through CDB training programmes which are essentially for management level staffs of government agencies and corporate firms. Second is joint training programmes coordinated by the ministry of commerce in conjunction with the World Bank usually covering new trends in finance and economic reforms as well as development. The third is through corporate leadership programmes where China Development Bank finances MBA studies for African entrepreneurs. And lastly, through China Development Bank scholarships which sponsor masters and doctoral studies of African students in Chinese higher education institutions (Bashir, 2015).

5. LOCALISATION STRATEGIES IN THE AFRICAN CONSTRUCTION INDUSTRY

According to the African Development Bank (2013), Chinese construction firms operating in Africa are gradually localizing their workforce. The extent at which transnational firms invests in local workforce training and welfare is not totally distinct. However, numerous reports have documented that Chinese construction firms are constantly increasing the numbers of African professionals employed in different capacities. Concerns have been previously raised on whether the Chinese framework for skills development fits into the need of African countries. However, it must be noted that skills are mainly needed in any sector of the economy that is a priority for growth. Therefore, when Chinese firms are operating in a particular economic sector, there is a need for skills in that sector. This means human capacity development programmes must be channelled to the sector of the economy in which Chinese firms are operating in (Bashir, 2015).

Auffraya and Fu (2015) posited that knowledge transfer might be impossible if there is a wide knowledge gap between indigenous firms and their foreign counterparts. Too much knowledge margin between transnational firms and local ones will not promote knowledge transferability as the locals will find it extra difficult to understand the vast knowledge outpouring. The concept of appropriate technology contends that the use of technologies from more developed countries might not perform at an optimized level because it might be too overwhelming for the available asset, including labour skill set and capital, in the recipient country. Therefore, appropriate technology advocates that the technology brought into a developing country must suit the local dynamics of such country (Fu, Pietrobelli, and Soete, 2011). Hence, transnational firms from developing countries like China can easily deliver appropriate technology in Africa since African countries are mostly also developing and the foreign technology being imported from China can be simply localised to suit the African style and purpose.

Chinese construction firms must begin to invest in ways to localise the skills, knowledge and technology they brought into Africa. This has become necessary due to the huge financial implications associated with hiring expatriates, gradually emerging fleets of indigenous professionals, and ethical responsibility of corporate firms. The cost of hiring an expatriate has escalated in recent times due to the emotional consideration of leaving their home country. Chinese firms looking to hire expatriate professionals must then offer alluring remuneration and benefits to attract these professionals which compound their operating cost. Furthermore, maintaining a good ethical image in the international front would involve training and development of indigenous workers to become experts in their various field (Auffraya and Fu, 2015). Therefore, it is of utmost importance that Chinese firms operating in Africa device localisation strategies as it would soon become a necessity in the near future. This will be a welcomed development as full localisation will enhance knowledge and skills transfer for foreign direct investment recipient countries.

In a bid to promote localisation of labour in Africa, some Chinese industries have moved their production facilities to Africa. However, there is no clear-cut way of measuring the rate at which transnational firms comply to environmental, safety, transparency or labour standards in their day to day operation within the continent (Benjelloun, 2015). However, Brautigam (2011) forwarded that Chinese construction firms have proven how adaptable they can be at the global level. They have adopted strategies to better enhance their cooperate social responsibilities and their safety and environmental practices seem to be improving quickly. The modernization of localisation strategies is further proof of this adaptability and a sign of a welcomed revolution in Chinese management.

6. LESSONS LEARNT

Africa's quest for human capacity development has been receiving a more positive consideration from China in recent times. Although this support is mostly channelled into higher education and vocational training, Notwithstanding, it is a welcomed step in the right direction. If this support is channelled to focus on the priority sectors of the economy, it will have a major influence in shaping the economy and developing the much-needed human capacity that will stimulate and facilitate significant development of the continent as a whole. Usually, transnational firms operating in foreign countries cannot completely internalize the bulk of knowledge at their disposal. Indigenous firms must take advantage of the knowledge trickling down from transnational firms (Crespo and Fontoura 2007). Furthermore, Bashir (2015) noted that strategic and action plans are very essential to human capacity development. While most African countries have developed strategic plans, they usually lack the action plans to implement the various strategies. Most times, efforts are often duplicated as a result of improper inventory of existing and required skills. On the other hand, Chinese firms in Africa could also learn valuable lessons from their operations within the continent as they are encounter and have to overcome challenges that are not present in their home country (Auffraya and Fu, 2015).

The degree and magnitude of localisation of Chinese construction firms when operating in Africa are likely to affect the transfer of knowledge through demonstration effects. If the localisation strategies deployed by Chinese firms in Africa are limited, then indigenous firms will find it difficult to acquire the relevant knowledge, skills, techniques and expertise they will need to operate at the level at which their foreign counterparts are operating. Familiarity between indigenous firms and transnational Chinese firms will encourage knowledge transfer and build better indigenous capacity through labour mobility and social networks. In reality, both the quantity of indigenous African professionals working with Chinese firms and the position which they occupy within these firms are pertinent to how effective knowledge is transferred. For instance, top executives and managers are in more suitable positions to acquire and assimilate knowledge as well as spread the acquired knowledge within professional and social circles.

7. CONCLUSION

In numerous African countries, the kind of skills readily available are predominantly substandard and outdated. The study revealed that strategies have been taken within the framework of the Sino-African relations to enhance capacity building in the construction industry. However, there are still voids to be filled as the partnership have not distinctively contributed to skills development and technology transfer to the construction industries in Africa. The voids in the system includes inadequate strategic and action plans which are very essential to human capacity development. While most African countries have developed strategic plans, they usually lack the action plans to implement the various strategies.

Localisation strategies are very important in the transfer of knowledge; therefore, African governments have a lot of work to do in ensuring that Chinese firms operating in their various countries are implementing localisation strategies. This can be done by setting up proper policies and regulatory framework to guide the process of knowledge transfer. Furthermore, visa policies and conditions of hiring expatriates could be made stricter in order to reduce the rate of permanent employment for Chinese nationals. This will serve as a subtle push for transnational firms to train local professionals to become experts in various aspects of construction. Since China had just experienced a swift development of human and professional capacity, African firms can easily consume and digest knowledge from their Chinese counterparts. The experience of China in the recent past can be easily extrapolated into the African context and used as a reference point in the development of professional and human capacity in Africa.

In all, skills transfer and ultimately capacity building must be addressed as an essential part of the regulatory framework, as African countries cannot keep depending on foreign professionals or expatriates to carry out vital economic development activities such as exploration of minerals, construction of infrastructures and complex buildings. One of the major reasons foreign partnerships is peculiar to African countries is because of the lack of experts in specific skills. To resolve this issue, skill transfer conditions must be agreed upon and enforceable. This will help African nations to develop skills that are alien to the continent and thereby build human capacity. Lastly, efforts should be intensified to ensure effective capacity building of all kinds of workforce in the major areas of operation of Chinese transnational firms. In the same vale, China African cooperation must also intensify efforts in education and research of African institutions to ensure that students are properly groomed for the challenges the future may bring.

Skills enhancement is an essential need for the African continent especially in the present 21st century which is characterized by rapid modernization as in the case of the fourth industrial revolution. The quality of the training, development and mentorship programmes organized within the framework of China-African relations must be upgraded to meet the requirements of the 21st century. It is not only important for African professionals to develop skills alone, but it is also important to develop skills that are highly relevant to solving the problems of the present day and age. In retrospect, while projects are being executed within the continent, peculiar skills must be transferred to the indigenous construction professionals. This will help improve the professional capacity within construction industries in Africa.

However, a major limitation to assessing the current state of skill transfer and localization strategies through the Sino-African relation in the African construction industry stems from the inadequacy of relevant data both from the industry and academia. Hence, there is a crucial need to conduct a primary study to fill this gap in the nearest future.

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INVESTIGATING REASONS FOR ENGINEERING SKILLS DEFICIENCY IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

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Abstract: Over the years, engineering skills shortages have been a serious issue in the construction industry of most developing countries including South Africa. Despite numerous education reform schemes, the country is still facing considerable shortages in the construction industry. This study is therefore aimed at identifying the factors responsible for the deficiency in engineering skills within the South African construction industry. Primary data for the study was sourced from construction professionals within Gauteng Province of South Africa while secondary data was sourced through archived literature. Results from the study identified the major causes of engineering skills shortages in South Africa as; retirement of veteran engineers; low success rate in Science, Technology, Engineering, and Mathematics (STEM) subjects; bad career counselling; and inadequate practical training. It was concluded that organizing efficient career guidance and mentorship programs will boost the availability of engineering skills within the country. Similarly, adequately addressing the issues identified in this study will not only improve the productivity of the construction industry but will also enhance the national economy.

Keywords: Engineering skills, engineering skills' shortage, construction skills, construction industry, South Africa.

1. INTRODUCTION

Over the years, the shortage of skills has remained a persistent challenge in the economic and social landscape. Globally, employers are finding it increasingly difficult to find needed skills for technical activities and there seems to be no foreseeable solution to this skills deficiency that has developed over the years (Department of Labour, 2003). Kraak (2008) opined that one of the major drawbacks for the progression of a country is the shortage of engineering skills. Globalization and constant technology modification have greatly catalyzed the skills deficiency around the world. Shortage of skills is becoming a huge challenge for employers as they struggle to find the necessary skills needed among the global talent pool (Zieminski, 2009). In implementing massive construction projects, shortage of engineering capacity has been the worst challenge faced in recent years (Manpower group, 2011a).

In South Africa, scarce skills are identified by the department of labour to cover the following professions; engineering and built environment; law; health; finance; IT/ICT; natural science; education; management; transport; and artisans. These professions experience a huge shortage of skills (Heyns & Luke, 2012). Rasool and Botha (2011) pointed out that the South African economy is tremendously strained as the construction industry is in dire need of skilled professionals. Compared to the US, China and India where there are 380, 95 and 95 engineers per million people respectively, South Africa's engineer density is quite small with only 45 engineers per million people (Engineering Council of South Africa, 2007).

Inadequacies in the present education system regarding sciences and mathematics will only continue to affect the intake of engineering students (Rasool & Botha 2011). Mackenzie (2008) forwarded that the policies of the Sector Education and Training Authority (SETA) has not been strong enough to adequately address the deficiency in engineering skills. And this shortage of skills poses significant limitations on the economic growth of the country (Sharp, 2011), as the construction industry is the backbone of every nation's economy (Thwala & Mofokeng, 2012). Bloomfield (2015) opined that necessary actions should be taken to encourage the younger generation to pick up interest in engineering and technology professions. The current study, therefore, examines the factors responsible for engineering skills deficiency in the South African construction industry. This is with a view to proffering workable solutions to ensure relevant engineering skills remains available within the South Africa construction industry.

2. A REVIEW OF ENGINEERING SKILLS' SHORTAGE

Various engineering sectors are subject to intense pressures, which in turn have increased demand for skills. Shortage of skills is felt at all levels, especially among professional engineers (Connor, Dench & Bates, 2000). Klosters (2014) pointed out that there is a significant problem in the construction industry around Africa owing to the inadequacy of engineering skills. This is evident by submissions made by Hafez et al. (2014) in Egypt, Okuntade (2014) in Nigeria, Trang Tran (2014) in Ethiopia, as well as Benjelloun (2015) in South Africa. This shortage of skills and experience makes it difficult for employers to fill vacant positions (Luke & Heyns, 2012). A survey of 200 engineering firms showed that 74% of employers ranked "…a lack of qualified candidates" as their greatest recruitment challenge over "specialized job requirements" and "non-competitive salaries" (Walpert, 2014).

The construction industry, despite its substantial contribution to the national economy, is still characterized with low quality, poor health and safety systems, chaotic working practices, a negative image and an industry with high costs (Ball, 2014). Image in any career choice plays a vital role as well as gender relations. The construction industry is associated with many negative images such as difficult working conditions, dirty, tedious, hazardous and non-professional people (Ginige, Amaratunga & Haigh, 2007). Also, remuneration and overall welfare packages are very significant factors young adults consider during career selection (Chileshe & Haupt, 2007), and people often believe that construction-related jobs pay less than other professional jobs. In addition, the career paths in construction jobs are not well defined which may confuse many students making a career in construction less appealing to deciding students (Makhene and Thwala, 2009). Schella (2010) observed that parents and mentors consider a career in construction as the last resort and often discourage students. When compared with other careers, construction is not usually perceived as the career of choice and necessary steps must be taken to redefine the image of the construction industry so as to attract the younger generation (Haupt & Harinarain, 2016).

Similarly, Mutodi, (2004) opined that societal beliefs and learning environment greatly affects students' motivation in science and technology-related fields. Self-assessment and personal ability appraisal also limit students' interest in science and technology as they are seen as a challenging career path (Hill, Corbett & Rose, 2010). Young students tend to heed to the advice of people they look up to like parents and teachers. Encouragements from mentors to continue in the science and technology field no matter how difficult they might find it, in the beginning, will likely push students to work harder and achieve good success (Mutodi, 2004). Perkins (2013), submitted that students lack awareness about the opportunities of studying within the engineering field. Young people who are not only technically and academically competent, but who are also inspired by the possibilities of engineering are needed to inspire students and help them to understand where different choices could take them in the future, even though engineering subjects in universities are perceived as difficult and not so interesting (Perkins, 2013).

It cannot be overemphasized that science and technology play a very significant role in national development. Any nation that fails to adequately consider Science, Technology, Engineering, and Mathematics (STEM) education will likely be left behind in all spheres of development (Ugo & Akpoghol, 2016). Banerjee (2016) pointed out that poverty often put people especially children in a deprived position. Underprivileged students often perform poorly in academics when compared to their comfortable peers (Steele, 2010; Reardon, 2011). Becker and Park (2011) pointed out that 75% of the fast-emerging occupations requires knowledge and skills in science and technology. Most importantly, the employment rate in STEM-related occupations is estimated to double that of other occupations (Craig et al., 2011).

Furthermore, the rate at which engineering students drop out of school has become a global issue in recent years. A study conducted by the Human Sciences Research Council (2007) revealed that out of about 34,000 engineering students who commenced their studies, only 14,000 students graduated. This means that a total of 20,000 students dropped out of their various engineering courses, of which most of them being either in their first year or midway through their second year of study. Engineering is one of the scarce professions around the world and this scarcity is further escalated by the fact that engineering students have been dropping out globally at similar rates for years. Studies have revealed that many engineering students tend to drop out of university within the first two years (Writer, 2013).

In addition, Horn (2006) forwarded that the higher education system is not preparing learners adequately in terms of skills required for the world of work. To support this, Darshanaben (2014) submitted that the higher education system has not been proven effective in delivering employable youths according to the needs of the job market. To deliver an employment-ready workforce in the near future, students of today must be equipped with the necessary skills set as prescribed by the industry (Darshanaben, 2014).

It is very important for engineering graduates to continuously acquire development training in the course of their career in order to develop the necessary skills needed to carry out their jobs. These training should be made attractive and easily accessible to ensure the future for the industry (Hampson & Brandon, 2004). Training schemes are struggling to keep up with the growing demands in response to the modernization of construction techniques and the ever-changing building technology (Watson, 2012). Employers should increase their investment in the development and training of personnel and offer more practical training opportunities, such as in-job training, paid internships and mentorship. The education system should also take necessary actions to better align academic curricular to the needs of the industry (The Conference Board of Canada, 2013).

The rising cost of tertiary education has gradually become a global issue. In countries such as Australia, Brazil, Nigeria, Germany, South Africa, Netherlands, and the United Kingdom, students have publicly protested fee increase. Tertiary education for most of the students especially those from poor backgrounds is a great opportunity to change their projected living standards, but without adequate financial resources, accomplishing the desire to be educated and effectively trained in a skill becomes a herculean task (Machika & Johnson, 2014). In South Africa, getting affordable tertiary education is a real issue. Government funding for tertiary education is constantly decreasing (1.1% in 12 years), while only 0.7% of the GDP is allocated to fund higher education which is very low by international standards. However, free education is quite essential to the economy as it will significantly help to optimize human capital investment (Langa, et al., 2016).

The construction industry is often perceived as one of the world's most dangerous work industries. Around 25% to 40% of work-related fatal accidents occur on construction project sites. There is also a variety of risks, health and safety hazards to which everyone in the construction industry is exposed (Hawkins and Wells, 2013). According to Danson (2012), health and safety hazards attributed to the construction industry include noise, irritants, dust, fumes, and gases as well as other hazardous materials which can result in harmful health risks. Also, it is a generally accepted assertion that construction employers are not respectful of the work-home boundary; mostly they give unmeetable deadlines and expect their workers to take work home, work till late, as well as travel often with little warning, all these with lack of clearly defined advancement (Danson, 2012). The poor working condition in the construction industry greatly fuels the limited interest in the industry.

Lawless (2005) submitted that salaries seem to be a distressing matter in the engineering sector. For most young professionals, inconsistency in the remuneration between engineers and other professionals contributes to the lack of interest in the engineering industry. Lawless (2005) reported that a study carried out by the UK Higher Education Statistics Agency revealed that the reasons most trained engineers defect to other careers could be driven by money and the image of the construction industry. Makhene and Thwala, (2009) also established that it is a general opinion that construction-related jobs pay less than other professions.

According to Brown and Gali-Debicella (2009) experienced professional workers have acquired knowledge and skills that made them proficient at their job. These skills were learnt over time and became part of their skill set. It is highly likely that in 15 years almost half of the entire workforce is due to retire. The big challenge is 'how positions are going to be filled if a huge number of professional with expert skills retires (Brown & Gali-Debicella, 2009). DeLong (2014) opined that experienced workers who have become experts in their fields should be part of a mentoring team to share the knowledge they have gathered over the years with younger and upcoming professionals. The construction industry is bound to lose more skilled professionals as it is saturated with aging population and employers are bothered about how to replace them considering there is a limited young workforce (UK Commission for Employment and Skills, 2014).

3. RESEARCH DESIGN

The nature of the research design is descriptive as the research seeks to examine the factors responsible for engineering skills deficiency in the South African construction industry. The survey method was adopted as the research strategy, while the methodology for this research is the quantitative study. A five-point Likert type scale questionnaire was designed to collect data with the goal of achieving the aim of the study. Data was collected from construction professionals which included architects, quantity surveyors, engineers, construction managers and project managers in Gauteng Province, South Africa. 200 questionnaires were randomly distributed in all to construction professionals while 153 questionnaires were retrieved back from the respondents and all retrieved questionnaire were deemed useable after they were checked for completion. The data collected through the questionnaire was analysed using Severity Index (SI) and presented in the section below.

4. RESULTS AND DISCUSSION

Background data collected for this study covers the respondents' educational qualification, years of work experience, sector engaged, employment level, occupation. Background information on educational qualification of respondents shows that 8.5% are high school graduate, 31.4% possess a diploma of some sort, 32.7% are bachelor's degree holders and 27.5% has a post-graduate degree. Respondents background information on work experience in the construction industry reveals that 39.9% of the respondents have between 4 and 9 years of experience, 24.2% between 9 and 14 years' experience, 12.4% between 14 and 19 years' experience and 23.5% has 20 years' experience and above. Background information on the sector which respondents are engaged in shows that 5.2% works for a client, 0.7% works for a private corporate firm, 32.0% works for private sector consultants, 43.1% works for a private sector contractor and lastly, 19.0% works for the public sector.

Table 1: Factors responsible for engineering skills deficiency in the South African construction industry

Factors	SI (%)	Rank
Retirement of veteran engineers	73.4	1st
Low success rate in STEM subjects	73.4	1st
Bad career counselling	72.2	3rd
Inadequate practical training	71.6	4th
Lack of mentors for new graduates	69.4	5th
Inadequate government funding for tertiary education	69.2	6th
Emigration of experienced engineers	66.6	7th
Low remuneration for engineering professionals	66.0	8th
Poor working conditions	64.0	9th
Lack of industry-specific qualifications and certifications	63.2	10th
Number of graduate dropouts	62.4	11th
Political instability	62.2	12th
Negative perception of the industry	59.8	13th
Affirmative action	59.2	14th
Cyclical economy shifts	58.8	15th
Rising crime rate	56.4	16th

The table reveals that respondents ranks 'retirement of veteran engineers' and 'low success rate in STEM subjects' as the top factors responsible for engineering skills shortage with severity index of 73.4% each. Economic shift and rising crime rate are at the bottom of the table with severity indexes of 58.8% and 56.4% respectively. Using a severity index of at least 70%, the study revealed that the major factors responsible for the deficiency of engineering skills in the South African construction industry include; retirement of veteran engineers; low success rate in STEM subjects; bad career counselling; and inadequate practical training.

The result from the study as shown in the table agrees with those of Anekwe (2003) and Suleymay (2008), which established that one of the major causes of shortage of engineering skills is the emigration of experienced engineers. Similarly, the results also confirmed studies of Osman (2011) which indicated low remuneration for engineering professionals as a cause of the engineering skills' shortages as well. Furthermore, the Australian Mathematical Sciences Institute (2012) and Dawes and Rasmussen (2013) established that bad career counselling and pass rates of students taking the STEM subjects is one of the highest factors responsible for shortages of engineering skills. While studies carried out by Pillai (2015) forwarded that the retirement of veteran engineers is a major source of engineering skills deficiency in the construction industry. However, the results from this study are not consistent with the studies conducted by Fourier (2006), Barry and Jordaan (2009), Alam and Hoque (2010) where rising crime and political instability ranked highest among factors responsible for engineering skills deficiency in the construction industry.

The empirical and theoretical findings of this study reveal that the major causes of engineering skills deficiency in the construction industry include, bad career counselling, retiring experts, negative perception of the industry, low pass rate in STEM subjects, low remuneration for engineering professionals, lack of experiential training opportunities, and a poor education system. To address the problems highlighted by this study, a system could be structured such that experienced engineers should mentor younger engineers to ensure transfer of knowledge and skills, as well as facilitate the availability of certain expert skills when older engineers retires. Secondly, more attention must be focused on the STEM subjects to ensure students pick up interests to study engineering right from a young age. Also, better career guidance and counselling should be made available to young students to aid proper selection of a future career. Furthermore, the tertiary educational system must ensure that engineering modules are being highly practicalized as against the normal theoretical way of study. Efficiently addressing the factors indicated in this study will increase the future supply of effective engineering professionals which will improve the physical as well as the social infrastructure development of South Africa. In real sense, infrastructure development is vital to every country's economic growth and prosperity

5. CONCLUSION

The study revealed that the main factors responsible for engineering skills deficiency in the South African construction industry includes; retirement of veteran engineers; low success rate in STEM subjects; bad career counselling; and inadequate practical training. Findings from the study imply that there is a need for the government of South Africa and other stakeholders to invest in the training and development of engineering skills in order to diversify employment opportunities for citizens which will improve the physical and social infrastructure as well as the national economy. Providing basic physical and social infrastructures within any society are to a large extent the responsibilities of the engineers within the society, and without these infrastructures, the society will crumble. It is, therefore, necessary to ensure that the supply of engineering skills in South Africa be able to meet the demand of the public. These will facilitate growth, self-sufficiency and ultimately catalyse national progress.

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AN INVESTIGATION INTO THE IMPACTS OF THE TECHNICIANS' SKILLS GAP ON THE DEVELOPMENT OF THE NIGERIAN CONSTRUCTION INDUSTRY

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Abstract: This study investigates the effect of the technicians' skills gaps and its impact on the building construction industry development in Nigeria. The technicians' skills gaps are considered critical in terms of the industry performances particularly in the workforce efficiency. This has led to poor performances of the industry in its competences and productivity, which affected the nation's economy. The paper critically assessed the technicians' skills gaps and most appropriate training on the output of the industry performances. Hence, identify the factors that negate growth in technicians' skills within the industry. The research method for this study is quantitative enquiry, through empirical literature and questionnaire survey. The questionnaire survey received 73% participants' response rate. These Participants are Project Managers, Technicians and Trainers within the Nigerian construction industry in Abuja Metropolis. Collected data was analysed using content means and frequency analysis, descriptive analysis. The findings of this study indicate that there are great demands for skilled workforce within the industry. More so, behavioural issues may exist between the employers and employees, which negate proper construction practices. This suggests that technicians' skills training and development is necessary for the industry to achieve effective output for its future growth.

Keywords: Construction industry, skill gaps, Nigeria, training.

1. INTRODUCTION

In a developing country that is currently undergoing economic reform, the Nigerian construction industry is one of the major contributors to the country's Gross Domestic Product (GDP) for its future development (Okoye, 2016; Abdullahi and Bala, 2018; Mu'awiya et al., 2018). In addition, there are evidences that construction industry originally contributed between 10% and 20% to the Nigeria GDP in the 1970s, before it declined to 4% in its current state (Jagboro, 1989; Mogbo, 2000; Ihua-Maduenyi, 2018). The decrease in the contribution to the nation's GDP is due to several factors which, includes inadequate training and skills development, motivation and labour relation practices, poor planning, problems of finance, corruption, recruitment and selection practices (Andrey, 2015; Oseghale et al., 2015; Tunji-Olayeni et al., 2017; Ameh and Daniel, 2017). More so, the rate at which buildings are collapsing in Nigeria today are increasing daily and this failure in buildings occur during construction work and use, which needs immediate attention (Okolie et al., 2016; Egunjobi et al., 2016). As cited by Okolie et al., (2016), the collapsed buildings are due to so many problems which include; Unethical behaviour and poor guidance in terms of commitment, knowledge, negligence, dishonesty, and unfair practices are prevalent in the Nigerian building industry (Iyagba, 2009; Shah and Alotaibi, 2018).

However, training and skills development in its current form is inadequate which has led to skill shortages, skills gaps within the industry. This has affected the performances of the industry which led to low and consistently poor productivity over the years. In addition, the quality of workers' skills is another pressing issue in the Nigerian construction industry and is already having serious implications for both the industry and the Nation's economy (Oseghale et al., 2015; Ahmeh and Daniel, 2017). Yet, there are inadequate studies that addresses the impact of training and skills development on the output of the construction industry in Nigeria. The importance of training and skills upgrading of workers in the construction industry should be a continuous improvement process. Unskilled workers affect the quality of products and impact on time as well as costs of projects that are undertaken in the country, thus endangering the success of projects' execution, which in turns affect the nation's economic growth (Bilau, et al.2015; Zannah et al., 2017).

The failure of construction industry to address skills gaps in terms of quantity and quality has seriously influenced the reduction in the Nigerian economic growth (Ekundayo, et al., 2013; Rahim, et al., 2016). Training and skills development are keys prerequisite for performances of any workforce, particularly in the construction industry (Banihashemi et al., 2017; Kassem et al., 2017). Hence, training of the workforce is important towards skills development, and it's a necessity for construction companies to understand the need for training and skills acquisition (Mpofu and Hlatywayo, 2015; Rashid et al., 2018). Therefore, the key objectives of this paper are: (i) conduct critical reviews of literature on worker's skill acquisition and training within the context of the Nigerian Construction Industry, and (ii) critically assess the current workers skills acquisition and training in Nigerian Construction Industry**.**

2. LITERATURE REVIEW

The achievement of every organisation's aims and objectives depends on the performance of its workforce, which is true for the construction industry. As such, well-trained workforce is generally one of the key requirements for an effective organisation. This implies that organisations should ensure that training and skills development of their workforce are paramount to the achievement of organisational goals and objectives. This important activity within the industry should be carried out regularly to add value to human resources.

2.1 Concept of Training

According to Armstrong (2017) and Armstrong et al. (2015) training is defined as the formal and organized or systematic modification of behaviour through learning that occurs due to education, instruction and development as well as planned experience. Similarly, Salas et al. (2012), Obisi (2011) and Ericsson et al. (2018) stress that training is a planned and a continuous process that is designed to meetup with the training needs of today and the future, enhancing organisation performance and productivity through knowledge improvement and skills development.

Following the above studies, training has to do with imparting knowledge, skills and change in behaviours for a great job with the best available information and to the best quality required. In this light, the best possible arrangement of methods, techniques, tools and practices should be assembled in an organised form to achieve such a goal.

The construction industry is labour intensive, particularly in developing countries around the world. This is where construction organisations depend on the effort of their workforce for better outcomes due to the manual activities. For this study, an effective training should create an enabling environment which trainees are able to;

- Learn the importance of knowledge, skills and attitude.
- Practise applying the learned knowledge, skill and attitude.
- Act on feedback, both negative and positive, to enhance future performance.

2.2 Training Methods

Bilau et al. (2015) explored the shortages of a skilled workforce in the Nigerian construction industry and identified numerous approaches to training. These include classroom training, trade group training, apprenticeship training, on the-Job-training, Craft Apprenticeship courses, conferences/discussion methods and an Apprenticeship Programme. These classifications of training methods are consistent with Craig (1996), who identified four basic techniques of training such as management development training, on the job training, classroom training and vestibule training. On the other hand, Naukrihub (2007) divides methods of training into two broad categories of behavioural and cognitive methods while Obisi (2011) and Raheja (2015) categorise training into two; as training on the job and off the job and the key issues are shown in Table 1.

2.3 The Nigerian Construction Industry

The Nigerian construction industry has experience failure, since the discovery of crude oil in the seventies (Chen et al., 2016; Ogunde et al., 2017). Prior to oil and gas discovery, the construction projects executed have been on a large scale and these projects include buildings, roads, bridges, sewage plants, and dams (Awe et al., 2010). However, training status within Nigerian context is ineffective with low quality coupling with challenges against the realisation of quality training (Ogbunaya and Udoudo, 2015; Okolocha and Baba, 2016). In addition, most of the technologies adopted by the construction industry in Nigeria are both local and imported. This suggest the needs for training and skills development plus steady supply of work force to the indigenous population to make use of the available resources and adapt the technology available (Ayonmike et al., 2015; Chen et al., 2016). These skilled shortages have been experienced in most of the urban areas where a large percentage of unemployed workers are accompanied by technicians' skilled gaps in the building trades such as bricklayers, carpenters and plasterers (Oseghale et al., 2015; Afolabi et al., 2016; Zannah et al., 2017). Technicians are trained skilled workforce that can either work under the supervision of a professional or independently in a complex system.

2.4 Skills Shortage within the Nigerian Construction Industry

Construction industry is mostly dependent on availabilities of its workforces due to its manual activities predominantly in developing countries. This implies that adequate supply of skilled workforce is of major concern to performances within the industry. However, the industry for many years undergo the shortages of skilled workforce and required materials (Bilau et al., 2015; Mukhtar et al., 2016). Furthermore, Healy et al. (2015) and Oseghale et al. (2015) state that skilled shortages and skills gaps are often portrayed as major hindrances to the development of the industry and the nation's economy. Likewise, failure of any project due to insufficient skills is due to inadequate training/education (Mukhtar et al., 2016; Agetue and Nnamdi, 2017).

Ihua-Maduenyi (2018) lamented that standard of competent skilled construction workforce is decreasing yearly, by 15 percent of technicians within the construction sector. According to the author, the poor performances of the Nigerian construction industry is due to inadequately skilled workforce and the need to improve the industry performance is paramount.

As Ihua-Maduenyi (2018) mentioned, the shortage of skilled workforce is mostly due to the weak stock of skilled construction workforce in the country. The paper further suggested a key strategy to the challenges and repositioning of the sector through enhancement of domestic construction skills. This is can be carried out through educational institutions, with emphasis on providing students with practical training to complement their theoretical knowledge.

2.5 The Nigerian Construction Industry Skills Gaps

Limited trained/skilled workforce is of major concern within the industry. Now it has affected the industry performances and the nation economy. This has led to technicians' skills gaps and skills shortages within the industry, which required immediate attention. In addition, studies indicate that there are shortfalls within the industry in terms of quantity and quality of technicians trained to satisfy the challenges (Afolabi et al., 2016; Bilau et al., 2015; Oseghale et al., 2015). Skills of the workforces is of great importance to the industry development, which is defined by Peterson et al. (2001:464) as "Skills represent a person's level of proficiency or competency to perform a task". The Government's Skills Task Force STF (2003) defined "skills gaps" - this is where members of the existing workforce lack necessary skills to do the job and "Skills shortages;" as absence of people with the required skills in the workforce.
However, further training of the existing workforce to improve industry performance can fill skills gap and the problem of skill shortages can be address through enrolment of more competent people in the industry. Article in Vanguard by Okogba (2019) lamented the skill gap in the Nigerian construction industry and poor project delivery has become a trend within the country and is of great concern. These skills gaps include: Masonry, carpentry, plumbing, electrical installation, painting and decoration among others.

2.6 Current Behavioural Patterns of Construction workers within the System

Construction is risky and one of the most precarious industries that needs to be properly managed (Ganah and John, 2015; Ganah and John, 2017). It can manifest itself through hazards of work patterns and behaviour problems at work, which may be linked to the low level of health and safety culture when compared with other related industries.

Recent studies reveal that the Nigerian construction industry has the highest human rights abuses and other social problems such as lack of training on health and safety, risk assessment, ethics in construction related works, among others, compared to other countries (Olutuase, 2014; Abubakar, 2015; Agbede et al., 2016). Ogundipe et al. (2018) highlighted that lack of awareness on health and safety issues among Nigerian construction workers as major concerns. Similarly, organizations' reluctance to health and safety management are the biggest cause of fatal injury in workplace. Consequently, the overall health and safety standard and corporate image of Nigeria's construction industry have been affected.

According to Zhou et al. (2015), the trend of accidents within the construction industry has reduced progressively, due to continuous effort of researchers/practitioners. Although, Ghasemi et al., (2015) argue that construction industry compared to other industries has a high rate of fatal injuries and there should be need for adequate attention. However, this study suggests that there should be more application on innovative approach on construction safety because at the present, the industry is one of the precarious industries.

2.7 Key Findings of the Literature Review

Based on the extensive reviewed of literature on the Nigerian construction industry, the key challenges identified for poor performances of the industry are: (See Table 1). There are inadequate skilled upgrades of workforce within the industry which required adequate attention (Ogunsanmi, 2016), inadequate investment on skilled artisan training, and workers'/ contractors' reluctance to invest on their training (Bilau et al., 2015; Oseghale et al, 2015).

Okoye and Arimonu (2016) enumerated inadequate funding of technical and vocational education; inadequate facilities; brain drain; staff training and retention; curriculum of technical education; policy issues as some of the problems of the construction sectors. It has also indicated that effective communication among the stakeholders within the industry is vital to improve performance (Ejohwomu et al., 2017; Nipa et al., 2018). However, there is ineffective communication among technicians and other stakeholders. This suggest that there can be no effective training and skills development in any successful organisation without effective communication.

Table 1: Outline of the Key issues on training in an organisation

• Training benefits are not clear to the top management
• Supervisors are not rewarded for carrying out effective training by top management
• Trainers provide limited counselling and consulting services to the rest of the organization
• There are great demands for skilled workforce in the Nigerian construction industry
• Construction related work is recorded as the most hazardous in terms of safety
• Most of the youths in Nigeria are not showing interest in construction related work
• There is insufficient funding on training of vocational and technical education
• In the literature, there are behavioural issues (i.e. attitude) from both employers and employees that are negating proper construction practices.

2.8 Outline of Conceptual Model of Training Development in Nigeria

The proposed model gives a top-level understanding of how training and skills that should be implemented for the construction industry. The model is in three stages and is based on the INPUT- PROCESS – OUTPUT (IPO) model. The P (i.e. Process) is what the researcher wants to effect change for the Nigerian construction industry. The new processes will include new behavioural patterns that will be embedded within the old processes, in an integrated format.

Such injection will involve for example, remodelling universities curriculum development and remodelling at the college and vocational level curricula.

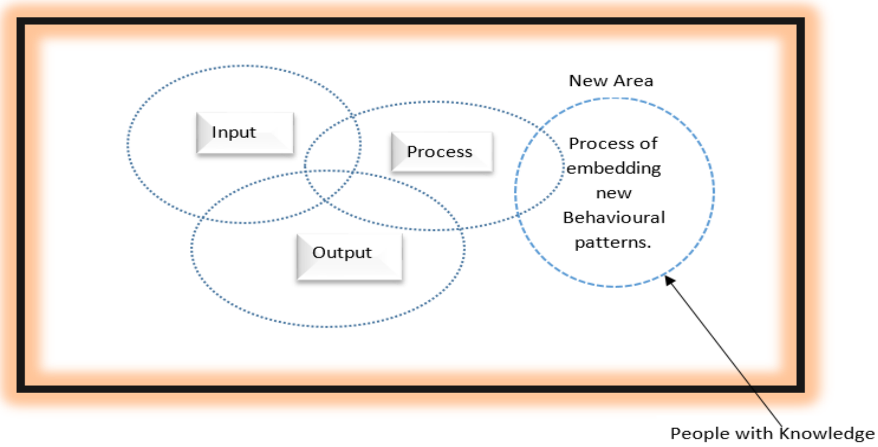

Figure 1: Outline for conceptual model for training and skills development.

From both primary and secondary data, it is clearly seen that there is a serious challenge within the construction industry in Nigeria regarding training. This has led to the shortfall in growth rate contribution to national growth and survival of the industry. This research investigates source of the problems to find a solution for developing a training and skills development model for workers of the Nigerian construction industry that will improve workers' skills quality. The model shown in figure 1 is an outline for the conceptual model, which serve as a guide for the researcher to develop a detail model as the research progress.

3. METHODOLOGY

In this study, quantitative method of enquiry through questionnaire survey has been chosen as the most appropriate due to the nature of the research. An extensive literature review has been conducted which has resulted in the above outline of a conceptual model (Figure). The quantitative method of enquiry is in accordance to the research objectives, data collection and data analysis (McCusker and Gunaydin 2015; Brannen, 2017; Nardi, 2018). The use of this method enables the researcher to fill in the missing gaps, such that a holistic understanding can be generated through the research. The second aspect of this paper is to gather an understanding from primary sources (i.e., technicians', project managers, educationist/trainers) in the Nigerian construction industry, whether what the researches, papers and articles in the literature corroborate well with the field work.

Quantitative method in this study utilised the questionnaire survey to data collected from participants; it was aimed at seeking the participants views on current workers skills within Nigerian construction industry. Structured questionnaires were developed on the premise of workers skills and based on the needs to fulfil the research gaps. The participants used for this study are group of project managers, technicians and trainers/educationist within the selected Nigerian construction industries.

3.1 Questionnaire Survey

A questionnaire survey was designed to collect and gather participant's views on the current technicians' skills within the Nigerian construction industry. In other to assess workers skills based on the problem statement of the study (Brace, 2018; Nardi, 2018), the questionnaire covers the important criteria of technicians' skill development identified from the literatures to fill in the missing gaps. In the questionnaire, the factors that negate the development of workers (technicians) skills and the growth of the industry performances were examined. This approach facilitates the gathering of opinions and allowed comparison as well as statistical aggregation of strategic data collection from the different group of respondents.

3.2 Pilot Testing of the Questionnaire Survey, Procedure and Result

The aim of the pilot study was to test the reliability, authenticity, feasibility of the approach that was planned to ultimately be used in a larger scale study and validation of the questionnaires with experts within the selected construction industry (Adeleke et al., 2016; Mani et al., 2017). Pilot testing is a technique which is valuable and viable for testing feasibility, acceptability and risk management in a study (Donovan, et al. 2019). This technique is a desirable effort before the major study commence. The Pilot study serves as a means of testing the procedure to employ in achieving the research objectives.

The questionnaire survey was first designed, and pilot tested with 12 participants within the Nigerian construction industry. Through stratified random sampling, the questionnaires were sent out to the participants through emails and post box.

3.3 Data Collection

In this study, the sampling population is from Abuja in central Nigeria, due to its expansion as the new capital city of the country. The population was estimated to be 4,000,000 by the National population commission (NPC) (CTGN Africa Published on July 20, 2016). A random sample technique was used for the population of construction workforce opinions (Teddlie and Yu, 2007; Creswell, 2009). This was accomplished using the construction industries drives from the Civil Construction Directory Gallery (CCDG) database within Abuja metropolis.

Sample size is the genuine number of sampling made on the aggregate population; this is the extent of the population that was served with the research instrument. This study considers 5% of size accuracy, 95% certainty level, 50% level of inconsistency and a purposive sampling technique was involved (Chuan and Penyelidikan, 2006). From there on, the sample size was chosen in view of this formula:

$Sampled\ size\ (n) = \quad (\frac{N}{1+N(e2})$ (Yamane, 1967) ………………. Equation 1

Sample Size (n) = $\frac{4{,}000{,}000}{1 + 4{,}000{,}000\ (0.052)} = 399$ ……………… Equation 2.

Where n is the sample size, N is the population, and the e is the level of precision. Considering the above factors for deciding sample size and using the formula gave 399 participants when applied, the figure indicate that the least questionnaire to be distributed for the whole research.

For this paper, 250 participants were selected through stratified random sampling, these are; Project/Site Managers, Technicians and Trainers/Educationists. Designed questionnaires were administered to the participants to identify the training analysis, actual skills and knowledge needed for the Nigerian construction industries. Against the backdrop, 250 questionnaires were distributed and 182 were retrieved and used for the analysis. An E-mail address was made available to the participants and self-envelop; Post Box is also available in Nigeria.

3.4 Respondents Profile

A total number of 182 questionnaires from different construction industries participated in this research and from the research demography shows that all the participants are with different qualifications (see Table 2). For the purpose of this paper, 63 questionnaires from technicians, 49 and 70 from project managers and trainers respectively were returned constituting 73% and were analysed. Table 2 indicates the Participants occupation, Level of education, Working Experience and Company size. Across the three groups, 18.2% are supervisory technicians, with higher qualifications, (11–15) years of working experience within the industries of various sizes (Micro enterprise, Small, medium and large enterprise). In addition, Table 2 indicates that 20.3% of the participants belongs to others (trainers/educationists) with Higher qualifications and a working experience in the industry for 16 years and above. These findings are in line with Bilau et al. (2015) and Ogunsanmi, (2016) studies, who argued that the young people are not interested in construction related skills. However, in developed countries like the United Kingdom (UK), reports indicate that demand from young people for apprenticeships is outstripping the number of training places available (Awe, 2006; Bilau, 2015).

Table 2: Respondents Profile

Current Job	**%**	**Education Level**	**%**	**Experience**	**%**	**Company Size**	**%**
Electrical technician	5.8	Primary School	14.3	0 – 5 years	26.6	Micro Enterprise	3.2
Mechanical technician	28.8	Secondary school	19.0	6 – 10 years	28.6	Small Enterprise	28.6
Project Manager	26.9	Higher Institution	26.5	0 – 5 years	16.4	Micro Enterprise	6.1
Supervisory technician	18.2	Higher Institution	18.0	11 – 15 years	19.5	Medium Enterprise	14.0
Others (Trainers)	20.3	Higher Institution	22.2	16 and above years	8.9	Large Enterprise	17.5

3.5 Data Analysis

A descriptive statistical technique was used to assess the data collected from the developed questionnaires (Cox, 2018; Nardi, 2018). The approach tends to describe the phenomenon and the attitude of those affected by it (Glaser and Strauss, 2017). Parametric tests have been used to analyse the reliability and validity, this provides empirical reliance on the data collected. The tests were used to analyse the data include the mean, a chi-squared test was used to explore relationships between variables and correlation analysis was conducted to measure the relationship among variables to accomplish research objectives.

4. RESULTS AND DISCUSSIONS

4.1 Most Appropriate Training Methods

The most effective method of training is the Polytechnic/Colleges of Technology (see Table 3) and this view is in line with study of Yusuff and Soyemi (2012), who argue that the polytechnic is the most appropriate training method for effective skilled development of construction workforce. Yet other studies rejected this assertion, saying that they are being discriminated by many professional bodies (Ogbunaya and Udoudo, 2015; Olibie et al., 2013). For instance, a Higher National Diploma (HND) graduates cannot gain admission for a postgraduate degree without an additional qualification and equal opportunities are not given during employment. However, Olibie et al. (2013) argue that the standard of all tertiary institutions should be raised to the same level, staff development and training intensified. In line with the above, adequate educational resources (human and material resources) should be provided and once existing be maintained. This study is in support of the participants views that the polytechnic/Colleges of Technology education is the most appropriate training method. This is due to the manual activities been carried out within the industry, mostly in the developing countries like Nigeria. The construction activities are mostly manual, and the polytechnic/Collages of technology mostly do constructions activities while the universities are more of theoretical work.

Table 3: Appropriate methods of training for apprenticeship in Nigeria

	Response scores in percentage %						**Mean Value**	**Standard Deviation.**	**Cronbach's Alpha**
	No. of respondents	**VS**	**S**	**N**	**DS**	**VD**			
Polytechnic/ Colleges of Technology	49	77.6	18.4	4.1	0.0	0.0	4.73	.53	0.80
University Education	49	73.5	24.5	2.0	0.0	0.0	4.71	.50	
Science and technology colleges	49	53.1	42.9	4.1	0.0	0.0	4.49	.58	

4.2 Hindering Factors of the Growth of TVET in Skilled Upgrade

Table 4 indicates the various factors hindering the growth of TVET in enhancing the skilled upgrade in construction industry concerning Quality standard and Quantity of skilled labour trained. These findings are in line with the findings of Okoye and Arimonu (2016), Ifeyinwa and Serumu (2016) and Ayonmike (2014) among others whose views are in line with the factors impeding the growth of Nigerian construction industry. However, there is a clear indication of challenges of TVET funding, training facilities, ineffective training methods, shortages of qualified TVET trainers with a mean value of 4.60, 4.19, 4.05, and 4.03 respectively. More so, the findings also indicated that the effect of the Quantity of skilled labour trained is a serious challenge within the organisation compare to the quality standard of skilled labour.

Table 4: Factors hindering the growth of TVET in enhancing the skilled upgrade

	Response scores in percentage %						**Mean**	**Std D**	**Cronbach's Alpha**
	No of respondents	**SA**	**A**	**N**	**DA**	**SD**	**Value**		
Poor funding of TVET in Nigeria	63	68.3	27.0	1.6	3.2	0.0	4.60	.685	
Insufficient facilities for training	63	25.4	68.3	6.3	0.0	0.0	4.19	.535	.87
Ineffectiveness of training models	63	14.3	76.2	9.5	0.0	0.0	4.05	.490	
Government lack of commitment to TVET	63	25.4	57.1	12.7	4.8	0.0	4.03	.761	
Shortages of qualified TVET teachers	63	25.4	54.0	12.7	4.8	3.2	3.94	.931	

5. CONCLUSIONS

This paper explores the effect of the technicians' skills gaps and its impact on the construction industry development in Nigeria. The technicians' skill gap is considered critical in terms of the industry performances particularly in the workforce efficiency. The paper critically assessed the technicians' skills gaps and training on the output of the industry performances. Hence, the factors that negate growth in technicians' skills within the industry are identified. From the study carried out, the findings from the analysis of the questionnaire survey indicates that the Polytechnics/Colleges of Technology are the most appropriate training method for construction related works. This is surprising that the polytechnic method of training is been given less attention to that of the university training. This study suggests that lack of interest shown by youths in acquiring construction related skills, poor funding of TVET, insufficient training facilities lack of government commitment are major concerns for poor performances. In addition, the study also suggests that training and skill upgrade is a necessity for the construction industry development. Despite different innovations in producing the needed skills apprentices for the industry, the expected effectiveness in the training of apprentices in the industry is still limited. The demand for skilled workforce has not been properly addressed within the Nigerian building construction industry. Hence, there is need to investigate further the behavioural issues of both the employees and the employers within the industry.

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Design and Urban Development

USING THE FEDUP GROUP SAVINGS SCHEME MODEL FOR THE PROVISION OF CONTEMPORARY SUSTAINABLE HUMAN SETTLEMENTS

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Abstract: The study aims to understand the Federation of the Urban Poor (FEDUP) group savings scheme model for self-help housing and how it can be used for the promotion of sustainable human settlements. This study, therefore, aims to evaluate this model, whether or not it could be replicated in the central region of South Africa as well as to devise a policy framework in order for the model to be used for housing consolidation in South Africa. The study will use the qualitative research approach for data collection, analysis and presentation. The data collection techniques include semi-structured interviews, structured observations, and focus groups. The preliminary results exemplified how the FEDUP group savings scheme model can enhance the current unsustainable public housing delivery mechanisms. The literature findings also show how this model can be an alternative to the current delivery mechanism for housing in South Africa. This study will, therefore, have a positive social impact by demonstrating how self-help housing can assist in enhancing the current unsustainable government system of low-cost housing provision, through community participation in the housing development process and production of an arguably better housing product. It also has the potential to make contemporary contributions to the public housing policy framework in South Africa.

Keywords: community participation, group savings scheme, self-help housing.

1. INTRODUCTION

In a rapidly urbanising and changing world, the provision of adequate and affordable housing remains a priority for the majority of governments across the world. However, it is paramount for governments to shift away from the provision of mere housing and instead focus on the delivery of sustainable human settlements, especially in developing countries. Sustainable development is referred to as a multidimensional process or principal for economic and social activities. According to the 1987 Brundtland Report (United Nations, 1987) and the 1992 Rio Earth Summit, the most popular definition of Sustainable development is “Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs”. The Breaking New Ground (BNG) policy (2004) indicates that sustainable human settlements are well-managed entities. In such entities, economic growth and social development are in balance with the carrying capacity of the natural systems on which they depend for their existence and result in sustainable development, wealth creation, poverty alleviation and equity.

Increasing urban poverty, severe shortages of serviced land and adequate housing, inadequate urban policies and planning approaches, and excessive urban dwellers are manifestations of the challenge well-articulated in the Sustainable Development Goal (SDG) 11. SDG 11 states that cities have become home to urban sprawl dwellers and centres of poverty. In order to make a city more sustainable, affordable housing needs to be created (United Nations Development Programme [UNDP], 2018). The report stipulated that the number of people residing in slums increased from 807million to 883million from 2000 to 2014 (see Figure 1). Figure 1 illustrates the number (in millions) of people living in slums in both developing and developed countries. The majority of people living in slum conditions are located in the following key areas; Eastern and South-Eastern Asia (332 million), Central and Southern Asia (197 million) and sub-Saharan Africa (189 million), (United Nations, 2019).

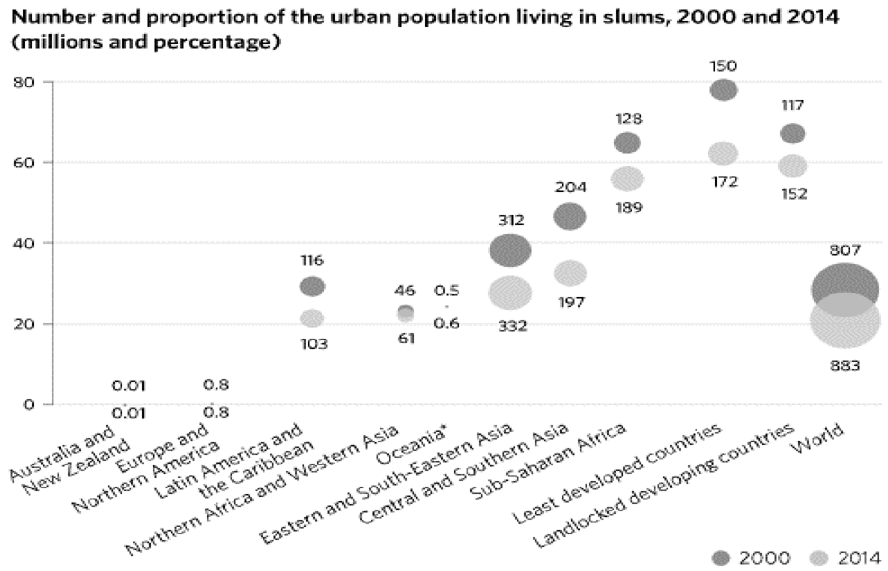

Figure 1: Number and proportion of people living in slums (Source: United Nations, 2019).

The main aim for this paper is to demonstrate how the Federation of Urban-Rural Poor (FEDUP) group savings scheme model can be used to engender a sustainable model for housing consolidation in the central region of South Africa. The term group savings scheme generally refers to a group of people with a common interest who enter an agreement to contribute a fixed amount of money that is pooled at intervals, which could be weekly or monthly (Sibiya, 2002). For housing development purposes, every member then receives a lump sum at an agreed time to buy durable or fixed property (Sibiya, 2002; Harper, 2003; Daphins and Ferguson, 2004).

2. LITERATURE REVIEW

For developing countries, informal settlements continue to pose a severe challenge for policymakers (UN-Habitat, 2003, cited in Maina, 2013). In addition, informal settlements convey numerous challenges which require urgent policy attention including high levels of overcrowding, insufficient access to services, inadequate housing, and socio-economic challenges such as high rates of urban poverty, crime, tenure insecurity, unemployment and marginalisation (Bolnick, 2009; Del Mistro and Hensher, 2009). Regardless of these challenges, informal settlements have a substantial role in cities such as access to housing for the majority of the low-income population (UN-HABITAT, 2011 cited in Maina, 2013).

South Africa is a country that is still reversing apartheid's wrong spatial planning legacy. The country is attempting to address the needs of rapidly growing populations; hence, millions of people are deprived of receiving adequate housing, which results in the development of informal settlements. The 2011 census report stated that 14% of households in South Africa live in informal settlements, and they increase annually (Statistics South Africa, 2019). According to Royston (2019), the government tends to hesitate to intervene in the property and land markets, which, in essence, lead to a lack of affordable and well-located land. This remains a crucial challenge to the provision of adequate housing for the urban poor. Urban poor refers to individuals or families in urban areas with incomes below the poverty line; they are underprivileged, residing in informal settlements within urban fringes (PCUP, 2019). In 2004, a new era of housing policy emerged, which is known as the Breaking New Ground: A Comprehensive Plan for sustainable human settlements. This policy encompasses several programmes which may be used in the provision of public housing, which shifts from eradicating informal settlements towards in-situ upgrading and incrementally in desired locations. In-situ upgrading is the process of consolidating/ delivering public housing on the current land in which beneficiaries live, mostly it is the opposite of relocation and may also be referred to as brownfield projects (Maina, 2013).

In the literature, it is argued that upgrading informal settlements may be a more suitable solution than the current delivery method of delivering public housing (Klug and Vawda, 2009; Western Cape Government, 2016; SDI South African Alliance, 2018). Self-help housing has been used for decades and popularised by coiners such as John Turner, Charles Abrams and Jacob Crane (Daphins and Ferguson, 2004; Harper, 2003; Harris, 1997). The FEDUP group savings scheme model, supports the notion of self-help housing by encouraging people to collectively pool money together for the improvement of their homes.

South Africa's current housing policy is primarily based on the understanding that housing is a basic need. The post-apartheid government inherited appalling housing conditions with a massive housing backlog. As a strategy to combat this housing backlog, housing subsidies were introduced. However, they only provided starter housing referred to as The Reconstruction and Development Programme (RDP) house under the 1994 Housing White Paper. RDP houses were articulated as the African National Congress (ANC's) manifesto for the 1994 election campaign. The official mandate of the RDP was for policy formulation before it was utilised for housing development. Thus it did not focus on addressing the individual household needs but rather on the mass production of housing (Huchzermeyer, 2001). The programme aimed to address socio-economic problems such as poverty and inadequate services which were created by the past apartheid government. However, RDP housing is only $35m^2$, and it is merely a starter house, which beneficiaries have to extend later using their funds in order to get their desired housing units.

However, during the housing policy shifts in South Africa during the early 1990s, NGOs had already started finding solutions for the provision of housing for low-income households. In 1991, the South African Homeless People's Federation (SAHPF) introduced the use of group savings schemes for housing as a model to assist the poor to better their living conditions. To exemplify the work of SAHPF is the Piesang River housing project in Inanda, Durban. The SAHPF's mandate was to make end-user finance available to the poor. SAHPF's leading role, together with uTshani fund was to help inspire women in the Piesang River community to mobilise their savings so that they could add-onto the RDP housing subsidy in order to have a better top structure (Khumalo, 2013). The Piesang River community was, therefore, the first community in Inanda that used the group savings scheme model for self-help housing (Sibiya, 2002). uTshani fund helped women to establish savings schemes and provided them with housing loans, which had low-interest rates. Group savings scheme members were given a maximum of R10 000 per member of the scheme with a fixed interest rate of 1% every month (Sibiya, 2002; Khumalo, 2013). In a study of women's participation in the planning and construction of their houses by Khumalo (2013) findings indicated that every woman received whatever they had saved to add to their subsidies.

Moreover, women were involved in the building of their homes. They helped during the construction of their homes physically. As a result, women were able to have control of the project, and they contributed to the decision-making process. After the implementation of this project, SAHPF was later enhanced to the Federation of the Urban Poor (FEDUP). The Piesang River housing project was able to demonstrate how group savings schemes can be utilised for housing because from this project; other communities also adopted the model.

This study will, therefore, use the lessons learned from this case study to evaluate the model on whether it can be used in central South Africa to aid with the eradication of slums as well as to devise a policy framework for self-help housing utilising the model.

2.1. Challenges of FEDUP Group Savings Scheme Model in South Africa

Land ownership is one of the critical challenges for FEDUP, mainly because of scarcity and cost. Khumalo (2013) noted that some of the FEDUP houses are built on municipal pipes and electricity power cables due to inadequate investigation and feasibility studies. Another challenge is the lack of required trust from community members. When FEDUP introduces the concept of group savings for the consolidation of housing (Mathoho, 2010), the people in the community tend to be sceptical because of continued dependency on the government to provide free housing for the poor in South Africa.

As a result, one of the crucial drawbacks of the model is mobilising people to save voluntarily and to introduce a paradigm shift from dependency towards a more self-help approach for housing. Relationships between municipalities, community members and the advocates of the FEDUP concept could be tense at times. For instance, public housing provided by the government is only $40m^{2,}$ and the FEDUP housing is $50m^2$, thus leading to conflict amongst the previously mentioned stakeholders (FEDUP profile, 2012; Khumalo, 2013).

In a country stricken by high levels of crime (Crime Stats SA., 2019), vandalism is another challenge with FEDUP. After construction and commissioning, vandalism from community members who are not beneficiaries of the model does occur. The model does not have an effective strategy to deal with defects and maintenance of the housing stock. Meaning, after the group savings scheme members have received their homes, they do not carry on with saving so that they can maintain the quality of the homes.

3. RESEARCH METHODOLOGY AND PHILOSOPHY

The research methodology is the broad conceptualisation of a research project. It is inclusive of the methods that will be used for generating data. It may also be described as a systematic analysis of the methods applied to a field of study (Bitzer, 2017). Evaluation research is selected for this doctoral project because Clarke and Dawson (1999: 35) say it produces information about how policies and programmes are implemented and even their effectiveness to bring about change. Moreover, its main objective is not to discover new knowledge but to study the effectiveness of existing knowledge and how it can be used to guide practical action (Clarke and Dawson, 1999).

The research philosophy will follow the interpretive approach as it integrates human interest into a study. Interpretive research philosophy favours qualitative analysis over quantitative analysis (Myers, 2008 cited by Dudovskiy, 2018) because a researcher is seen as a social actor that appreciates the differences between people. The interpretive approach is centred on a naturalistic approach of data collection, such as interviews and observations. Secondary data research is also shared with the interpretive philosophy (Dudovskiy, 2018). Concerning this study, the interpretive approach is deemed most appropriate because the study is based on a social challenge (housing) and therefore relies on the openness of people, which will form part of the naturalistic approach.

3.1 Research Strategy Rationale

The purpose of the research methodology is to determine how the objectives of the study will be achieved and how the questions will be answered. The research focuses on self-help housing in South Africa and its interventions towards sustainable housing consolidation. The study shall provide critical analysis of the current policy framework for housing delivery systems and examine whether the FEDUP group savings scheme model as opposed to the current housing delivery strategies can contribute to the creation of sustainable human settlements in South Africa.

The qualitative research approach will be utilised for this study, including both primary and secondary data sources. Primary data is the original data, which is collected for a specific research goal (Kumar, 2008). In this research, primary data shall be collected to understand the FEDUP group savings scheme for the delivery of self-help housing based on the information that might be left out in secondary data. Two methods will be undertaken in order to collect data primarily, which include face-to-face interviews and focus group discussions.

According to Johnston (2014), secondary data is data that specifies a second-hand account about people, events, topics, or places that is based on what some other writer has experienced. Secondary data in this research will involve reviewing literature that relates to the use of group savings schemes for self-help housing, which assists in highlighting the gaps within the use of incremental financing methods for the delivery of self-help housing that still needs to be filled. Secondary data sources will be inclusive of books, journals, articles, academic papers and relevant dissertations about incremental financing methods such as group savings schemes and self-help housing projects.

3.2 Proposed Instruments for Data Collection

As mentioned earlier, the primary data shall be collected using multiple tools, which include:

- Semi-structured interviews: This comprises of pre-set open and closed questions which will be used to stimulate the interviews. This instrument is a purposive and non-probability sampling method. Non-probability sampling is a sampling technique in which the researcher selects samples based on a particular judgment of the researcher rather than random selection (Etikan et al., 2016). According to Saunders et al. (2009), semi-structured interviews allow the researcher an opportunity to investigate answers when the interviewees are requested to elaborate on their responses.

- Furthermore, semi-structured interviews complement the interpretivist epistemology, which will be used in this research. The researcher adopted this instrument as it allows the researcher to conduct further discussions into areas that the researcher might not have previously considered but would still enhance rich research data while addressing the research questions and objectives (Saunders et al., 2009). The researcher will, therefore, choose the critical informants based on their expertise so they can positively contribute towards the study and they will be able to add value during probing of questions through the semi-structured interview.
- Non-participant observation: This involves the researcher collecting data by observing the informal settlements in South Africa in terms of their spatial patterns, social, economic and environmental aspects and how they have contributed to the development of slum dwellings, and
- Focus groups: Discussions will be held briefly with selected informal settlement dwellers based on their availability and approval by community liaison officers and ward councillors.

4. DISCUSSION

The study suggests that low-income communities and government can utilise the FEDUP group savings scheme model for self-help housing as an alternative to the current public housing delivery programmes. This model is seen as a means to curb the high subsidies grants spent by the government while enhancing beneficiary satisfaction. The model is underpinned by the self-help housing principles whereby beneficiaries are given the freedom to build their own homes according to their needs. With the use of this model, low-income people will have their dignity restored through the notion of community participation; thus, there will be fewer houses being sold or rented due to satisfaction. Moreover, the model can also be used to address the challenges of urban poverty in developing world cities as it encourages low-income communities to save in groups in order to consolidate housing but most importantly, to better their standard of living.

Figure 2 shows the FEDUP group savings scheme model. Level one in the figure indicates the steps taken by key stakeholders and their roles within the model. The second level explains the relationships between these various key stakeholders. The roles of the key stakeholders in the project are listed as they occur during the implementation of the FEDUP group savings scheme model for self-help housing. The relationships are sequenced to show the implementation roles of housing project actors. This study is thus important as it aims to suggest an alternative model for the delivery of public housing and housing consolidation based on a bottom-up approach, a more sustainable model. The model will serve as a mechanism to curb the current rapid sprawling informal settlements which keep emerging as the phenomenon of urbanisation keeps increasing.

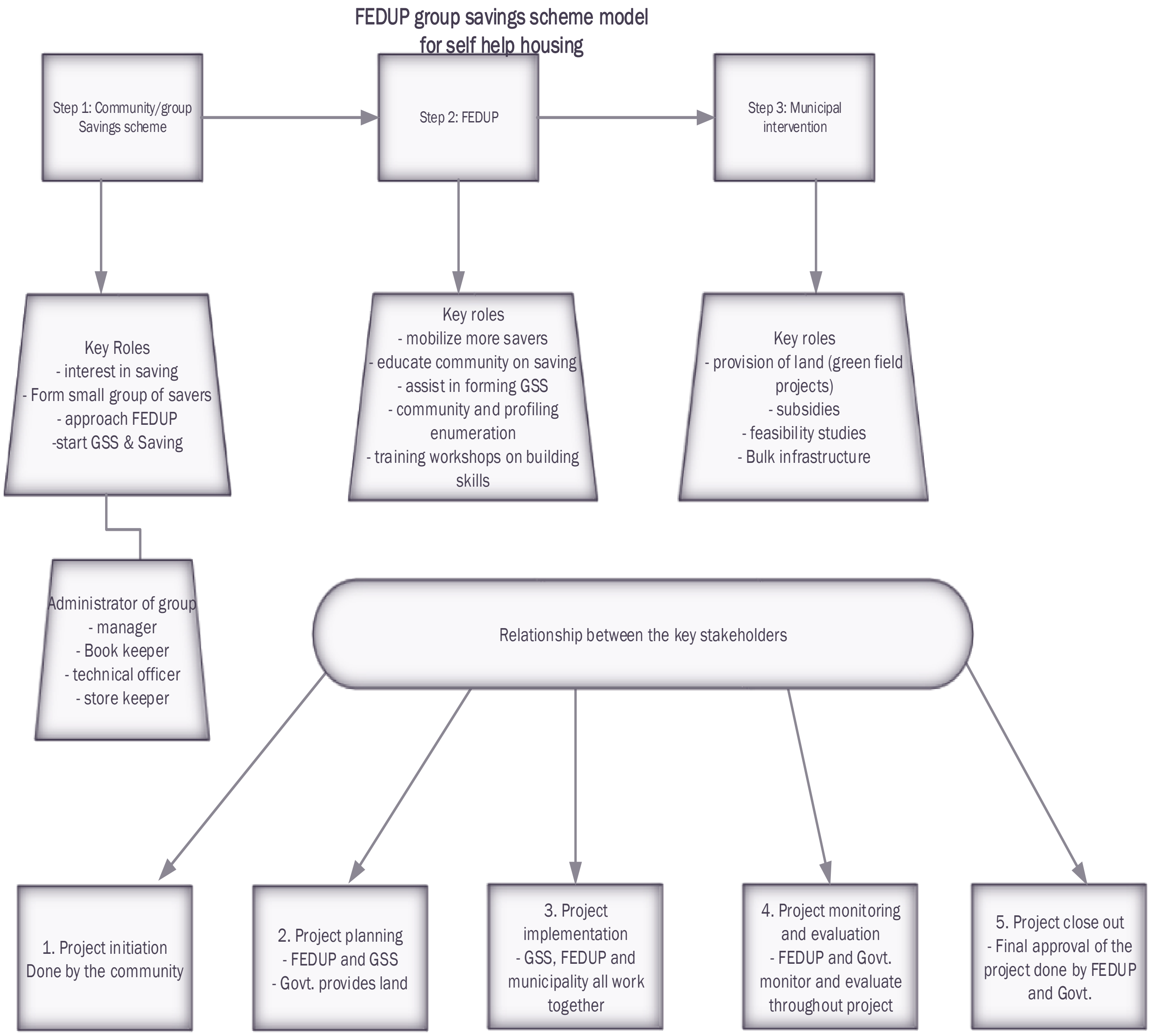

Figure 2: The FEDUP group savings scheme model: Source: (Author, 2019).

5. CONCLUSIONS

The research aims to understand how the FEDUP group savings scheme model can be used for the provision of low-income housing in central South Africa to develop a new policy framework for self-help housing. The study will focus on group savings schemes, self-help housing, sustainable human settlements, informal settlements upgrading. As a result, the study has the potential to yield a very positive social impact in urban peripheries, which prone to urban poverty emanating from the rapid development of informal settlements. The researcher's contributions will assist the South African government in combating one of the third world's greatest challenge, the eradication of slums and the prevention of emerging slums. Moreover, the FEDUP group savings scheme model will also encourage a paradigm shift, where the financially weak move away from the dependency syndrome into a more independent state of mind as they learn how to use their savings to change their lives.

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TACKLING SPATIAL INEQUALITIES THROUGH MIXED INCOME HOUSING: A QUALITATIVE ANALYSIS OF STAKEHOLDER PERCEPTIONS

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Abstract: Although several studies have sort to establish the influence of mixed income housing (MIH) on eradicating urban poverty, few of such studies have appraised the utility of MIH initiatives in combating spatial inequalities in a manner that tackles the incidence of urban poverty, particularly in South African cities. This is the gap which this study seeks to contribute to bridging. Adopting a case study research design, this study elicits the perceptions of a cross-section of stakeholders on the development of a new MIH scheme as it pertains to the usefulness or otherwise of proposed scheme in combating urban poverty through spatial restructuring. Semi-structured interviews and a focus group discussion exercise was conducted with purposively selected interviewees and discussants. The emergent data was analysed thematically. Preliminary findings highlight a consensus among relevant stakeholders on the MIH's potential to curb urban poverty through the facilitation of spatial restructuring. However, they observe that the MIH under the present delivery arrangements was only inclined to the geographical aspects of resolving spatial inequalities and not the social relations aspect. This inadequate consideration of the social relation facets signals the potential of the approach to underperform with regards to resolving spatial inequalities, and by extension, urban poverty. This study holds salient implications for stakeholders involved with the planning of MIH developments.

Keywords: Mixed income housing, qualitative analysis, urban poverty, South Africa.

1. INTRODUCTION

Globally, the mixed income housing (MIH) strategy has gained prominence as the strategy of choice among policy makers, practitioners and researchers with an interest in affordable housing provision. Its popularity derives from the strategy's potential to serve as a panacea to social challenges like urban poverty and socio-spatial segregation. Its reputation for enabling the integration of a variety of persons from low-, medium, and high-income households in an inclusionary manner has been elucidated (Joseph, 2006). Considering its perceived usefulness in the provision of a variety of housing products to suit different income groups within a location, MIH is now regarded as an innovative housing delivery strategy (Vale and Shamsuddin 2017, Joseph 2006, Onatu 2012).

Having highlighted the positive aspects of the MIH concept thus far, it is imperative that the downsides of the concept be stated accordingly. Opposition to the MIH in several climes has emanated from the NIMBY (Not-In-My-Back-Yard) syndrome afflicting residents of areas bordering proposed MIH development sites. An example of such instance can be deciphered from the perceptions of original residents of such areas concerning the effect of such developments on property values in the area. Other fears which have been expressed concern the influence of expected levels of multi-dimensional social cohesion on the pervading cultural values of the area prior to the advent of the proposed MIH development. Social cohesion in this instance connotes social order and control; shared values and civil culture; social solidarity; social networks and connectedness; and a sense of place attachment and identity in the urban area. Although these facets of social cohesion can sustain positive change among residents belonging to different income groups, there is a perception that the disparity in values between these groups could exacerbate the incidence of crime in the area (Kriegler & Shaw, 2016; Lukhele, 2014).

Cities in the Global South are experiencing unprecedented levels of urbanization and, this trend has been predicted to continue (Guneralp et al. 2017, UNECA 2017). According to Guneralp et al. (2017), Africa's urban population is expected to triple over the next 40 years. Accordingly, the continent's urban population will rise from 395 million in 2010 to 1.339 billion in 2050, thus constituting 55% of the continent's estimated population of 2.5 billion and 21% of the projected global population (Guneralp et al. 2017). Corroborating these projections, the Economic Report on Africa (UNECA, 2017) reiterates that 90% of the increase in global urban population will occur in Africa and Asia, thereby making these continents the fastest urbanizing centres.

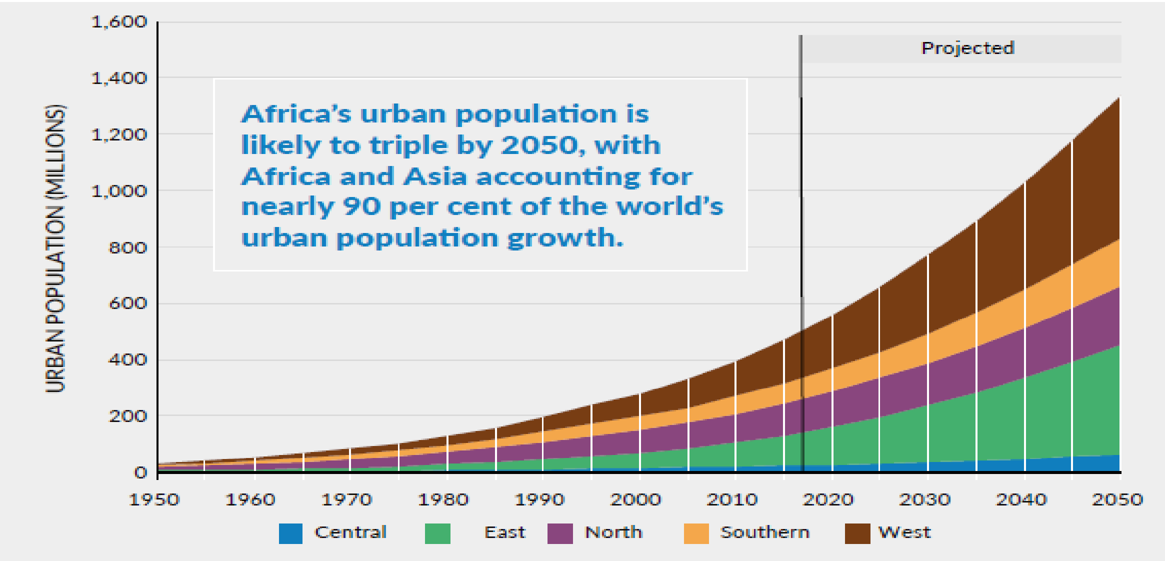

Figure 1. Urban populations by African subregion, 1950-2050 (UNDESA 2014; UNECA, 2017)

According to the postulations presented in Figure 1, the urban population in Southern Africa is expected to rise to 800 million from its current state of less than 350 million- an increase of 450 million. With this projection, the region will rank only second to Western Africa in terms of urban population growth over the course of the next 31 years. Given the dominant size of South Africa within the Southern Africa region, it can easily be deciphered that it will contribute significantly to this urban population growth when compared to its peers in the region.

Such unplanned levels of rapid urbanization have attracted high levels of urban poverty in the face of extant spatial inequalities. Literature highlights the nexus between spatial inequalities and urban poverty (Rogerson 1996, Grant 2010, Viljoen and Sekhampu 2013, Turok et al.

2017). Left unchecked, this projected increase in the urban population will lead to an exacerbated level of urban poverty in South African cities, particularly with the incidence of spatial inequalities experienced in those areas. In the third quarter of 2017, the unemployment rate of the country stood at 27.7% with youth employment rate constituting 38.6% (Hurlbut, 2018). This underscores the impending challenge posed to South Africa if issues such as urban migration and spatial inequalities are not properly managed. Therefore, it has become imperative to explore strategies for restructuring the spatial patterns in the country in a manner that reduces the spatial inequalities experienced, whilst indirectly tackling the incidence of urban poverty.

The MIH strategy has been proposed as one of the several strategies for overcoming spatial inequalities through housing delivery. The strategy seeks to propagate inclusionary housing in a way that ensures the juxtaposition of households from various income categories through co-location of affordable housing, public housing and market-rate housing. This is based on the expectation that co-location will lead to multi-dimensional spatial integration amongst persons belonging to these diverse classes. The success or otherwise of this approach in delivering this mandate has been seemingly underreported, particularly in the Global South. Although evidences have been drawn from the effects of the Housing of People Everywhere (HOPE), a precursor of the global MIH initiative, focusing on different implementation facets and benefits; yet, this has not been reported in a comprehensive manner.

Whilst a paucity of studies into the utility of MIH strategies in facilitating the restructuring of spatial patterns resulting from a plethora of apartheid policies, within the South African context has been noticed (Viljoen and Sekhampu 2013), an even fewer number of studies have sought to explore the perceptions of planning experts concerning the concept's usefulness in engendering such restructuring. This is the aspect to which this study makes considerable contributions. This study forms part of a wider study seeking to establish a multi-dimensional, systemic MIH implementation framework for spatial restructuring of urban areas in South Africa. However, the study being reported in this paper only seeks to gauge the perceptions of a section of stakeholders within the implementing subsystem of the MIH delivery system- planners in the Metro municipality as reiterated previously.

The rest of this paper is structured as follows: a review of relevant literature on the concept of MIH and the nexus between MIH, spatial inequalities and urban poverty, and; a description of the study's context- Bloemfontein, South Africa and the proposed MIH project; a justification of the research methods for the study, and the presentation and discussion of preliminary findings from the study. The conclusion ensues afterwards.

2. LITERATURE REVIEW

2.1 Mixed Income Housing - a Definition

The "Mixed income housing" (MIH) concept has been defined differently by various scholars to accommodate a diverse range of housing typologies. This has culminated in the existence of different connotations of the concept. Some of these connotations include, racially integrated developments, mixed tenures, mixed housing typologies, mixed housing options, mixed income levels, etc. (Onatu,2010; Landman, 2010; and Joseph et al, 2007). The MIH is an urban redevelopment strategy which serves as a transformative tool for unsuccessful housing developments. Onatu (2010:204) defines mixed income housing as "developments that combine market-rate and public assisted units, for people with income levels ranging from the above-moderate income to very low". Also, MIH has been used to depict an approach that "covers a broad spectrum of levels of economic integration" (Joseph et al. 2007:371). Joseph (2006:209) adds that the spectrum covered by the concept "ranges from private-sector, market-rate developments that include a small percentage of affordable housing to development built exclusively or moderate-and low–income families". This definition corroborates the previously stated definition provided by Onatu (2010). The MIH approach has been applauded and adopted by policymakers, local governments and academics because of the improvements that it renders within extant social networks whilst allowing for the integration of persons who would, hitherto, have not been able to be integrated within market-rate neighbourhoods. Vale and Shamsuddin (2017) allude that MIH represents a planning strategy aiming at replacing deteriorated urban areas with sustainable communities that are safe and attractive. This is in alignment with Goal 11 of the Sustainable Development Goals (SDGs), which identifies with the need for inclusive, safe, resilient and sustainable cities as a way of empowering the individual (United Nations, 2016). Joseph (2006) restates the MIH's potential, as a policy strategy, to curb urban poverty through the provision of a suitable response to the social isolation of the urban poor. He buttresses this claim, in the same study, by highlighting that the main driver for the development and adoption of MIH lay in the need to reverse the racial and socio-economic segregation which had long persisted in urban America. In another contribution, Berube (2005) and Darcy (2010) suggests that the MIH strategy is supportive of social inclusion as it stems from the need to address extant socio-economic inequalities being experienced across various locations, globally.

From the foregoing, it is evident that a consensus exists among various scholars on the ability of MIH under any guise to contribute towards restructuring spatial patterns to combat urban poverty in contemporary society. However, the lack of evidence concerning this ability implies that the adoption of the MIH has largely been premised on faith rather than empirical evidence (Joseph 2006, Kontokosta 2013, Fraser et al 2013, Moos 2018).

2.2 MIH, Spatial Inequalities and Urban Poverty - Connecting the Dots

As stated in the previous section, a consensus exists among scholars and policymakers alike on MIH's potential to contribute towards restructuring discriminatory spatial patterns, thereby eradicating spatial inequalities and, tackling the incidence of urban poverty. In this section, effort will be dissipated towards an attempt to establish the connections between the three concepts of MIH, spatial inequality and urban poverty. David et al. (2018) admit that spatial inequality constituted a key dimension of inequity. They maintain that it relates to the nature of spatial distribution of economic and productive activities within a given area. Spatial inequality has been found to contribute towards the entrenchment of welfare and economic disparities among different classes of individuals. According to David et al (2018), the causes of spatial inequalities were traced to a plethora of factors, namely: initial conditions, history of a community, (non)availability of endowments, institutions, trade, increasing returns to scale, imperfect information, and transaction costs among others. A closer consideration of these factors reveals that certain areas (neighbourhoods) will experience spatial inequalities as a result of institutional or historical occurrences. This historical notion will imply that the residents of the area will become disadvantaged in terms of economic productivity and welfare. This will invariably situate them in the urban poverty trap due to no direct fault of theirs. This scenario is described as the urban spatial poverty trap (Grant, 2010).

Grant (2010: v) reiterates that spatial inequality is "…linked to the development over time of distinct areas of urban deprivation that undermines the benefits of physical proximity that urban residence may offer". Therefore, spatial inequality is a lot more than the positioning of certain areas populated by low-income households in high proximity of the centres of work and transportation as well as other basic amenities which can impact on the welfare and economic productivity of the households.

In the South African context, Turok et al (2017) admit to the existence of severe cases of spatial inequalities. They admit that South Africa remains one of the most unequal countries in the world with conspicuous imprints of spatial inequalities across its landscape. Corroborating this assertion, Viljoen and Sekhampu (2013) lament the state of spatial inequalities which, according to them, has led to an increase in the levels of black urban poverty. Continuing, the authors blame three aspects of the apartheid policy for this, namely: racially forced relocations, nature of housing provisions and the character and regulation of urbanization.

Two dimensions of spatial inequality stand out, namely, "the physical separation of people from productive activity and, the under-development of informal settlements and enterprises" (Turok et al, 2017: ii). In a review of the state of spatial inequalities within South African cities, Turok et al (2017) admit to the divided spatial patterns evident in South African cities. They lament the replacement of administrative controls which had hitherto served as a platform for enabling racial segregation-based spatial divisions within these cities with economic mechanisms of labour and land markets. As a result, black, low-income households have continued to be subjected to urban poverty as they are allowed to reside in informal settlements within the urban area or in townships situated at the urban area's periphery-settlements replete with substandard amenities and involving a long, costly commute to the areas of work, and education (Turok et al., 2017). Furthermore, their study points out the failure of the mass RDP house building initiative to resolve this imbroglio, admitting instead that the initiative has contributed to worsening the incidence of spatial inequalities in the country due to the programme's inability to consider the salient nature of the land market in influencing spatial development patterns. Obviously, the incidence of spatial inequality and other associated economic factors have led to the growing unemployment rate and the feelings of perceptions of injustice and resentment among most of the populace.

The MIH strategy has been recommended as a panacea for stemming this tide through a restructuring of spatial patterns to eradicate spatial inequality and combat urban poverty not just in South Africa, but globally (Vale and Shamsuddin 2017, Kontokosta 2013, Fraser et al 2013, Joseph 2008). Although there appears to be a lack of empirical evidence to prove this (Joseph 2006, 2008, Fraser et al. 2013), recent studies indicate that MIH remains the planner's choice strategy for sprawl reduction, development of lively neighbourhoods and promotion of economic growth (Moos et al. 2018). Yet, certain scholars have maintained that MIH requires a lot more than the adoption at face value to make the desired impact. Appraising the potential of the MIH strategy to cater for spatial restructuring and urban poverty, Kontokosta (2013) maintains that a variant of the MIH, inclusionary zoning (IZ) can only be successful if the following conditions are taken into consideration:

a. Existing tenants remain despite the influx of in-movers
b. Allocation of IZ dwellings are done in relation to income-eligible population by race, and;
c. IZ units are not allowed to crowd out other forms of low-income housing in the area.

Corroborating this perspective, Vale and Shamsuddin (2017) articulate four dimensions which may impact on the success of MIH initiatives, namely:

a) Allocation: Distribution of units by subsidy type- public housing, affordable housing, and market rate housing.
b) Proximity: Spatial separation of income mix.
c) Tenure: Distribution of homeownership versus rental units.
d) Duration: Time limits for subsidies that preserve the income mix.

Obviously, these suggestions are reflective of an overt concentration on the physical nature of the MIH as a means of facilitating social integration and not the social structure of such developments. In another study, Joseph (2006) posits that MIH developments are only designed to cater for resolving the social isolation of the urban poor and not in integrating them in a manner that enables them to overcome urban poverty. Furthermore, he provides four propositions regarding the nexus between MIH and urban poverty, namely: social networks as social capital; social control, culture and behaviour, and the political economy of place. For more insight into these propositions, see Joseph, (2006). For the purpose of this paper, these propositions serve as an indication of an existence of sociotechnical (geographical/physical and social networks) system which enables the successful deployment of MIH to combat urban inequality. Therefore, solely relying on the geographical/physical subsystem will not suffice. Also, the inability of the MIH to resolve other structural and systemic causes of poverty limits its potential for engendering social mobility and cohesion (Joseph, 2008).

Based on the foregoing, the rest of paper will seek to explore the perspectives of a cross-section of stakeholders concerning proposed MIH development as a mechanism for addressing spatial inequalities directly and, urban poverty, indirectly.

2.3 Description of Study Context

For decades, Bloemfontein, like many cities in South Africa, has encountered an increase in housing demand due to rapid urbanization, increase in population and densification. The increase in urban poverty, inadequately serviced land and urban policies and planning strategies led to the emergence of informal dwelling in the municipality. Mangaung Integrated Development (2017/18) indicates that the entire municipality has a housing backlog of approximately 31 200 housing units. This housing demand emerged from illegal occupation of land in the form of informal settlements in the township. Ogra and Onatu (2013) support the motion that housing demand is seen a societal ill in terms of affordability and a choice about tenure. The local sphere has a shared responsibility with provincial and national spheres to meet the housing needs of the citizens. In 2013, the Mangaung Metropolitan Municipality (MMM) adopted the Integrated Human Settlement Plan (IHSP) with the aim to integrate mixed housing typologies. In addition, the IHSP aims at changing the character of the city in terms of diversity of housing typologies. Focus is on changing provision of low-income housing to mixed housing developments. The municipality identified seven land parcels earmarked for mixed use development with the inclusion of integrated human settlements (Mangaung Metropolitan Municipality Built Environment Performance Plan, 2017/18- 2019/20).

Continuing, the municipality adopted the “Implementation of Mixed Developments” strategy to curb the challenges of human settlement as stated by the National Development Plan. The approach is an effort to facilitate social integration and cohesion by making provisions for different housing typologies to accommodate all income levels. The approach of mixed income housing provides a variety of tenure options to beneficiaries. These include ownership of housing, rental and bonded housing options within the same geographic setting. Currently, the municipality has two mega catalytic projects in the Vista Park area for mixed income housing (Mangaung Metropolitan Municipality Built Environment Performance Plan, 2017/18-2019/20). The mixed income housing developments in the Vista Park area comprise of Vista Park 2 and 3. These developments emerged as a result of housing backlog and emergence of informal settlements in Mangaung townships. The residential component of the developments will include Social, Gap and Subsidized housing which have different rental and financial options.

Vista Park 1 is a brownfield development whereas Vista Park 2 and 3 are greenfield developments located on the remaining portion of Farm Bloemfontein 654 which is owned by Mangaung Metropolitan Municipality (Figure 2). Greenfield developments are undisturbed portions of natural environments which are not connected to municipal services such as water, sanitation, stormwater and electricity (Department of Human Settlements, 2019). Vista Park 2 and 3 are in an area accessible to the community and will be provided with different amenities. The developments are located closed to an existing development, Vista Park 1. It is an extension of the existing development with bonded housing. These mixed income housing projects pose challenges to the residents of the existing Vista Park area who believe that the development will pose challenges for the properties. The planning of the proposed developments commenced in 2013 but no development has been finalized yet. This is an indication that the supply-led approach to housing delivery is slower that the demand-led approach (Onatu, 2010).

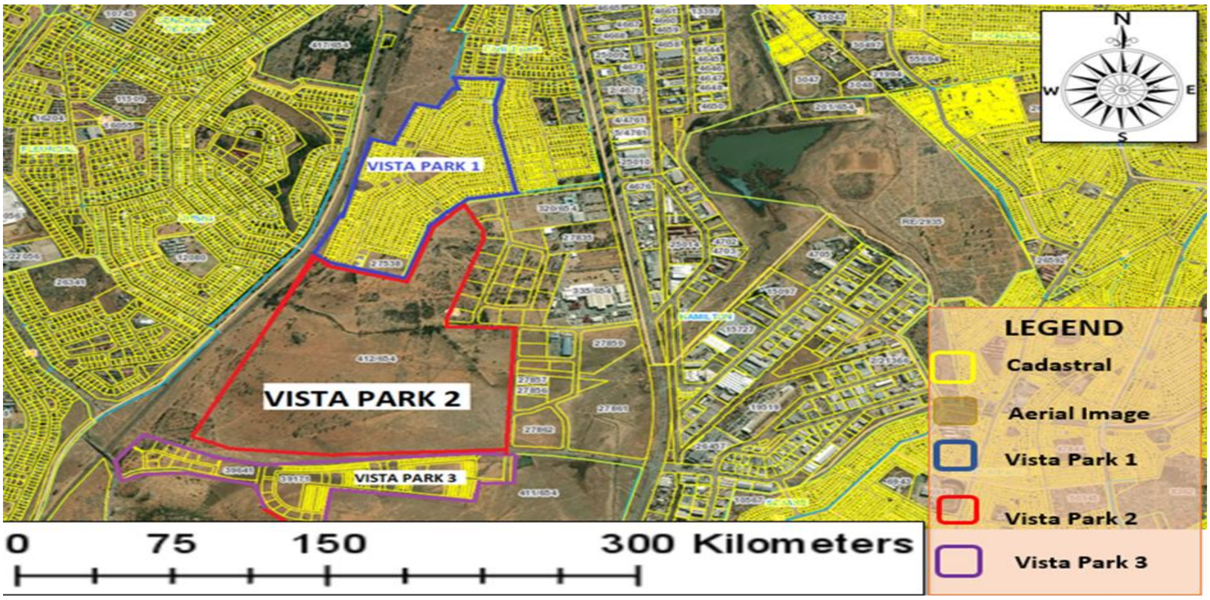

Figure 2. Vista Park area inclusive of the greenfield developments, Vista Park 2 and 3 (Map retrieved from MMM GIS division, August 2019)

The proposed land uses in the MIH development is provided in Table 1. However, it should be noted that the residential properties are not further delineated into sections detailing the number of allocations made to public housing initiatives, subsidized housing schemes and market-rate properties as indicated by Onatu, (2010).

Table 2 Allocations within Proposed MIH

Development	Proposed Land uses
Vista Park 2	Residential (5660), Sports facility (1), Education (3), Retail (2), Business (8), Public Open Spaces (19), Municipal purposes (22), Worships (4) and Crèche (2)
Vista Park 3	Residential (5131), Business (5), Garage (1), Education (3), Hospital (1), Worships (4) and Crèche (4)

Source: Mangaung Metropolitan Municipality Built Environment Performance Plan, (2017/18- 2019/20)

3. RESEARCH METHODOLOGY

The study seeks to gauge the perceptions of the residents of the Vista Park area in Bloemfontein, Free State Province in South Africa on the upcoming development. A qualitative case study research design was adopted in this study. Creswell and Poth (2018) allude that a case study research design allows the researcher to explore a bounded system and to collect thoroughly detailed, in-depth, contextual data pertaining to the phenomenon being understudied. The choice of this research design was further strengthened by its potential to avail the researcher with an opportunity to use a mixture of different methods for data elicitation. In this instance, the researchers collected data from different stakeholders using semi-structured interviews, personal observations, focus group discussion and document reviews. Yet for the purpose of this study, only the data elicited through semi-structured interviews and focus group discussions with the community is reported. It is imperative to mention herein that the study is still on-going, and the findings reported herein are subject to modification upon the completion of the study. Bernard and Ryan (2010) describe semi-structured interviews as a data collection technique that put emphasis on similar and not identical questions being asked to the same sample size. Focus groups, as a method of data collection, refers to the form of group interviews wherein the discussants deliberate over the issues brought forward by the facilitator or researcher (Bryman, 2012; Merriam and Tisdell, 2016).

During data collection, individual semi-structured interviews were conducted with purposively recruited town planning, human settlements and transport planning professionals from the local government. Only six (6) interviewees were interviewed for the study at the municipality government offices due to the personnel constraints. However, due to the deployment of purposive sampling, the interviewees were drawn from a population of individuals involved with the proposed development. The community members staying in the Vista Park area formed part of the focus group discussions. Prior to the focus group discussants, discussions with the ward councillor responsible for the study area was conducted. Ten (10) discussants participated in the focus group discussion. Both data collection methods were deployed independent of each other but comprised of similar questions. The questions posed were focused on the need to establish the stakeholders' perception of MIH as a veritable tool for spatial restructuring to combat urban poverty and, an identification of factors influencing the effectiveness of the proposed MIH development's capability to realize the stated objectives especially as it concerned spatial restructuring. The interviews and discussions were recorded using a voice recorder with the consent of the interviewees and the discussants, and subsequently transcribed. The transcripts were read variously by the corresponding author to make sense of the responses taking cognizance of the research aim. Relying on pre-determined themes, the researchers analysed the data by identifying excerpts from the transcripts which were aligned with pre-determined themes.

4. DISCUSSION OF PRELIMINARY FINDINGS

Preliminary findings emanating from the study will be discussed according to pre-determined themes resulting from the study's guiding research question: Does the mixed income housing strategy possess the potential to contribute towards the restructuring of hitherto existing (apartheid-induced) spatial patterns in Bloemfontein? And, what are the probable factors affecting its successful implementation in the case of the proposed Vista Park MIH development?

4.1 Theme 1: Perception of Stakeholders Concerning the Potential of MIH to Facilitate a Restructuring of the Spatial Patterns in the New Developments being Proposed and Curb Urban Poverty

It is important to gauge the perception of stakeholders who are directly or indirectly involved with the proposed MIH project named Vista Park 2 and 3. Such an endeavour will provide an insight into their understanding of the objectives behind the project. To elicit their perceptions, the interviewer had to commence by exploring the understanding of the interviewees and the discussants as it pertains to the MIH concept. Obviously, whilst the concept was well-understood by planners, most of the discussants representing the residents of the Vista Park Zone 1 which is situated in proximity to the intended MIH development (Vista Park Zones 2 and 3) indicated their lack of knowledge of the MIH concept and the proposed development. Having established their level of understanding of the MIH concept, the interviewer proceeded to gauge the opinions of the implementers and the residents of the Vista Park area within which a MIH development is being proposed, on the expected benefits from such development as well as the development's ability to cater to curbing urban poverty.

However, most of the discussants to the focus group discussion feigned ignorance of the utility of the proposed MIH to be situated within their locality. Also, a few who had admitted to having heard about the concept reiterated that it was alien to black communities but common place in white communities. Surprisingly, most of the discussants failed to highlight any salient benefit from the proposed MIH development or even the concept of the MIH as they could only express fears concerning the negative impact which such development would have on the area.

Such fears are not new as literature is replete with the notion that most of the expected benefits accruable from such developments are usually not focused on the original residents, hence resulting in an exodus of sorts by these persons when such developments come to fruition (Kontokosta, 2014). Therefore, there is a need for these residents to be properly educated on the usefulness of the MIH development in combating urban poverty by the relevant personnel.

4.2 Theme 2: Probable Factors Influencing the Potential of MIH to Achieve the Restructuring of Spatial Patterns in the Proposed Vista Park MIH Developments

As reported in the literature, a deficit in the number of empirical evidences buttressing the usefulness of the MIH concept in engendering the direct restructuring of spatial patterns around the proposed locations and indirectly, enabling tackling of spatial inequalities and urban poverty in these areas. Accordingly, this study sought to explore the views of the various stakeholder groups involved with or influenced by the siting of the development in the Vista Park area concerning the probable factors capable of affecting the proposed MIH development's potential to achieve the previously mentioned objectives. Two major factors indicated as being capable of undermining the utility of the proposed development included: funding and fear of value depreciation and insecurity.

4.2.1 Funding

Most of the interviewees (planning professionals) identified the inadequate funding as a probable challenge to the proposed development. At this juncture, it should be noted that the proposed Vista Park MIH development is expected to be fully funded by the government. This makes the successful implementation of the project subject to the availability of government funds and susceptible to the vicissitudes associated with government finances. Whilst funding has been identified as a challenge in studies focusing on other climes, the use of public-private partnership arrangements has been reported as a panacea to overcoming the incidence of poor funding (Joseph et al. 2019). However, this challenge was not mentioned by the community members during the focus group discussions.

4.2.2 Value Depreciation and Insecurity

The issue of value depreciation of properties in neighbouring localities as a result of the siting of a MIH development has become an issue of concern. According to Joseph and Chaskin (2010), Kontokosta (2014), and Vale and Shamsuddin (2017), adopting a wrong approach in the allocation of low-income housing in MIH developments and the percentage of households holding different tenures will culminate in these fears among the original residents of the area. Such fears will bother on insecurity and value depreciation.

Unsurprisingly, discussants to the focus group articulated their fears around this nexus. Their views imply a possibility of the original residents relocating from the area thereby undermining the strategy's potential to combat spatial inequalities. Making sense of the views expressed by planners during the interviews, it appears that these fears are real as the interviewees admitted to low engagement with the original residents of the area during the planning stages. Such engagement would have provided a platform for these residents to make contributions as it concerns the allocation model, the issue of proximity, the nature of tenure and the duration – all key factors influencing the perception of original residents (Vale and Shamsuddin 2017).
Based on the foregoing, there is need for proper engagement with the host community concerning the proposed project if the expected objectives are to be met. Yet it must be noted that the findings elucidated herein are at indicative of preliminary findings and that the study is ongoing. Therefore, these findings must be taken with a note of caution as the data saturation has yet to be reached.

5. CONCLUSION

MIH is defined differently by various scholars to accommodate a variety of housing types. It has been used as one of the strategies to overcome spatial inequalities through housing delivery. This study aimed to gauge the perceptions of the stakeholders concerning the potential of MIH to facilitate a restructuring of the spatial patterns in the upcoming developments as well as the probable factors affecting the development. Focus of the study is in Vista Park area, Bloemfontein in the Free State Proving, South Africa because the municipality proposed two catalytic projects on MIH in close proximity. For data elicitation, semi-structured interviews, observations and focus groups with the community were used. Findings of the study are preliminary because the study is ongoing and the data saturation is not yet reached.

Bloemfontein, in South Africa, is faced with housing backlog due to rapid urbanization, increase in population size and densification. This is evident to the mushrooming of informal settlements in the township. The municipality adopted housing programmes with the intent to integrate mixed housing typologies, facilitate social integration and social cohesion by accommodating all income levels. However, focusing on the perceptions of the stakeholders, emphasis is placed on the factors capable of undermining the proposed development, namely, funding and fear of value depreciation and insecurity.

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INVESTIGATION OF EMOTIONAL STATES IN DIFFERENT URBAN SOUNDSCAPES THROUGH LABORATORY REPRODUCTIONS OF 3D AUDIOVISUAL SAMPLES

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Abstract: Sounds in urban areas have traditionally been treated as an annoyance for which noise control solutions aim mostly at reducing sound levels. However, recent studies demonstrate that soundscapes could also enhance the quality of life and become a resource for urban planning. This work aims to investigate how human presence in urban settings can modulate human emotional states and change how humans describe soundscapes through audio-visual laboratory reproductions using virtual reality. Several places with representative soundscape categories--exciting, calm, chaotic, and monotonous--in the Manchester (UK) region were identified through structured interviews with local people. Audio-visual recordings using a soundfield microphone and a 360º camera were made at the identified locations. These recordings in different human density (empty, medium, and busy) were subjectively evaluated (self-report) by the participants, regarding the emotional states and soundscape descriptions through an audio-visual reproduction using headphones and a head-mounted device. Pilot results suggest that crowd density may significantly affect soundscape perception. By understanding the emotional responses in different soundscape scenarios, the knowledge of the acoustic environment approaches towards the management of urban sound as a resource for design in practice.

Keywords: Human presence; emotional states; soundscape; urban design; virtual reality.

1. INTRODUCTION

Soundscape consists of a transdisciplinary research field that includes physical, social, cultural, and psychological aspects of sound (Dubois, Guastavino, and Raimbault, 2006; Kang, 2007; Davies *et al.*, 2013; Aletta and Xiao, 2018). The International Organization for Standardization (ISO 12913-1, 2014) describes soundscape as the human perception, experience, or understanding of an acoustic environment in context. The context is human-centred, therefore, includes the auditory sensation, the interpretation of the auditory sensation, and the responses to the acoustic environment which influence the soundscape. The sensation represents the physical process of how the ear captures the audio stimuli. The interpretation implies transforming the signal into useful information that can establish knowledge of the acoustic environment. Finally, the responses relate to human reactions, emotions, and behaviours (ISO 12913-1, 2014). Furthermore, to construct the soundscape scenario rests in a procedure which should capture the "local uniqueness" (Adams *et al.*, 2006) or "acoustic character" (Bento Coelho, 2016) of each community in place and time.

In most soundscape researches, to approach the characteristics and human preferences, studies use self-report surveys in soundwalks (site visits with the intention to observe the acoustic environment) to identify sound sources, human expectations, their appropriateness to space (Davies, Bruce and Murphy, 2014), and their relations to activities (Steele, Steffens and Guastavino, 2015). Questionnaires mark soundscape through semantic differential scales within two-dimensional axes--arousal and valence--which originates from psychological studies and evolved to the emotional dimensions of eventfulness and pleasantness (Axelsson, Nilsson and Berglund, 2010). Arousal represents the degree of alertness in someone's emotional state which can go from positive (frenetic excitement) to negative (sleepy), while valence consists in the degree of pleasure (positive) to unpleasurable (negative) emotions (Russell, 2003). These terminologies gained space among researchers and advance towards standardization (Davies, Bruce, and Murphy, 2014).

Differently from mood, emotions are caused by a specific object or event (Beedie, Terry and Lane, 2010), which can be an audible event in context, time, and space, and also considered as a soundscape. Given the relations of emotions and the auditory system, studies have also argued that sounds indicate the perception of safety (Andringa and Bosch, 2013; Sayin *et al.,* 2015; van den Bosch, Welch and Andringa, 2018; Calleri *et al.*, 2019), and, therefore, can change public behaviour towards liberty to attend to their own matters when normalness is indicated, or to become vigilant, when safety is so uncertain that results in difficulty to relax and concentrate on other self-chosen activities (Andringa and Bosch, 2013). In short, the auditory perception evokes emotions which serve to determine what environment people are attracted or repelled to (van den Bosch, Welch and Andringa, 2018).

The emotion of fear related to the lack of audible safety in public spaces increases the emotion of anxiety, resulting in the public avoiding the place and, consequently, creating financial depreciation of the venue (Sayin *et al.*, 2015). On the contrary, the influence of natural sounds has been demonstrated to stimulate the emotion of tranquillity (Watts and Pheasant, 2015) and to induce stress recovery (Annerstedt *et al.*, 2013). Also, ambient sounds demonstrated influence on perceptions of social presence, perceived safety, satisfaction, and willingness to purchase (Sayin *et al.*, 2015). However, the emotions promoted by vibrant and lively soundscapes such as those created by humans (chatting and children playing) in public urban areas still lack investigations.

Forces to identify enjoyable and pleasant emotions towards places, situations, and people should be aimed for and maintained to create flourishing behaviours (van den Bosch, Welch and Andringa, 2018) for a healthier society. Further, studies point out that understanding emotional responses to soundscape gives support to design decisions, a better opportunity of achieving users satisfactions (Cain, Jennings and Poxon, 2013), and quality of life (Andringa and Bosch, 2013).

In practice, urban planning has gradually included soundscape solutions in design (Kang *et al.*, 2016; Aletta and Xiao, 2018). Some applied design solutions incorporate functional approaches dealing with noise barriers, water structures, surface acoustic treatment, and use of vegetation (Dzhambov and Dimitrova, 2014; Rehan, 2016), while others have an additional aesthetic component such as music interventions, sound installations, and sculptures (Nilsson, 2008; Witchel *et al.,* 2013; Steele *et al.,* 2016; Lavia *et al.,* 2018; Meng, Zhao and Kang, 2018). Altogether, soundscape design solutions still need research support to reduce the gap between theory and practice.

A way of making design options easier to communicate to designers and different agents in the community resides in three dimensional (3D) simulations of real or future scenes. With technological advances, the reproduction of the real world in virtual environments became so realistic that the user, immersed into the experience, has the sense of being in a real-life place, also called the "sense of presence" (Slater, 2009). The sensation can be created through multimodal sensors such as audio, visual, and tactile. Here, the audio-visual virtual reality (VR) will be observed to aid soundscape research.

For example, Maffei (Maffei *et al.*, 2016) concluded that field and VR soundscape experiences are congruent enough to be used as a tool to understand human actions, movement, and perception towards the complexity of the environment. Also, street management strategies for vibrant areas such as shared-street design and traffic restrictions simulated in an online VR survey indicated improvement of soundscape quality rating (Jiang *et al.*, 2018). Furthermore, physiological stress recovery was achieved using birdsong and the sound of water in a green forest simulated in VR (Annerstedt *et al.*, 2013). Therefore, VR soundscape experiments may reproduce real-life situations in conditions such as laboratory which increases experimental control and still have high "ecological validity" (Loomis, Blascovich and Beall, 1999).

The present paper introduces the investigation on how human presence, specifically crowd density, in urban settings can modulate human emotional states and change how people describe soundscapes through audio-visual reproductions using VR. The goal here consists of presenting results from a pilot test in a preliminary analysis level given the stage of the research. By understanding the emotional responses in different soundscapes, the knowledge of the acoustic environment approaches towards the management of urban sound as a resource for design in practice. Furthermore, the findings, using soundscape approaches, may contribute to urban planners in security interventions in no-go urban areas since VR can be used as a low-cost and non-intrusive strategy (Calleri *et al.*, 2019).

2. METHODOLOGY

Figure 1 presents an overview of the workflow for the VR experiment. First, from a structured interview with 23 subjects from the University of Salford staff and students, several places with representative soundscape categories--exciting, calm, chaotic, and monotonous--in the Manchester (UK) region were identified. The questionnaire consisted of four open questions asking for participants suggestions on the public spaces which best characterised the above-listed categories.

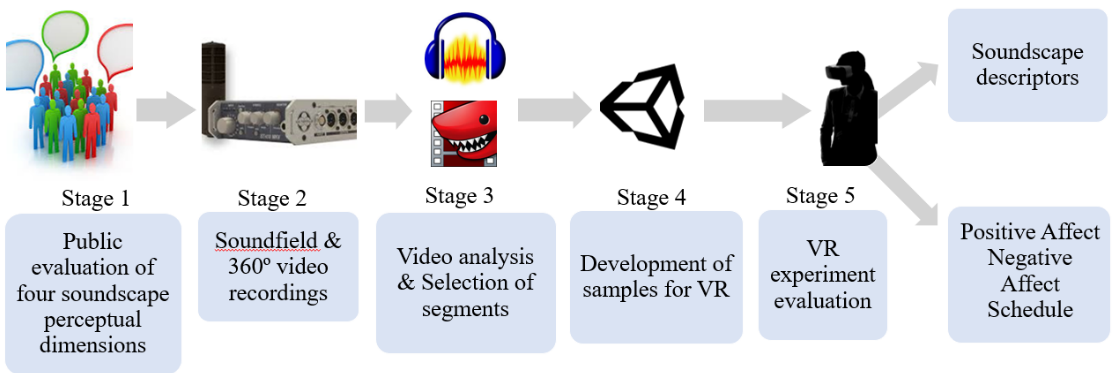

Figure 1 – Workflow methodology for laboratory VR experiments.

On the second stage, some of the identified urban areas were visited and recorded with the Sound field microphone ST250 with the ZOOM H6 Handy Recorder for the audios and Ricoh Theta camera for the 360° videos. Equipment setup is illustrated in Figure 2. The camera was positioned approximately 1.20 m from the ground and the microphone placed close to the ground under the camera to avoid wind sound interference on the recordings.

Given ethical approval restrictions, a sign warning “Filming in progress” was displayed with the equipment for public awareness, and the video recording resolution setting was low to reduce face recognition. The recordings lasted approximately 12 minutes. A sound level meter, type BSWA 308, was used to register a one-minute sample of the equivalent sound level, $L_{eq(A)}$, to adjust sound levels from field to laboratory.

Figure 2 – Equipment setup on field recordings with Ricoh Theta camera (1), Sound field microphone ST250 (2), and ZOOM H6 Handy Recorder (3).

Recordings made on different days during June 2019 followed two specifications: a sunny moment and three different crowd densities. To unify terminology in this paper, the term "crowd density" represents the number of people on the video sample that will be ranked in "empty", "medium", and "busy". Sunny days were chosen by weather forecast while the crowd density was selected in three weekdays as follows: during an early hour (4 to 6 am) of a weekday for empty, in the afternoon (2 to 4 pm) of a weekday for medium, and in the afternoon (2 to 4 pm) at a weekend day for busy.

Next, in the third stage, the recordings were analysed, and 30-second segments were extracted from the full video. Initially, the selection estimated visually the medium and busy crowd density while the empty one consisted of a void moment. After selection, the video and audio were synchronised, given they were recorded separately, in Lightworks x64 (14.5.0.0 version) video editing software. The four audio channels of the ambisonic audio were edited with Audacity software to be synchronised and exported to Unity 3D--software used to develop videos for VR head-mounted devices. The audio and video were imported separately into Unity

3D for adjusting head and audio synchronisation with the user's movement. Once edited, samples were exported to a SHIELD Tablet K1 which was adapted to a Dive head-mounted device. The audio was replayed through a Beyer Dynamic BT100 headset (Figure 3).

A pilot test with 11 participants in a public academic event took place on 5th July 2019 at the University of Salford. Each participant watched randomly three audio-visual samples with different crowd densities (empty, medium, and busy) of Piccadilly Gardens, Manchester, UK through the head-mounted VR system.

After each video, the subjects answered two short questionnaires on a sheet of paper. In the first questionnaire, they rated in a 11-point scale the samples in the four main soundscape descriptors (pleasant to unpleasant, eventful to uneventful, exciting to monotonous, and calm to chaotic) according to the draft ISO 12913-2 (ISO12913-2, 2017). For the second survey, the PANAS (Positive Affect Negative Affect Schedule) model was used to assess emotional states in a small version of ten emotional states (upset, hostile, alert, ashamed, inspired, nervous, determined, attentive, afraid, and active) (Thompson, 2007). Subjects were asked to respond to what extent they would generally feel the presented feelings in a 5-point scale of "never" to "always".

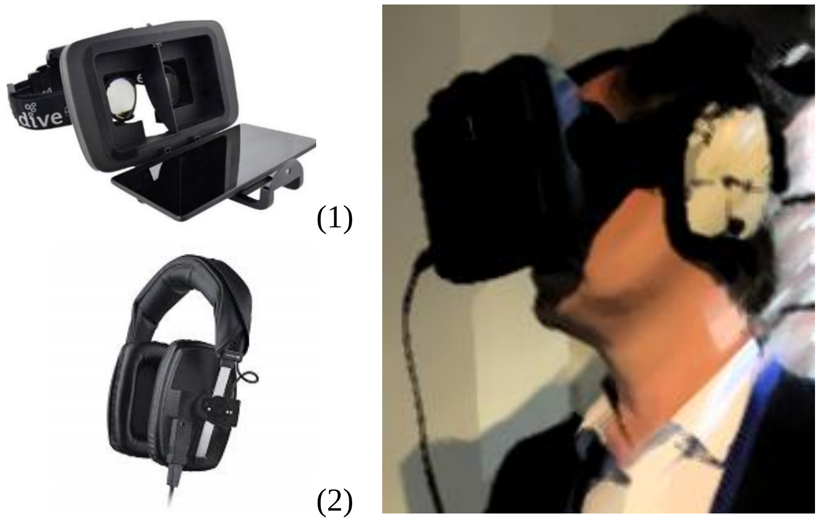

Figure 3 – SHIELD Tablet K1 with head-mounted device Dive (1) plugged to a headset Beyer Dynamic BT100 (2) used in the pilot test.

For the statistical analysis, the study design was for "group differences" among the three crowd densities where all participants rated all conditions ("within-subjects design", also called repeated measures design). The independent variable was crowd density in three levels (empty, medium, and busy). To simplify the analysis, each outcome (dependent variable) was tested separately as an ordinal variable given the ordered or ranked categories used ("semantic differential" scale for the soundscape descriptors and "rating" scale for the emotional states) (Laerd, 2015).

Given all participants rated all samples and there were more than two conditions for the independent variable, Friedman's ANOVA was used to assess the significance of the crowd density as an independent variable (Field, 2018). As has been said, separate tests were done to determine if there were significant differences among the three conditions for each of the four soundscape descriptors and ten emotional states ratings, that is 14 individual tests. Once identified the significant difference among the three conditions, results were followed up with the Wilcoxon test for the effect size. All statistical tests were processed in IBM SPSS (SPSS Statistics, 2016).

3. RESULTS AND DISCUSSION

In November and December of 2018, a group of 23 members of the University of Salford community was consulted about what were the public spaces they considered representative of the four perceptual dimension soundscapes. Figure 4 illustrates the responses, where the size of the font increases with the number of occurrences within each group sample, with no relation between groups. Images were developed in TagCrowd, online software for building word clouds (https://tagcrowd.com/).

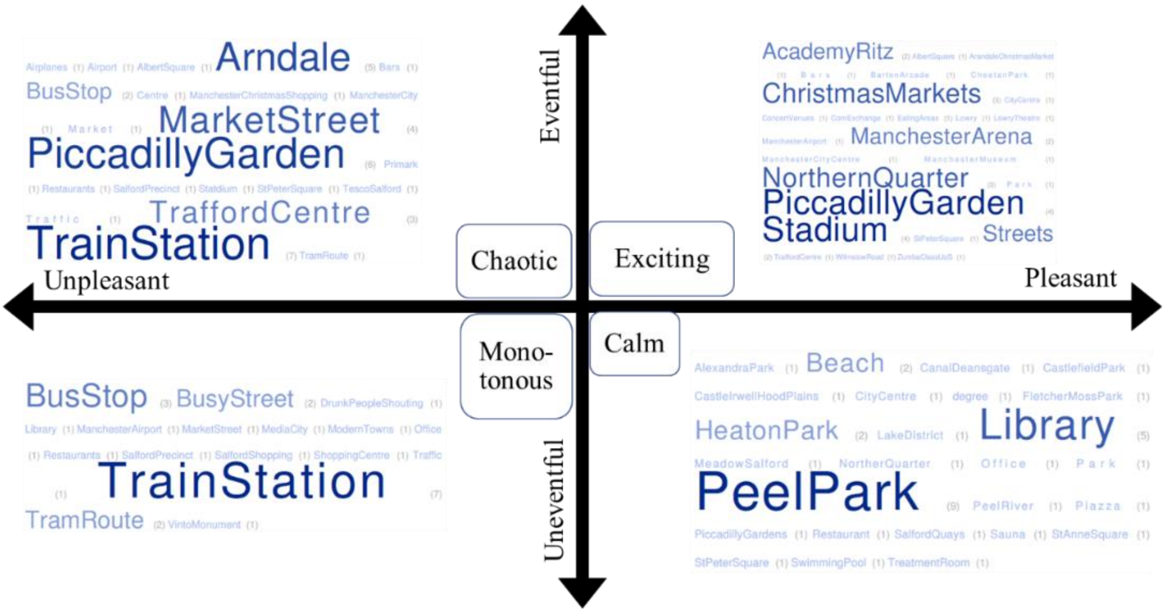

Figure 4 – Results from structured interviews with residents to determine the types of soundscapes in public places of Manchester (UK) region.

Piccadilly Gardens appeared in the chaotic, exciting, and calm quadrants with respectively six, four, and one vote. This observation led to the study of crowd density to be developed where the number of people occupying the space was considered to influence the shift from one type of soundscape to another.

Figures 5 present the medians and their ranges in boxplots for the results of the soundscape descriptor ratings in the three conditions. Perceptions of medium crowd density soundscape (Fig. 5b) characterised the scenario as pleasant while in the busy and empty conditions results were not so consistent. Regarding the eventful descriptor, the busy (Fig. 5c) and empty (Fig. 5a) crowd densities indicated opposite differences in perception--eventful and uneventful respectively.

However, an experimental error was identified in the medium density sample where the audio was louder than the empty and busy scenarios. Therefore, the significance of the medium crowd density results was associated with the disproportional sound level of the sample. In the future, to correct this mismanagement, all samples will be calibrated to reproduce at their respective sound levels, as in real life. For example, quieter places will have lower levels than busier ones.

Although respondents in our initial survey (Figure 4) had described Piccadilly Gardens as a calm, exciting, or chaotic soundscape, the outcomes of the soundscape ratings did not confirm the place as such. Instead, the scenario in the empty condition (Fig. 5a) was reported as monotonous. Also, soundscapes in medium (Fig. 5b) and empty (Fig. 5a) conditions were assessed to be calm indicating a low effect of the human presence on this scale.

Table 1 presents the statistical analysis of soundscape descriptors results in which significant difference due to crowd density was identified in all four soundscape scales. However, only for the eventful-uneventful descriptor did the effect size have a positive relationship among conditions. That is, the scores for eventfulness increased with crowd density.

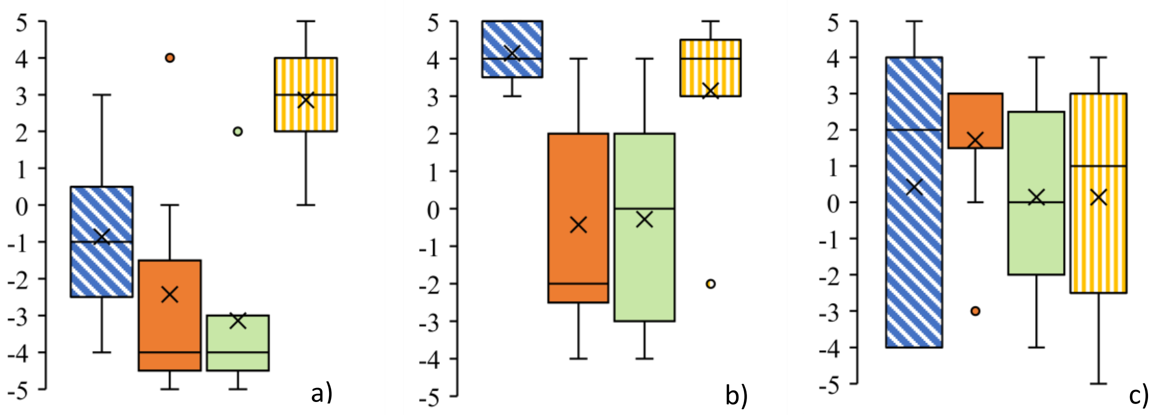

Figure 5 – Distribution for Piccadilly Gardens Soundscape descriptors rating in (a) busy, (b) medium, and (c) empty crowd densities. Numeric semantic scale (-5 to 5) for the descriptors Pleasant-unpleasant, Eventful-uneventful, Exciting-monotonous, and Calm-chaotic.

Moreover, for the score of exciting to monotonous, as crowd density increased also was the soundscape rated livelier and more exciting. However, no relationship was evident among medium and busy conditions. Such result should be further investigated to establish clearer differences among the crowd densities. Finally, there was a negative relationship among variables for the calm soundscape rating, where it decreased when the crowd increased. Nevertheless, the empty and medium conditions have a low relationship, that is as the crowd increased so did the rating for calmness, but in a smaller magnitude.

*Table 1: Statistical results for soundscape descriptors. *significant difference p<0.05*
+significant effect size -.3 (negative) < r <.3 (positive)

Soundscape descriptors	Friedman value		Wilcoxon signed-rank test					
	$\chi^2(2)$	p-value	Empty - Medium		Empty – Busy		Medium - Busy	
			T	***r***	***T***	***r***	***T***	***r***
Pleasant/Unpleasant	7.762	.021*	53.5	.5673+	44	.2092	11.5	-.3503+
Eventful/Uneventful	12.634	.002*	57	.4563+	62	.5530+	31	.3929+
Exciting/Monotonous	14.683	.001*	66	.6287+	45	.5714+	31	.0772
Calm/Chaotic	6.186	.045*	39.5	.1241	7	-.4951+	1.5	-.5665+

Figures 6 to 8 illustrate the medians and their ranges in boxplots for the results of the ratings of the emotional states in the three soundscape conditions. In contrast to the soundscape scales in Figure 5, most of the emotion scales in Figures 6-8 show small effect of the three crowd density conditions. In particular, the results for “upset” and “ashamed” are almost unchanging across the three conditions, and most of the other emotional scale results overlap considerably from one soundscape condition to another.

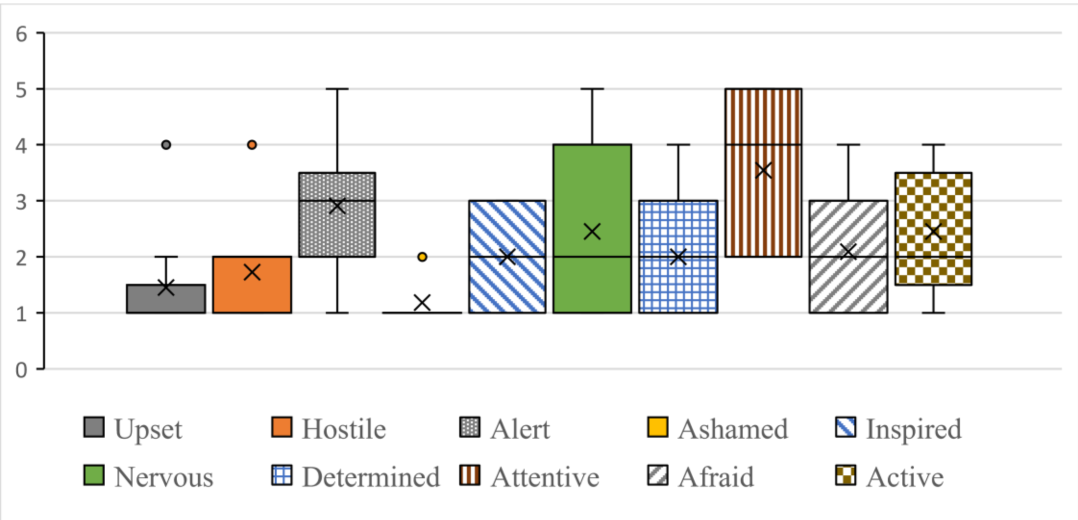

Figure 6 – Distribution for Piccadilly Gardens PANAS emotional rating for empty crowd density.

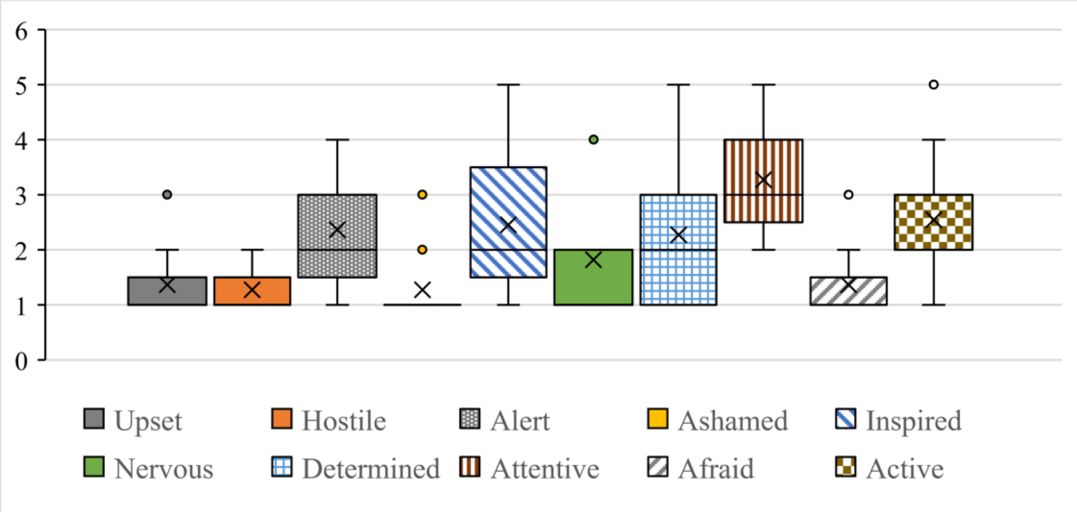

Figure 7 – Distribution for Piccadilly Gardens PANAS emotional rating for medium crowd density.

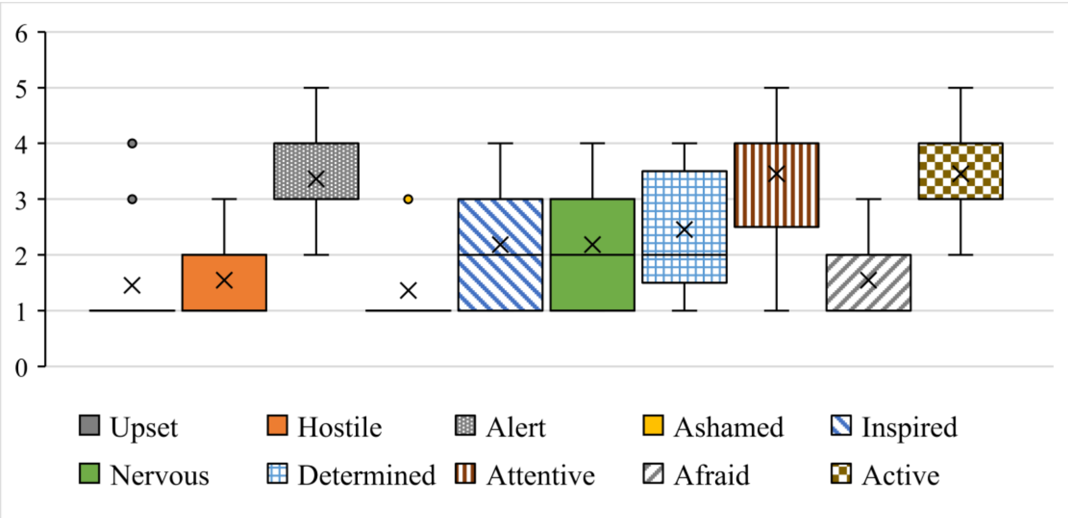

Figure 8 – Distribution for Piccadilly Gardens PANAS emotional rating for busy crowd density.

Table 2 presents the statistical results for the emotional state ratings in the three crowd density conditions. Only the "active" emotional state had a significant difference among conditions. Furthermore, the correlation coefficient resulted in a positive relationship for the empty to busy and medium to busy, that is, people rated more towards always "active" when crowd density increased. Four of the other emotional scales produced significant differences between one pair of conditions (Wilcoxson), but not for the scale as a whole (Friedman). These four individual results are probably unreliable.

*Table 2: Statistical results for soundscape descriptors. *significant difference $p<0.05$*
$^{+}$significant effect size -.3 (negative) < r <.3 (positive)

Soundscape descriptors	Friedman value		Wilcoxon signed-rank test					
			Empty - Medium		Empty – Busy		Medium - Busy	
	$\chi^2(2)$	*p*-value	*T*	*r*	*T*	*r*	*T*	*r*
Upset	1.077	.584	2	-.123	4	-.0806	2	.0953
Hostile	3	.223	3	-.3554^{+}	14.5	-.1094	3	.2861
Alert	2.513	.285	14	-.2194	28.5	.1534	47.5	.4435^{+}
Ashamed	3	.223	1	.2132	3	.3015^{+}	1	.2132
Inspired	1.514	.469	34.5	.1580	20.5	.0765	13.5	-.1379
Nervous	1.867	.393	3.5	-.2411	19	-.0895	21	.2697
Determined	1.238	.538	9	.0878	8.5	.2748	13	.1153
Attentive	1.032	.597	14	-.123	17.5	-.0151	13	.1153
Afraid	3.931	.140	0	-.4413^{+}	12	-.2793	14	.1740
Active	6.75	.034*	15.5	.0563	26	.4371^{+}	41.5	.4972^{+}

These results are preliminary given their lack of statistical power due to the small number of participants (11). Potential confounds include the uncontrolled background sound level at the time of recording, experimental error in the reproduction of medium density sample, individual differences between participants and the “social desirability” of the participants to want to appear good in the responses (Mortel, 2008).

Nevertheless, the results suggest that crowd density may exert a significant influence on the perception of a soundscape, as measured on the four standard response scales. This means that soundscape researchers may need to account for (or at least to measure) this variable in future experiments. New methods shall be studied to achieve better results on the investigation of the emotional responses towards the soundscape conditions such as physiological tests.

4. CONCLUSIONS

The present paper reports preliminary results of a pilot test integrating the investigation of the emotional states and perceptual description of the soundscape in three crowd densities of Piccadilly Gardens, Manchester, UK, through VR samples. Although there are limitations related to interferences, noises, and differences in the participants' responses, outcomes were expressive for the soundscape descriptors. Therefore, the experience demonstrated validity in using the soundscape descriptors to assess human soundscape perception.

Even though crowd density had a significant treatment effect on all soundscape descriptors ratings, only on the "eventful" to "uneventful" descriptors had a positive relationship with an increasing trend. In other words, the results suggested that participants considered the soundscape to become more eventful with the increase of people in the scene. Nevertheless, the use of questionnaires for identifying the soundscape perceptual dimensions shall be maintained given the positive outcome.

In contrast, results for the emotional states in the three soundscape conditions were scattered and overlapped. Statistically, only the “active” emotional state had a significant effect on the treatment in a positive and increasing trend. Given the lack of expressive outcomes in these results, other forms of identifying human emotional states shall be investigated through the Arousal-Valence Space (AVS) model (Russell, 2003), obtained by physiological tests, such as pupil dilation for arousal (Partala, Jokiniemi and Surakka, 2004) and Electroencephalography (EEG) for valence responses (TSANG *et al.*, 2001).

The next steps of this research consist on systemizing the criteria for establishing the crowd density, inserting a virtual tablet in the VR samples in which the participants will rate the soundscape within the virtual environment, and to calibrate the sound levels in the laboratory to those measured in real life.

The topics discussed in this paper such as the emotional responses and perceptual descriptions of urban soundscapes still need further studies to give support to design decisions. VR reproductions of the real or simulated world consist of a strong tool to get planners and users attention. Therefore, urban design practices gain with VR soundscape research in which solutions can be tested to develop soundscapes for a healthier urban society.

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THE GHANAIAN CONSTRUCTION INDUSTRY AND ROAD INFRASTRUCTURE DEVELOPMENT: A REVIEW

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Abstract: The construction industry contributes largely to the economy of a nation. This makes the industry one of the major backbones of a thriving economy. Employment is created by the industry while infrastructure to facilitate business transactions are also provided by the industry. The Ghanaian construction industry is not an exception to this phenomenon as it helps in shaping the country's economy although there are challenges facing the industry. These challenges have limited the impacts of the construction industry which is patterned after the UK Built environment. Road infrastructure in the Ghanaian construction industry can be traced back to 1850 which started with pathways before they were widened and hammock was used for the road surfacing. Over the years, road network in Ghana has improved and developed to boast of 72,381km road networks in which 75% of the paved road networks are in good condition and 74% of unpaved road networks are in good condition in 2017. Findings from reviewed literature revealed that the Ghanaian construction industry in gaining more grounds and with the recent improvement in the activities of the industry, it is obvious that there are various opportunities emerging from the initiatives that are being put in place in the industry. These improvements among others include the effect of globalisation; Public-Private Partnerships; growth of information and communication technology (ICT). The study concluded that even though the industry is faced with numerous challenges, there are opportunities and innovation to be explored by the construction industry stakeholders.

Keywords: Construction industry, Ghana, infrastructure, road.

1. INTRODUCTION

It is a generally accepted phenomenon that the construction industry plays a key role in the development of socio-economic growth of a country. This extends to the development goals of making necessary infrastructure available, providing employment opportunities and also shelter for society. Among these socio-economic development goals are urban infrastructure, highways, schools, hospitals, houses, townships, roads, railways, airports, seaports, power systems, agriculture systems, telecommunications and others (Chileshe and Berko 2010; Osei 2013). A large part of the economy of a country is constituted by the construction industry which contribute up to 10% of the gross domestic product (GDP) and also employs about 10% of the working population. The construction industry deals with the creation, repair, renovation or extension land improvements, of buildings of an engineering nature referred to as the fixed assets of the country. About half of the gross fixed capital formation of an economy is also constituted by the construction industry which shows how relevant the construction industry is to the country's economy (Ofori-Kuragu, Owusu-Manu, and Ayarkwa 2016). With the government being responsible for majority of the investment in the construction industry, the level of spending can be regulated in order to make some expected changes in the economy as the industry is seen as a potential economic regulator. Although the construction industry has complex linkages to several other sectors in the country, these linkages can be used as stimulants for activities of the sectors. This is because inputs from these sectors are necessary for the operations in the construction industry and in return the sectors need infrastructure to function. This shows that the linkage is a two-way mechanism which if well harnessed will help boost the economy of the country. By holding huge potential for boosting the export of projects, stimulating growth and also employment generation, the construction industry is one of the fastest growing sectors amassing an average of 7-8% growth per annum (Ofori 2012; Osei 2013). This research work seeks to understudy the Ghanaian construction industry.

The Ghanaian construction industry which is patterned on the UK built environment is not an exception as it contributes largely to the economy of the country. This is evident from the observation of the regulatory and legal documents of the building regulations used in the Ghanaian construction industry. According to the submission of Frimpong, Oluwoye, and Crawford (2003) and Osei (2013) the construction industry in Ghana can be likened to the UK construction industry of twenty (20) years ago owing to the serious shortfall experienced in safe working practices, material handling, quality and the timeliness of construction projects in the industry. Similar to the construction industry of every developing country, labour in the Ghanaian construction industry is comparatively cheap. The industry is characterised by asset-based-lending and physical infrastructure which serves as a means of development and growth. There are various key stakeholders involved in the activities of the industry which are main contractors and sub-contractors of every tier; design community; client community (private and public); economic drivers (financial corporations and banks); supply chain (machinery manufacturers and material suppliers); trade unions; professional associations; technological institutions and universities (Ofori, 2012; Osei, 2013). These stakeholders can be categorised into four groupings which are discussed below.

1.1 Users and Consumers of the Ghanaian Construction Industry

The largest user and consumer of the construction industry is the government that owns most of the costliest housing, infrastructure and tertiary buildings. In Ghana, the Ministry of Works and Housing oversee the activities of the construction industry together with state-owned corporations and ministries. Even though government is responsible for the activities of the construction industry, the private sector is the driver of the expansion of the construction industry. These private sectors include civil society and non-governmental organisations; individual home owners; business organisations; unregistered business owners and residents (Ofori-Kuragu, Owusu-Manu, and Ayarkwa 2016; Osei 2013).

1.2 Demand Side Operator

This category involves the users and consumers of the industry. Real estate developers and property agents invest in the construction industry in order to make provision for both speculative and client proposed developments while government, businesses and state owned corporations also invests in the construction industry (Ofori 2012; Osei 2013).

1.3 Regulators

There are building regulations and planning schemes developed for the Ghanaian construction industry which are fashioned after the UK system. Environmental Protection Agency (EPA) through Environmental Impact Assessments (EIAs) developed environmental regulations and are in charge of enforcing these in the construction industry. District assemblies and metropolitan officials are responsible for development control through guidelines put in place for the submission and approval of plans (Osei 2013).

1.4 Supply Side Operator

The Ghanaian construction industry has supply side operators which can be referred to as traditional professional groups. These include civil engineers, architects, quantity surveyors, electrical and mechanical engineers; and material/machinery suppliers for construction projects. The professionals register with their professional bodies which accredit them for professional practice in the construction industry. These professionals also make up the contracting organisations coupled with trade union members who plays a major role being the most visible stakeholders of the construction industry (Duah 2016; Ofori 2012; Osei 2013).

This review research study employed the use of SCOPUS and ISI Web of Science databases to access published articles using the keywords: "Ghanaian Construction Industry"; "Road Construction in Ghana"; and "Construction Industry in Ghana". This assisted in gathering 47 related and relevant articles used in carrying out the review study.

2. CHALLENGES FACING THE GHANAIAN CONSTRUCTION INDUSTRY

With Ghana being a developing country, the challenges facing the Ghanaian construction industry are similar to those reported from other developing countries. Even though developing countries attribute the development of the country's economy to the construction industry, the industry is yet to be given the acknowledgement that it deserves. The industry is not planned holistically which has resulted in its operations being carried out in fragments, using of conflicting components with inefficiency, wastage and inability to make proper plans that will lead to development. With the government being the major client of the Ghanaian construction industry, there is limited financial commitment from them to meet the large demand for several categories of outputs expected from the industry (Ofori, 2012; Osei, 2013). Some of the challenges facing the Ghanaian construction industry are explained below.

2.1 Delayed Payments

Since government are the main client of the construction industry in Ghana, payments by government agencies for construction projects executed have been observed to be delayed which has a negative impact on the credibility of local contractors in obtaining loans from their creditors for future projects. Payments delayed by clients to contractors always result in late completion of projects, reduce contractors' profit margins, promotes corrupt practices, contractors' attention being divided and capital being tied up. Delayed payments are influenced mostly by the improper classification of contractors and lack of technical assistance on the part of government agencies (Amoatey and Ankrah 2017; Frimpong, Oluwoye, and Crawford 2003; Mensah, Adjei-Kumi, and Nani 2016; Osei 2013).

2.2 Land Tenure Challenges

This is a challenge faced by most African countries and it is not peculiar to Ghana alone however, the nature of this challenge varies based on each locality and culture. In Ghana, customary ownership of land is family-based in that the decisions about the use of land is determined by the customs of individual families. These decisions are mostly not taken up into written records which makes it difficult to obtain the evidential basis for the use rights. Therefore, this results in the uncertainty of ownership in most cases (Agyeman and Ampadu 2016; Osei 2013; Owusu-Bio, Frimpong, and Duah 2016).

2.3 Preference for Imported Raw Materials

The construction industry clients and stakeholders in Ghana prefer the use of imported raw materials to proven alternative local materials. This has resulted in the inadequate use of vast quantities of local materials which are readily available in the country. Government can assist with the promotion of locally produced materials by evolving strategies that will exploit the local resources (Danso and Antwi 2012; Ofori-Kuragu, Owusu-Manu, and Ayarkwa 2016; Osei 2013; Tefe and Jones 2013).

2.4 Lack of Technology

Incorporation of new technologies into the Ghanaian construction industry is still low as this is evident on construction sites around the country. There are new technologies which has been put in place to assist in the construction process and improve the productivity and quality of the products of the construction industry. The implementation of these technologies will no doubt increase development of the construction industry which will in turn improve the economy of the economy of the country (Assibey-Mensah 2009; Forster and Mensah 2013).

2.5 Financial Constraints

The Ghanaian construction industry operates on donor-funding for construction projects. Inadequate credit facilities to the necessary players of the industry (private sector) by financial institutions result in little growth of the industry owing to it relying too much on government funding. The unavailability of appropriate funding for projects reduces the performance of the industry. Therefore, this poses problems in mobilising workforce and equipment for massive construction projects (Amoatey and Ankrah 2017; Osei 2013).

Some other identified challenges associated with the Ghanaian construction industry include but are not limited to the following: insufficient capacity in engineering; poor level of workmanship; shortfall of management abilities; low productivity; inadequate operating cashflow; inadequate maintenance culture; inadequate revenue base for construction project funding; ineffective reporting and information management system; incapability of local contracting and consultancy; serious management gap; lack of training opportunities; long gestation period for loans; and low scale of professional fees (Amoatey and Ankrah 2017; Mensah, Adjei-Kumi, and Nani 2016; Ofori 2012; Osei 2013).

3. OPPORTUNITIES AND INITIATIVES OF THE INDUSTRY

The Ghanaian construction industry in gaining more ground and with the recent improvement in the activities of the industry there are various opportunities emerging from the initiatives that are being put in place in the industry. One of the opportunities in the Ghanaian construction industry is the effect of globalisation which will manifest through the creation of job opportunities with the inflow of investments into Ghana. Although this will result in competition for local contracting and consultancy organisations which might have little experience compared to their foreign counterparts, it will also provide the opportunity to learn from the influences of the foreign professionals and exploit the opportunities offered by organisations such as the Economic Community of West African States. Another opportunity the industry can benefit from is the Public-Private Partnerships which will play an increasingly essential role in the development of infrastructure in the country. The partnership will give room for investing, operating and owning infrastructure within the construction industry by both parties thereby influencing formulation of policies and management of the construction industry. In order to achieve this, the professionals in the construction industry must acquire the required skills that will enhance the partnership (Ofori, 2012:17; Osei, 2013:69).

The growth of information and communication technology (ICT) will always influence many aspects of the construction industry. This will bring about changes in the construction industry environment which will require the professionals to keep up with trends in the construction industry globally. ICT will affect the nature, items, design and construction process of infrastructure while materials and other technologies incorporation will not be left behind and will require practitioners and professionals to be proficient in their applications (Hosseini et al. 2017). Globally, there are ongoing research studies related to improving the performance of construction industry. Findings from these studies has resulted in the adoption of techniques and processes used in the manufacturing industry into construction industry since they have been successfully implemented in developed countries. These techniques and processes include total quality management, supply chain management, knowledge management, lean production, and re-engineering, among others. All these innovative ideas can be incorporated into the Ghanaian construction industry in order to make the industry more productive and increase the standards and quality of the industry (Ofori, 2012).

Initiatives such as the establishment of the Construction Industry Development Institute (CIDI) together with the work of the Association of Building and Civil Engineering Contractors of Ghana (ABCEG) are some of the few steps taken to ensure the Ghanaian construction industry is developed. The CIDI as the think tank are sanctioned with the sole responsibility of offering strategic leadership by "providing the opportunity to promote understanding and support for construction industry development and improved delivery of infrastructure to the Ghanaian public". The ABCEG on the other hand has undertaken some consultations with the players and professionals of the construction industry in order to consider the establishment of a development and regulatory agency for the construction industry with some delegates visiting South Africa to understudy the approach used (Ofori 2012; Ofori-Kuragu, Owusu-Manu, and Ayarkwa 2016).

4. ROAD CONSTRUCTION IN GHANA

One of the major assets of a country is a road network as it gives both social and economic benefits to individuals, groups of people and the whole country at large. The road infrastructure being the backbone of the transport system serves as a connection between the populace. This keeps the economy of the country flowing thereby establishing a crucial constituent of the economic, environmental and social well-being. Road infrastructure is important because it is the most prevalent means of transportation of goods, people and services from the origin location to the preferred location having a single benefit of an added time and value chain. Road networks helps more than half of the world's population, especially in the urban areas which are the centres for business and many other socio-economic activities (Fragkakis, Marinelli and Lambropoulos 2015; Forster and Mensah 2013). The Ministry of Transport (2011) reported that 95% of transportation in Ghana is by road. This is an indication that road transport is the predominant means of transportation by Ghanaians which is used for passenger travel as well as movement of goods across the country and neighbouring West African countries.

According to the Medium Term Expenditure report submitted by the Ministry of Roads and Highways (2016), there were 72,381 km or road networks in Ghana as at 2017 with 14,873 km being trunk road, 15,463 km being urban roads and the remaining 42,045 km being feeder roads. It was also reported that 31% of these roads are being maintained or rehabilitated as required with 66.6% of the road having rural accessibility index (i.e. the percentage of human population within 2 km of the roads). Routine maintenance was carried out so that 10,250 km of the trunk roads, 10,679 km of the feeder roads and 7,200 km of urban roads were being maintained as at September 2017. As at this period also, periodic maintenance (resealing works, spot improvement and re-gravelling) was carried out on 199km of trunk roads, 205 km of feeder roads and 295 km of urban roads. Minor upgrading was also carried out on 47 km of trunk roads, 313 km of feeder roads and 26 km of urban roads. A total of 75% of the paved road networks are in good condition while 74% of unpaved road networks are in good condition.

Roads in Ghana started with pathways which were a few feet wide and only suitable for pedestrian. In the capital of Ashanti Kingdom (Kumasi) around 1850, there were some important roads with four (4) of them being the principal routes that connected the area with the coast. The improvement of these pathways came in the late 1800s when the British took over administration and the roads were widened to enable the use of hammocks. The major reason for constructing roads then was to complement the railway system such that they were feeders to the railways. These roads were therefore divided into important and less important roads with the Roads Ordinance taking responsibility for the maintenance of the important roads (South-North routes) and the local chiefs being responsible for the less important roads which were cleared occasionally. New roads were later constructed to a width of about 3.5 m compared to the 5 m wide roads constructed in Togo by the then German administration around 1890. These roads served their purpose as they were good for traction engines and motor cars but heavy trucks used by companies damaged the roads. This prompted the regulation of vehicle weights and the use of pneumatic tyres to suite the bearing capacity of the road surface which consist mostly of laterite. More roads were constructed at the end of the World War I and aided the transportation of cocoa to the large towns. These roads were constructed by local people without the funding of the colonial government. This was owing to the fact that they profited from the construction of roads as they experienced between a 100-300% profit increase after the construction of the Kumasi-Ejura road. This increase in the road construction was recorded to be about 2000km of roads in 1925 compared to the 260km of 1914. Since these roads were not perfectly motorised, they wore out easily; therefore, the need for a better construction method arose.

The cost of constructing concrete and/or tarmac roads was too high, therefore *tarmet* was devised which is a combination of *tar*red and *met*alled road. With the survey carried out in 1935, a total length of 10,000 km was motorable in Ghana, with 2,390 km being gravel roads, 84 km being tar-sprayed gravel roads and only 661 km were in a good condition and are made with tarmet treatment. Twenty years after this period, road development in the country was limited with most of the first-class roads declining to second class owing to a lack of proper maintenance. A Road Funds organisation was established in 1985 to cater for road maintenance in the country with the funds being paid through vehicle inspection fees, tolls and fuel levies. Since the organisation did not function efficiently, it was restructured in 1997. The first tarred road in Ghana was later built in the 1990s but today there are well over 70,000km of tarred road network. These roads connect the major cities and the rural areas to enable the passenger travels as well as movement of goods (Burchardt 2014; Boni 1999; Dickson 1961; Jedwab and Moradi 2011; Ntewusu 2011; Pedersen 2001).

4.1 Classification of Roads in Ghana

Roads in Ghana have been carefully classified into three sections by the government based on their connection to various locations within the country using the network of the roads as the criterion. The essence of this classification is to allow the proper allocation of funds and designation of responsibility to the various road agencies. Roads can also be classified using the type of surface each road with roads in Ghana having asphalt concrete surface; bituminous surface; Portland cement concrete surface; earth surface; and gravel surface roads. Majority of the roads in Ghana are paved and are in good conditions (Charles 2007; Ministry of Roads and Highways 2016). Roads are therefore classified into three networks namely: Trunk roads; Urban roads; and Feeder roads. Ghana Highway Authority, Department of Urban Roads and Department of Feeder Roads are in charge of the planning, administration, development, control and maintenance of trunk roads, urban roads and feeder roads respectively together with their related facilities within the country.

- **Trunk Roads:** These are the roads that forms the mainframe of national road network in Ghana spanning about 14,873 km. These roads provide an economical, safe, efficient, smooth and reliable road network as they link the regional, national, district capital, major cities, towns and neighbouring countries. They are of national economic and strategic importance and have been sub-classified functionally into primary trunk roads, major secondary trunk roads and minor secondary trunk roads. This classification was based on long-term function of the roads rather than the traffic experienced on these roads. The primary trunk roads are the corridors for long distance journeys and large movement within and also to neighbouring countries while the secondary roads functions as the connector of feeder roads to the primary trunk roads. The trunk road routes are designated by the alphabet **N** which is followed by a number which indicates the specific route with even numbers showing the route runs through North to South while odd numbers indicate the route running through East to West. There are eighteen (18) various routes numbered from N1 to N18 as shown in figure 1 (Charles 2007; Ministry of Roads and Highways 2018).

Figure 1: Trunk Road Network in Ghana (Source: Wikipedia 2018)

- **Urban Roads:** These are the roads found within the municipal assemblies and metropolitan areas in Ghana. They provide safe and reliable all-weather access roads to the community thus reducing travel time of goods, people and services which promotes socio-economic development. These roads are found in five cities, namely Accra, Secondi-Takoradi, Kumasi, Tamale and Tema together with the urban areas found in Ga District. Urban roads are also known as the Inter-Regional roads. These roads are designated with the alphabet **IR** followed by a number which indicates the specific route with even numbers showing the route running North to South while odd numbers indicate the routes through East to West. They span about 15,463km of the total 72,381km roads in Ghana. There are about eleven (11) of these roads numbered IR1 to IR11 (Charles 2007; Ministry of Roads and Highways 2018).
- **Feeder Roads:** These are the inter-district roads, access roads and connectors also known as the regional roads. They cross through more than one district and they sometimes link a trunk road to another or to a farming community. Most of these roads are earth surfaced while some are gravel surfaced and others are bituminous-treated surfaced. They also facilitate the movement of goods (mostly agricultural products), services and people across the districts. Feeder roads can be major or minor and are designated with the alphabet **R** followed by two-digit numbers for the major feeder roads and three-digit numbers for minor feeder roads. There are 65 routes of major feeder roads while there are 31 routes of minor feeder roads (Charles 2007; Ministry of Roads and Highways 2018).

5. LESSONS LEARNT

The Ghanaian construction industry contributes largely to the economy of the country and it is patterned on the UK built environment. Just as the construction industry of every developing country, labour in the Ghanaian construction industry is comparatively cheap. Despite all the challenges faced by the industry, there are opportunities in the industry such as the effect of globalisation which will manifest through the creation of job opportunities with the inflow of investments into Ghana; the Public-Private Partnerships which will play an increasingly essential role in the developments of infrastructure in the country; and the growth of information and communication technology (ICT) which will always influence many aspects of the construction industry.

Road infrastructure in the Ghanaian construction industry is the backbone of the transport system which serves as a connection between the populace while keeping the economy of the country flowing and constituting a crucial constituent of the economic, environmental and social well-being. Roads in Ghana started around 1850 with pathways which are a few feet wide and only suitable for pedestrian. New roads were later constructed to a width of about 3.5 m compared to the 5 m wide roads constructed in Togo by the then German administration around 1890. An increase in the road construction was recorded to be about 2000 km of roads in 1925 compared to the 260 km of 1914. The total length of 10,000 km were motorable in Ghana, with 2,390 km being gravel roads, 84 km being tar-sprayed gravel roads and only 661km were in good condition being made with tarmet treatment in 1935. The first tarred road in Ghana was built in the 1990s but today there is well over 40,000 km of tarred road network. These roads connect the major cities and the rural areas to enable the passenger travels as well as movement of goods. Roads in Ghana are classified into three sections by the government based on their connection to various locations within the country using the network of the road as classification criterion. These classifications are namely: Trunk roads; Urban roads; and Feeder roads. Ghana Highway Authority, Department of Urban Roads and Department of Feeder Roads are in charge of the planning, administration, development, control and maintenance of trunk roads, urban roads and feeder roads.

6. CONCLUSIONS

The Ghanaian construction industry just as the construction industry of every developing country plays a significant role in the achievement of the national socio-economic development goals of the country. This is achieved by making the necessary infrastructure available and providing employment opportunities and also shelter for society. Even though the industry is faced with numerous challenges, there are opportunities and innovation to be explored by the construction industry. With road construction dating back as far as 1850 in Ghana, road infrastructure has experienced evolution over the years with modern road infrastructure being put in place by the Ghanaian government.

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THE URBAN GOVERNANCE AND INFRASTRUCTURE NEXUS: DEVELOPING A CONCEPTUAL FRAMEWORK FOR URBAN NIGERIA

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Abstract: It is widely acknowledged that urban governance is vital to the functioning of cities. Accordingly, scholars and experts continue to suggest that effective and efficient urban governance could help redress the dire infrastructure conditions in African cities, a situation that is being compounded by rapid unsustainable urbanisation. However, the link between urban governance and infrastructure provision has been rarely explored by detailed empirical studies. This work is a precursor to a study that seeks to evaluate urban governance in Nigeria in the context of its potential to facilitate infrastructure and services' delivery. The aim is to provide a conceptual understanding of how urban governance can influence the provision of infrastructure and services based on an extensive review of the extant literature. Based on the literature reviewed, a conceptual framework will be developed. This framework, following refinement, will guide the use of relevant concepts and theories to explain the complexities of governance structure for the provision of infrastructure. It will guide the identification of variables to be measured as indicators for linking good urban governance and infrastructure provision.

Keywords: Infrastructure, participation, urban governance, system theory.

1.0 INTRODUCTION

The provision of adequate infrastructure is vital for sustainable development and poverty alleviation (Gutman, Sy & Chattopadhyay, 2015; Baffour Awuah, 2016). The role of infrastructure in cities is imperative given that over 80% of global GDP is generated in cities (World Bank, 2015) and the fact that safe, resilient, inclusive and productive cities are driven by infrastructure (Arimah, 2017; Baffour, 2016). As an example, adequately constructed roads with drains are essential for community growth and development (Baffour Awuah, Hammond, Booth & Lamond, 2014). In addition to property value appreciation, roads ensure the smooth traffic flow of human beings and materials in society, good drainage and sanitation, and a reduction in pollution and associated health problems. In addition to other infrastructure in urban areas, roads create incentives for investment in commercial developments such as shops, offices, banks and schools (Baffour Awuah et al., 2014).

However, in developing countries, there appears to be a deficiency in both the capacity to provide and in the current stock of infrastructure which has affected the ability of these countries to develop strong foundations for sustainable growth and for lessening poverty. This is true, especially in African countries like Nigeria which suffer from colossal infrastructure deficit (Abubakar, 2014; Baffour Awuah and Morenekeji, 2017). Several studies on infrastructure in Nigeria (Akinyosoye, 2010; Bello-Schünemann & Porter, 2017; Ogu, 2009) have shown that an inadequacy of infrastructure and services (such as inadequate water supplies, waste management systems, healthcare, housing, schools, leisure facilities, roads, and power supplies, amongst others) have become a norm in most cities (Omar, 2009). For example, most electricity consumers do not have access to a continuous supply of electricity because there is low power generating capacity relative to the installed capacity (Fatai, Omolara, & Taiwo, 2016). The poor state of infrastructure in Nigeria is further revealed in "The Global Competitiveness Index" developed by the World Economic Forum (for 2016-17) which ranks Nigeria's infrastructure at 132 out of 138 countries (Bello-Schünemann, & Porter, 2017).

The fundamental function of urban governance is to set the framework for the delivery of urban infrastructure and services through appropriate institutions and protocols. Building a suitable database of infrastructure needs and requirements, determining target groups, assessing resources (both human and material including finance requirements), finding/mobilising the required resources and allocating them appropriately, amongst other factors, can help deliver the required infrastructure (Moretto, 2007; Ogu, 2009; Olayiwola, 2005; Olowu, 1996; Razak, 2016; Salim, 2020).

However, despite the volume of literature discoursing on urban governance (Aribigbola, Folami, Williams-Adewinle, & Karimu, 2013; da Cruz, Rode, & McQuarrie, 2019; Daramola & Olowoporoku, 2017) and on the provision, access and role of infrastructure in sustainable development (Chatterjee & Mahbub Morshed, 2011; Cunningham & Kwakkel, 2009; Ilesanmi, 2012; Jerome, 1999; Malaveev & Baskakova, 2015; Udoudo & Udoidem, 1999) there are rarely empirical studies that have asked the following questions:

- Why are the infrastructures provided?
- Whose interest do the infrastructures serve?
- What kind of negotiations are involved in the process of provision?

This paper attempts the development of a conceptual framework that links urban governance and infrastructure provision within urban Nigeria. In so doing, the paper, after this introduction, examines the concepts of urban governance and infrastructure provision. Thereafter, the link between urban governance and infrastructure provision is explored to develop a conceptual framework.

2.0 URBAN GOVERNANCE AND INFRASTRUCTURE: A LITERATURE DISCUSSION

Urban governance refers to how government (local, regional and national) and stakeholders decide how to plan, finance and manage urban areas (Avis, 2016). Urban governance is a continuous process of negotiation and contestation over the allocation of social and material resources as well as political power (ibid). Urban governance involves a network of stakeholders with diverse interests and perspectives to exchange skills, resources and technology to achieve a collective goal that enhances sustainable growth and development (Daramola & Olowoporoku, 2017).

Walters (2004) distinguishes the concept of governance into the old and new governance. He describes the old governance as a world in which economy, society and the state are governed from a fixed authority in a top-down fashion, while new governance pertains to a novel form of society where the traditional goal of governments such as welfare, prosperity, and security can no longer be accomplished by the central government acting alone.

According to Walters (2004), theorists of governance have argued that state monopoly in city management is a passing phase because societies have become more complex, and social demands have become varied and multiple. There is a call for a shift from government to governance where there is a decrease in power from government civil servants and elected officials towards private actors. Henrick (2014) opined that, rather than thinking in terms of a single replacement of one thing by another, thoughts should move more towards institutionalised working arrangements, involving both new and old types of steering, both nonformal and formal rules, and both horizontal and vertical types of relationships. The role of government in such a scenario will be to serve as network coordinators (da Cruz et al., 2019).

Olowu and Erero (1996) opined that governance relates to the rule-ruler-ruled relationship, in which they identified three dimensions: firstly, the functional dimension which deals with how rules are made, legitimised and enforced; secondly, the structural dimension comprising three distinct institutions, the ruler or the state, the ruled or the society, and the rules or laws. Governance is the relationship between state and society institutions. The third dimension is normative, which highlights the values associated with (good) governance (values such as transparency, organisational effectiveness, accountability, the rule of law, legitimacy, popular participation). Within the role of urban governance is the provision of infrastructure.

The concept of infrastructure is often ambiguous as it is used in different contexts. It is explained according to its function and attributes by most scholars. Development economists refer to it as the social overhead capital and investment for the provision of vital facilitators of economic activities such as transportation, water, sewerage, power, communication, and irrigation systems. The variations in definition illustrate the considerable difficulty in trying to understand the concept of infrastructure. The term infrastructure is a generic term, and it is interpreted broadly as physical, personal and institutional infrastructure (Howes & Robinson, 2006).

However, there is no standard definition of infrastructure (Torrisi, 2009), but varying perspectives across disciplines. Malaveev and Baskakova (2015) agree that the concept has no universal definition and outline the stages of infrastructure which span from the economic perspective to technology.

The need for infrastructure in the proper functioning of cities is a fundamental reason for the growing interest of researchers, thus providing a variety of definitions and classifications (Syuhaida & Aminah, 2009). Infrastructure in the context of this paper is described as a system of physical facilities, utilities and services that enhance economic growth and the quality of life.

Numerous studies on infrastructure delivery in terms of policy, planning, design construction and operation have revealed a failure to adopt an integrated approach that will facilitate the understanding of the different components in the infrastructure delivery chain (Howes & Robinson, 2006). It is necessary to view infrastructure in a holistic way rather than via a traditional approach to facilitate an understanding of the interrelationship between the critical elements of the infrastructure delivery chain, from policy formulation to operations, conservation, and sustainability of infrastructure (Howes & Robinson, 2006).

Infrastructure is central to household, community and economic activities and is very important in facilitating human development, economic growth, improving public service and productivity in the industry (Babatunde, 2015).

There are increasingly global business and complex activities involving the interaction of national and international agencies which call for global involvement in the provisions of infrastructure. This is due to the following factors (Howes & Robinson, 2006):

a. Budgetary concerns on investments and maintenance.
b. Growth in international trade is providing full access to the infrastructure market.
c. Change in international security and the relationship between nation-states because of terrorism, drugs and human trafficking.

The quality of infrastructure depends strongly on the character of the negotiated arrangements called infrastructure governance (Cunningham & Kwakkel, 2009). It is, however, essential to identify the stakeholders and the reasons behind their provision of infrastructure. Infrastructure provision depends on an array of institutional actors with complex, and sometimes contested, motives in the provision of new infrastructure (ibid).

3.0 THE LINK BETWEEN URBAN GOVERNANCE AND INFRASTRUCTURE PROVISION: TOWARDS THE DEVELOPMENT OF A CONCEPTUAL FRAMEWORK

Previous studies (Adama, 2012; Adams, Sambu, & Smiley, 2018; Aribigbola et al., 2013; Daramola & Olowoporoku, 2017; Dubresson & Jaglin, 2002) have indicated failures by the structures and actors of urban governance but have not revealed detailed evaluative and empirical studies that address the feasibility of the concept of urban governance in the provision of urban infrastructure. Furthermore, studies have indicated the failure of collaboration among the different actors in urban areas concerned with the provision of infrastructure (Smit, 2018; Wapwera, 2014), but have not provided the extent of the failure of this poor collaboration on the provision of urban infrastructure. Furthermore, available studies on governance and infrastructure provision have revealed a deficit in infrastructure and issues relating to resources, corruption, and conflict among the various actors. There is a need to evaluate the nature of the relationship of the actors and why they have failed to provide the required infrastructure even with increases in funding and resources over the past few years. Therefore, the effect of urban governance in the provision of infrastructure needs to be viewed from the lens of a collaborative process which ensures coordination, communication and resource sharing in order to arrive at a suitable outcome. The nature of urban governance and planning in Nigeria over time has relied on government-led decisions and implementation and has been affected by several issues relating to jurisdiction and responsibility among the tiers of government, government agencies, ministries and parastatals.

For this reason, conflict usually arises, which makes it difficult for a coordinated process of governance, especially in the provision of infrastructure. Governance in most urban areas appears to fail in the provision of infrastructure due to weak institutions (R. Stren, 2014; R. E. Stren, 2007). However, an innovative process of good urban governance has been advocated by both scholars and international organisations. This process allows all stakeholders in urban affairs to participate in decision making and in the implementation of policies for managing urban areas.

The gap in the relationship between state and non-state actors has led to increasing activities in the unregulated informal sector, leading to inadequacy in the urban infrastructure. However, the provision of these infrastructures, when viewed as a system, supports the involvement of a network of actors interacting to ensure the availability, adequacy and efficiency of the infrastructure needed by people. Some stages in the infrastructure provision cycle have been identified and include the following:

- Planning and evaluation of infrastructure need.
- The making of decisions to provide infrastructure and the identified process.
- The preparations for project implementation or construction of an infrastructure project.
- The operation, delivery and maintenance of the infrastructure(OECD, 2015).

Figure 8: Infrastructure provision cycle (Adopted from (OECD, 2015))

The provision of physical infrastructure, the services inherent and the stakeholders involved in the planning, operation and maintenance of infrastructures require a deliberate process of coordination. The provision of infrastructure to new developments has always been a central issue in the bargaining process between local planners, developers and infrastructure providers (Marvin & Guy, 1997). It is pertinent to note that the interests of the stakeholders in the infrastructure provision cycle are not always aligned, especially in the poorly developed systems and institutions of African cities. It is hoped that an understanding of the critical role that each actor plays in the process will support the success of the provision of urban infrastructure; each stage in the process has an actor or a number of actors that form part of the cycle to deliver the required infrastructure, therefore, if one of the actors or stages is negatively affected the outcome will also be undesirable. Hence, there is a need for the collaborative engagement of all actors to ensure success (see Figure 1). As noted earlier, the process of infrastructure provision is long and involves planning, design, operation, and maintenance. The major actors must interact in such a way to achieve the goals of providing people with infrastructure that is adequate, efficient, available and sustainable. Also, infrastructure provision cannot be solved in isolation but rather in the broader policy context of national growth strategies, economic development planning, fiscal policies and federal budget priorities (Mehdi Azizi, 1995).

In the quest to develop a conceptual framework for this study, the general system theory was useful to show the relationship between urban governance and infrastructure provision.

3.1 General System Theory

The general system theory was first made public by the work of Ludwig Von Bertalanffy between the 1960s and 1970s. It was initially a theory that sought to explain a biological system, but it has been adopted in much academic research, making it useful for interdisciplinary studies of the different kinds of activities that form a system. This theory has been applied to explain the interconnectedness of different elements as part of a system, where every part plays a significant role in the function of the entire system. Studies in management studies, organisational studies and sociology, amongst others, have used the general system theory. For example, organisational studies have adopted the general system theory for showing the interaction of various components within an open system in the process of delivering the desired outcomes of an organisation and how they relate to their environment.

The general system theory is adopted for this paper because of its robustness in capturing the various concepts and assumptions that relate to the actors and processes of urban governance and infrastructure provision. A system approach looks at the whole system working together to arrive at a goal; it explains how these systems take multiple methods to achieve their goals. The proponents of the theory argue that everything is a system with parts that interact to make a whole. This theory indicates fundamental concepts like input, process, output, feedback, openness. In this view of the system theory, it involves human relations and activities that are connected by a network of people, materials, energy and information (Jiriko, 2008). Even though the system approach has been criticized for not having specific tools or techniques, and for being too abstract and challenging to address social issues (Hughes & Hughes, 2000), others have promoted its ability to deal with complex problems and to involve a holistic approach that utilises feedback to improve the entire system (James & Verrest, 2015). This paper feels it is useful on the basis that no system functions effectively in isolation. The basic concept is that any organised group constitutes a system which is composed of regularly interacting or interrelating groups of activities or people performing activities (Bourne, 2012). The governance system is responsible for setting the strategy and for ensuring that resources are used effectively (Bourne, 2012). Therefore, approaching governance from a system theory point of view underscores the interrelationship of the different components of the system for the provision of urban infrastructure. To be able to illustrate the application of the general system theory (which has input, process, output and feedback) to urban governance and infrastructure provision, it is suitable to look at the infrastructure provision cycle and the variables that constitute urban governance. The variables such as actors, policies, institutions, resources, skills and technology are necessary for the initiation of the processes of collaboration, coordination, integration, communication and data collection that will ensure the provision and delivery of good infrastructure. If one component of the system is dysfunctional, it will result in a negative outcome.

In the urban governance cycle, these actors and resources interact in some defined processes that guide the achievement of desired outcomes. This interaction can be described in diverse ways such as interactive, network base or multi-level (Ansell & Torfing, 2016; Gupta, Verrest, & Jaffe, 2015). Collaborative governance has been observed to be applicable in many different modes due to its flexibility in approach and its prospect for broader participation (Ansell & Torfing, 2016).

The conceptual framework for this study is drawn from the general system theory, which links all the components towards the desired outcome. It is hoped to view the process of urban governance, especially as it involves the provision of urban infrastructure (see Figure 2).

3.1.1 Input

The input is what will be required for the process of governance and the provision of infrastructure to take place, without which there will no meaningful activity. In this case, several variables can form the input in the urban governance system for the provision of infrastructure. Among these variables are:

a. Actors of urban governance: The actors of urban governance are classified into state and non-state actors. The state actors include the government in the area obliged by the constitution to embark on the functions of governing; these could be federal, state or local governments, while the non-state actors are civil society, international organisations, and community organisations that may have a stake or are engaged by the state actors to perform a specific function.
b. Policies/laws and legislations: These are instruments that guide the actions of the actors in the process of governance and chart a course of action for all the stakeholders in the process. Some of the laws or policies are made by government or maybe by international protocols and conventions that have been signed and agreed by the country.
c. Institutions: These include special-purpose bodies established to achieve one or more aims of governance.
d. Skills: This relates to the capacity of the actors and institutions to perform the assigned functions. It is related to the qualifications of the actors and the experience that is required in translating available resources to tangible outcomes.
e. Resources: This plays a significant role in any governance process. Resources can be both material and human.
f. Technology: The level of technology around the world has grown tremendously, and no nation will expect to sit back without making efforts to advance technologically. The level of technology has caused the world to be more connected and appear as a ‘global village’. Therefore, this variable will play an essential role, as does urban governance, in enhancing the provision of infrastructure and service.

3.1.2 Process

The interaction of the variables discussed above determines the process in the system of governance. For the process to be suitable for the provision of urban infrastructure, it requires:

a. Effective collaboration among the variables in the input component of the system.

b. Adequate coordination of the variety of actors in the entire process to ensure legitimacy; acceptance and inclusion by all the actors to provide services for the populace.
c. The integration of the input variables in order to avoid conflict and ensure the collaboration of the actors in the urban area and beyond.
d. Communication is an essential aspect of a relationship in a system that seeks to be whole and wishes to avoid the chances of failure.
e. Data collection is vital for identification of needs, planning, implementation, delivery, maintenance and monitoring of the process of governance for the provision of urban infrastructure.

3.1.3 Outcome

Many outcomes can result from the interaction of the variables, which could be positive or negative depending on what the variables in the input generate in the process and on the feedback mechanism employed by the system (Bakare, 2014).

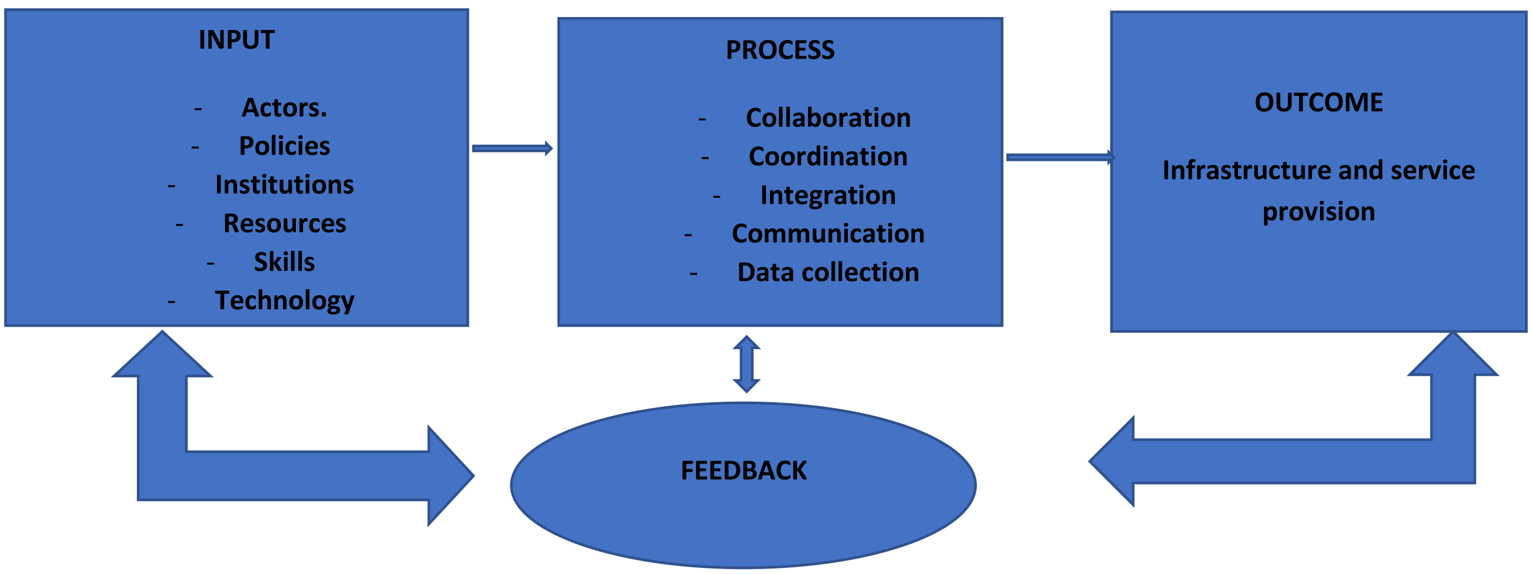

Figure 2: The conceptual framework for urban governance for infrastructure provision

4.0 CONCLUSIONS AND RECOMMENDATIONS

This paper has presented its discussions based on a review of the extant literature to establish the role of urban governance in the provision of infrastructure in urban Nigeria. The literature has indicated the challenges of infrastructure provision in Nigeria which are related to issues of governance, particularly among the actors, and the processes of delivery or provision. It is also necessary to state that the fundamental role of urban governance includes the initiation and management of the process that leads to the successful delivery of the infrastructure. The success of this role in Nigeria has appeared elusive.

The paper has also attempted to reveal the challenges in the relationships and in the negotiations for the delivery of infrastructure in Nigeria which often results in conflict by the actors thus creating an avenue for the unregulated informal sector to provide infrastructures that may not be adequate. The general system theory is adopted to reflect the process involved in the infrastructure provision cycle. The framework creates an ideal system that connects all the stakeholders and the processes for the achievement of the desired outcome. This view means that governance may not succeed in isolation; rather, it is regarded as part of the system that makes a whole.

Urban governance has been described as a process that encourages the inclusion of a variety of actors (both state and non-state actors) for the management and planning of urban affairs. This involves the application of diverse approaches that will engage relevant stakeholders to actualise the process. It is the view of this paper that the development of strong institutions with effective data collection systems will ensure success in the provision of infrastructure, whereby all the actors are captured in an integrated system and then assigned responsibilities according to their capacity and the need for integrated approach to governance, thus participating without isolating any actor.

Therefore, recommendations for the success of the governance infrastructure provision should include:

- Strengthening of institutions (both private and public) to meet the needs of the public in term of infrastructure and service provision.
- Development of an effective and efficient database system for monitoring and evaluation.
- Capacity building for personnel to improve professionalism.
- Inculcation of a collaborative approach in governance through collective decision making.
- Continuous monitoring and evaluation of the governance structure by addressing the essential requirements and capacity of governance institutions to provide for the needs of the citizens.

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Sustainability and Environmental Systems

EXPLORING UNCHARTERED TERRITORIES OF BUILDING ACCREDITATION RATINGS IN THE UK

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Abstract: There are several factors used to determine the energy performance of buildings. These factors range from the size, location, building fabric and other associated components. There seems to be a streamlined approach in determining the energy performance of buildings. This study intends to broaden the assessment of the evaluation process, explore the key attributes associated with building accreditation and the nature of buildings. The energy performance of buildings and certifications are based on several factors, which culminate into the category of energy ratings for a building. The correlations and significance of building parameters, which are not usually explored in energy performance, were taken into consideration. These factors were taken from 117 samples from the Building Cost Information Service (BCIS) repository for the UK. Based on hypothesis aimed at testing the relationship between procurement, gross internal floor area, type of house, building frame and the number of floors with the energy ratings. The analysis revealed that there is a significant relationship between the type of house, the number of floors in a building and the building energy ratings. The descriptive analysis indicated that the code for sustainable homes; code 3, forms a larger percentage of 49.6% of building energy ratings in the UK. Consequently, the findings in this study related the codes for sustainable homes with the type of house and number of floors. In conclusion, other outliers outside the regular scope of factors have no effect on building accreditations.

Keywords: Accreditation, building, ratings, UK.

1. THE NATURE OF BUILDING ENERGY ACCREDITATION IN THE UK

There are various types of building accreditation certifications for energy performance in the UK. These are based on the nature of the building, construction project and location. From recent studies, there are buildings with multiple accreditation ratings from bodies. Suzer (2019) posited that some buildings receive different scores from various building certifications for energy performance based on different parameters during the assessment. While the classification may be based on resources, building materials used, sustainable weighting and characterisations based on environmental impact projections or simulations (Fenner and Ryce, 2008), other factors such as building size, gross internal floor area, and procurement method, may also contribute to the energy performance of buildings. However, these aforementioned factors may seem absurd, until investigated.

The most popular building accreditation certifications for UK homes will be reviewed in the subsequent sections to evaluate the attributes of domestic buildings and understand the widely used building accreditation ratings in the UK. This paper aims to further correlate the features of domestic buildings in the UK with their building accreditation ratings. This is imperative for further research into the building accreditations and a standardised rating system.

1.1 BREEAM

The Building Research and Establishment (BRE) in the UK developed the Building Research Establishment Environmental Assessment Methodology (BREEAM) in 1990 as a voluntary, consensus-based and market-focused building assessment method (Crawley and Aho, 1999). According to Khezri (2011), BREEAM aims to mitigate the impact of buildings on the environment, enable buildings to be recognised according to their environmental benefits, provide a credible environmental label for buildings and stimulate demand for green buildings. The assessment method can be used across disciplines including clients, designers, developers and building managers (Lowe and Watts, 2011). Thus, the use of BREEAM encourages teamwork and collaboration between various operators in the construction industry (Lowe and Watts, 2011). The assessment of buildings using BREEAM is based on a rating and scoring system whereby ten different assessment sections are assessed and appropriate credits are awarded to each section (Schmidt, 2012). The sections in BREEAM are management, health, and wellbeing, energy, transport, water and materials (Schmidt, 2012). Others are waste, land use, and ecology, pollution and innovation. Subsequently, a weighting system is applied to each section and aggregated into a single score, measured as a percent of maximum achievable (Haapio and Viitaniemi, 2008). When a building is assessed using BREEAM, a single score is generated Crawley and Aho, 1999). BREEAM can be adopted in other countries. When it is applied, BREEAM international promotes the use of local best practice codes and standards where such standards exist in a country or region (Khezri, 2011; Abdalla, Maas, Huyghe, 2011). Meanwhile, BREEAM is criticized for not using the budget aspects to evaluate projects, suggesting that it does not ensure project success from the project management perspective (Kirkpatrick, 2009). In addition, there is a debate about the cost-effectiveness of the implementation of BREEAM. Lowe and Watts (2011)'s study contributed to the debate that the implementation of BREEAM increases construction costs. Often, the increased costs are associated with BREEAM installations and solutions (Lowe and Watts, 2011). Furthermore, BR4 identified more criticisms of BREEAM. Firstly, it does not sufficiently include the social and economic components to address the whole concept of sustainable development in building assessment. Secondly, BREAM sections, especially innovation, have many subjectivities that are very difficult for assessors to recognise during the assessment. Thirdly, BREEAM does not provide a post-occupancy assessment of buildings

1.2 DREAM

The Defense Related Environmental Assessment Method (DREAM) was developed by the Ministry of Defense (MOD) in 2006 as an in-house environmental performance tool for integrating sustainable development considerations into defense new build and refurbishment projects (Kirkpatrick, 2009). It was developed as a web-based information system (IS) application designed to enable project teams, designers and contractors to deal positively with environmental issues and meet environmental assessment commitments at low cost (Sustainable Development Commission, 2006). With the web system, the MOD can centrally access, minimise paper copies of the assessments and minimise user errors (Kirkpatrick, 2009). According to Kirkpatrick (2009), it is similar to BREEAM; in that, it is a credit rating building process. In assessing buildings, DREAM uses the following sections: biodiversity and environmental protection, external environmental quality, energy, and internal environmental quality. Others are procurement, travel, water, and waste. Meanwhile, DREAM scores over four phases the total of which are used to determine an overall final score. The phases are initial survey, design, construction, and operation; with the final score being awarded a year after the building has been occupied (Kirkpatrick, 2009). In terms of criticism, DREAM does not oblige actors to verify that buildings are built as specified or function as expected (Robertson, 2008).

1.3 ECOHOMES

Waters, Plimmer and Kenny (2007) describe ECOHomes for evaluating environmental performance. It is mainly used for new builds or major refurbishments and to assess the environmental performance of residential dwellings. The assessment of buildings using ECOHomes is undertaken at both the design stage, which allows adjusting the specifications before work commencing, and the post-construction stage, to monitor the achievements. Furthermore, the scheme establishes best practice criteria for a broad range of environmental issues ranging from climate change, use of resources and impacts on wildlife and the need for a high-quality internal environment. Contrastingly, EcoHomes XB is a separate tool for the assessment of existing buildings, applied to assess minor works and minor refurbishments. It is organised around a number of environmental measures and indicators including: management policies (energy efficiency and labelling); energy (fabric loss, heating systems, SAP rating); access to public transport; pollution (zero-emission energy sources); water usage; health (internal and external private spaces, controlled ventilation) and waste reduction/management.

1.4 Envest

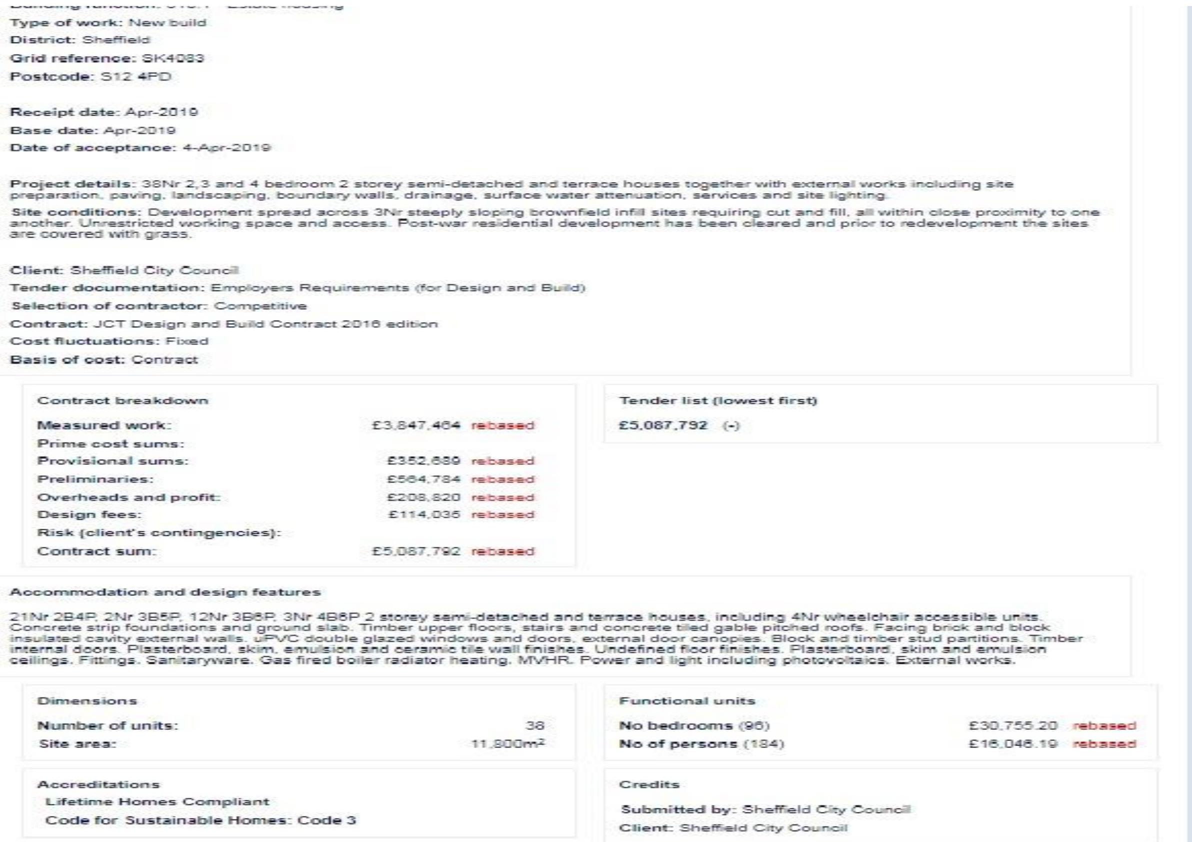
According to Waters, Plimmer and Kenny (2007), Envest 2 is a web-based tool, designed to simplify calculations relating to the environmental and whole life costs of building, thereby allowing for easier comparison to be made about different strategies in a way that allows for the environmental and financial tradeoffs. In its use, building design elements are the input (height, roof covers, number of storeys, etc), and the system identifies which element has the greatest environmental impact and allows for the effects of choosing different materials to be seen. The system can also be used to evaluate different strategies of heating, cooling and operating the building.

1.5 SAP Codes

According to SAP1, the Standard Assessment Procedure (SAP) is a UK national rating system for evaluating the energy performance of a dwelling based on steady-state principles whereby temperature and heat flows are independent of time (Crawford-Brown, 2012). The objectives of SAP are to enhance the role of building energy efficiency for all buildings sold and let, use SAP rate as a trigger for improving the energy efficiency of buildings and introduce minimum SAP rates into building regulations for new buildings (Waters, Plimmer and Kenny, 2007). SAP is based on a 2-zone model as defined in building research establishment domestic energy (BREDEM), with zone 1 being the living area of the home and zone 2 the bedrooms (Baker, and Steemers, 2002). BREDEM defines the lower limit of heating these areas to be 21°C and 18°C for 2 heating profiles, covering the weekday and weekend bedrooms (Baker, and Steemers, 2002). Contrastingly, while BREDEM requires the input of physical building characteristics but also details about occupancy and weather that is generally location-specific in the estimation of energy demand in buildings, SAP is an indicator of relative building energy performance (as opposed to estimating energy consumption directly), estimated independent from occupancy, behaviour and weather characteristics (Crawford-Brown, 2012). The SAP methodology used to assess the energy performance of buildings is based on simple physical equations and empirical evidence; this is also true for the assessment of building-integrated solar thermal and photovoltaic systems (Crawford-Brown, 2012; Baker, and Steemers, 2002). Using the methodology, the main outputs of the new rating system was an energy efficiency index, ranging from 1-100, known as the buildings SAP rate (Crawford-Brown, 2012). Thus, the SAP rate represents an estimate of the annual cost in £/m2 for providing heating, hot water and lighting to a dwelling - the higher the SAP rate the lower the expected energy cost (Crawford-Brown, 2012). Regulations are used to promote the use of SAP. In 1994, SAP was incorporated into Part L of building regulations, while from 2006, new building regulations stipulated the use of SAP2005 for all newly constructed buildings (Crawford-Brown, 2012). According to Murphy et al., (2009) SAP is a key regulatory framework for dwellings in the UK that plays a significant role in the establishment of innovative measures and technologies.

1.6 Codes For Sustainable Homes

Even though the code for sustainable homes has now been withdrawn, the large amount of data associated with this energy rating system is very relevant to extrapolating statistical conclusions on building accreditations criteria. Furthermore, recent studies also reveal that the code for sustainable homes are still being used but is generally voluntary (BRE, 2019). Investigations into the latest buildings accreditation ratings from BCIS reveals that the code for sustainable homes is still being used by some clients in 2019 (Please see screenshot).



Type of work: New build
District: Sheffield
Grid reference: SK4083
Postcode: S12 4PD

Receipt date: Apr-2019
Base date: Apr-2019
Date of acceptance: 4-Apr-2019

Project details: 38Nr 2,3 and 4 bedroom 2 storey semi-detached and terrace houses together with external works including site preparation, paving, landscaping, boundary walls, drainage, surface water attenuation, services and site lighting.
Site conditions: Development spread across 3Nr steeply sloping brownfield infill sites requiring cut and fill, all within close proximity to one another. Unrestricted working space and access. Post-war residential development has been cleared and prior to redevelopment the sites are covered with grass.

Client: Sheffield City Council
Tender documentation: Employers Requirements (for Design and Build)
Selection of contractor: Competitive
Contract: JCT Design and Build Contract 2016 edition
Cost fluctuations: Fixed
Basis of cost: Contract

Contract breakdown

Measured work:	£3,847,464	rebased
Prime cost sums:		
Provisional sums:	£352,689	rebased
Preliminaries:	£564,784	rebased
Overheads and profit:	£208,820	rebased
Design fees:	£114,035	rebased
Risk (client's contingencies):		
Contract sum:	£5,087,792	rebased

Tender list (lowest first)

£5,087,792 (-)

Accommodation and design features

21Nr 2B4P, 2Nr 3B5P, 12Nr 3B6P, 3Nr 4B6P 2 storey semi-detached and terrace houses, including 4Nr wheelchair accessible units. Concrete strip foundations and ground slab. Timber upper floors, stairs and concrete tiled gable pitched roofs. Facing brick and block insulated cavity external walls. uPVC double glazed windows and doors, external door canopies. Block and timber stud partitions. Timber internal doors. Plasterboard, skim, emulsion and ceramic tile wall finishes. Undefined floor finishes. Plasterboard, skim and emulsion ceilings. Fittings. Sanitaryware. Gas fired boiler radiator heating. MVHR. Power and light including photovoltaics. External works.

Dimensions

Number of units:	38
Site area:	11,800m²

Functional units

No bedrooms (96)	£30,755.20	rebased
No of persons (184)	£16,046.19	rebased

Accreditations
Lifetime Homes Compliant
Code for Sustainable Homes: Code 3

Credits
Submitted by: Sheffield City Council
Client: Sheffield City Council

Figure 1: Code for sustainable homes in a 2019 project

From figure 1 extracted from BCIS (2019), the client is city council based in England and one of the building accreditation is code for sustainable homes: code 3.

According to Robertson (2014), Codes for Sustainable Homes (CSH) is a variant of BREEAM, but specifically for carbon IV oxide reduction residential buildings. It uses the same nine sections as BREEAM, and a rating system from levels one to six (six being the lowest) (Robertson, 2014). Furthermore, according to Robertson (2014), there are three uncredited mandatory categories in CSH; the environmental influence of materials, management of surface water run-off and storage of non-recyclable and recyclable household waste. If these are met, there are four further mandatory issues in which points are awarded: fabric energy efficiency, Lifetime Homes (a design standard aimed at adaptable dwellings to suit residents throughout their lives), dwelling emission rates and indoor water use. Dwelling emission rates and indoor water use are progressively more onerous as the rating achieved improves. In 2007, the CSH replaced the ECOHomes and was also voluntary at the time (Kirkpatrick, 2009). However, it became mandatory for newly built houses, and a minimum code level of 3 was set – the aim was by 2016 all new housing to meet the codes level six requirements and help meet the government's tight carbon dioxide targets (Kirkpatrick, 2009). Building assessment using CSH is carried out in two stages. The first stage involves the interim assessment and initial certification of the building design, drawings and specification, while the final assessment is carried out after construction to confirm the compliance to first stage propositions (Kirkpatrick, 2009).

2. RESEARCH HYPOTHESES

This investigation seeks to explore the relationship with building accreditation and variables associated with building components, such the procurement route, building frame, and the number of floors, cost per square meter and the gross internal floor areas. Consequently, energy certifications in UK buildings may be influenced by the aforementioned factors. The following hypothesis hopes to theorise the findings of this study.

- H1 Building energy certification is influenced by the procurement route
- H2 Building energy certification depends on the type of building frame
- H3 Building energy certification is influenced by the number of floors
- H4 Building energy certification has a relationship with the cost per meter squared values for building
- H5 Building energy certification is influenced by the gross internal floor area (GIFA)

The null hypothesis negates each aforementioned hypothesis.

3. METHODOLOGY

Secondary data analysis of data extracted from the database of Building Cost Information Service (BCIS), UK was explored for all possible building types ranging from detached houses, flats, semi-detached houses and bungalows using a mean average of 100 for the location factor. Second data from BCIS is preferred for this study as opposed to the English Housing Survey, Scottish Housing Survey and Welsh Housing survey because it provides a unified database of all building accreditation since the 1970s. Furthermore, the BCIS database also provides a unified UK wide information about procurement, contracts and construction conditions for various types of buildings.

The residential building floor area of 500m² to 2000m² along with a limit of 5 stories provided rebased sample of 117 across the UK. These samples were rebased using the tender price index (TPI) for the first quarter of 2019 as being 321. Within the build-up to the results, all building accreditation for the UK explored (See figure 1). Each sample were explored for the type of procurement, gross internal floor area (GIFA), building frame, type of house, cost per meter square of the floors and the number of floors. These variables were selected for statistical analysis purposes. Cramer's V analysis expressed the influence of each variable on building energy certification, while Spearman's rho correlation revealed the relationships between building energy certification and other variables, the asymptotic significance of the relationships were also explored to further support this analysis (Pallant, 2013).

Figure 2: All building accreditation types for UK buildings

The data extraction process in this study was aimed at investigation all possible building energy accreditations for residential buildings in the UK from the year 1973 to 2019. Furthermore, the adoption of Spearman's rho's correlation for this analysis exposed unexplored buildings construction life cycle criteria which may influence the decisions to accredit buildings in the UK.

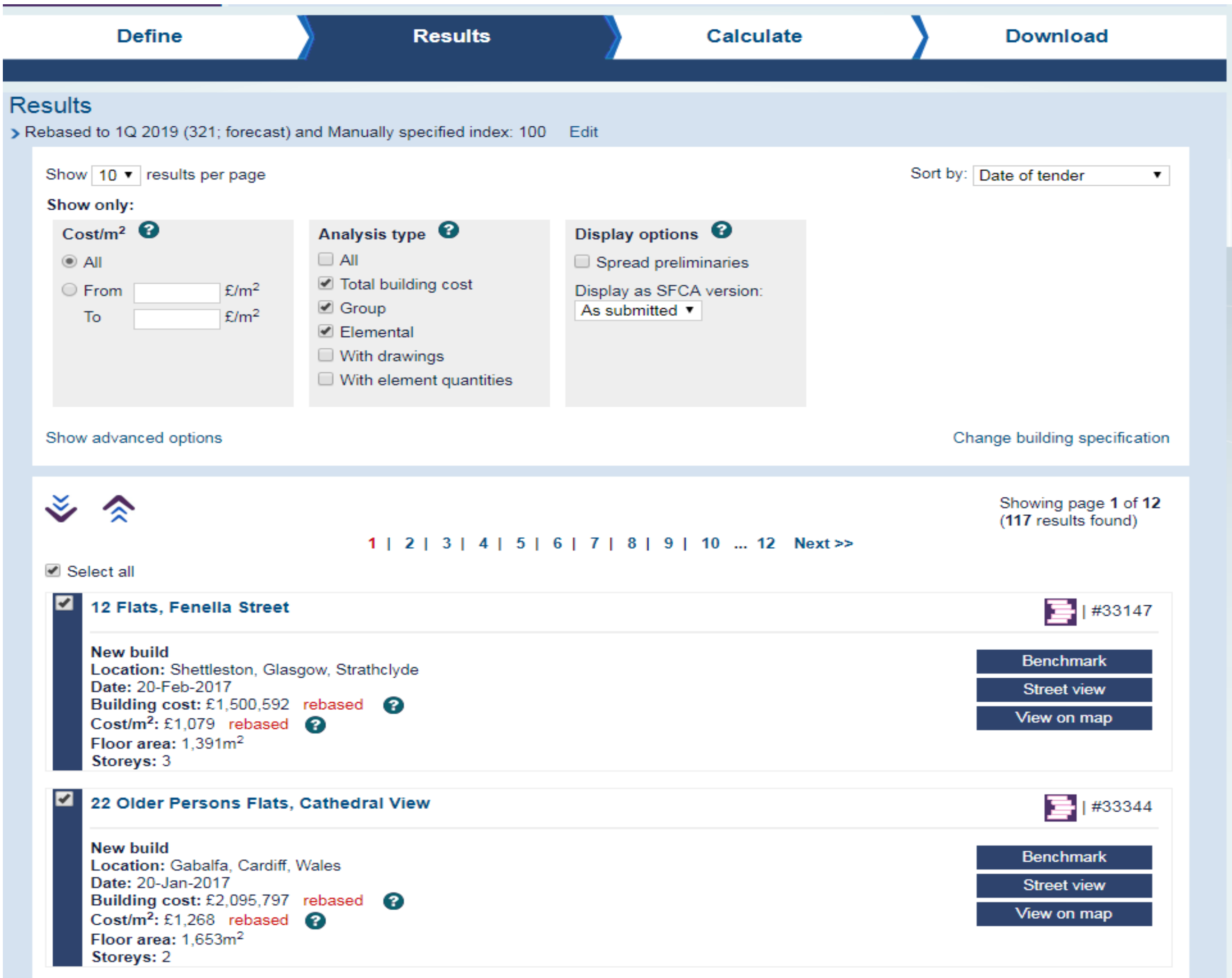


Figure 3: Samples from BCIS

The 117 samples provided by BCIS were sorted in Microsoft excel files and exported to Statistical Package for Social Sciences 25 (SPSS25) for analysis.

4. ANALYSIS AND FINDINGS

The first section of this analysis involved sorting every 117 samples extracted from BCIS. The samples were explored for the type of building energy certification issued out to all residential building types since 1973. The findings revealed that the Code for sustainable homes: Code 3 is the most issued energy accreditation for buildings in the UK. 49.6% of the buildings energy certificates issued were Code 3 of the code for sustainable homes. Code 4 had 16.2% and 13.7% of all certifications were a combination of lifetime homes compliant and code 3 for sustainable homes. Furthermore, a distribution of 0.9% for each category of building energy accreditation went to SAP 2012; Energy performance rating B; Excellent and very good for BREEAM; Code 4 for sustainable homes; SAP 2009; Energy Performance rating B; and code 5 for sustainable homes. However, the focus will be on the first three categories in Table 1 with a cumulative percentage of 79.5%. Additionally, Table 1 also displays combinations of building accreditation types. It was discovered that many buildings had more than one building accreditation.

Table 1: Building energy certification for extracted samples

S/N	Type of building energy certification	Percentage (%)
1	Code for Sustainable Homes: Code 3	49.6
2	Code for Sustainable Homes: Code 4	16.2
3	Lifetime Homes Compliant; Code for Sustainable Homes: Code 3	13.7
4	Lifetime homes and Code for Sustainable Homes: Code 3	1.7
5	Lifetime Homes Compliant; Code for Sustainable Homes: Code 4	11.1
6	SAP 2012: Energy Performance Rating B	1.7
7	BREEAM: Excellent, Code for Sustainable Homes: Code 4	0.9
8	Lifetime Homes Compliant; SAP 2009: Energy Performance Rating B; Code for Sustainable Homes: Code 3	0.9
9	SAP 2009: Energy Performance Rating B; Code for Sustainable Homes: Code 3	1.7
10	SAP 2009: Energy Performance Rating B	0.9
11	BREEAM: Very Good	0.9
12	Code for Sustainable Homes: Code 5	0.9

The findings from Table 1 may have had an implicit effect on the correlation between building accreditation categories highlighted above and the procurement route; building frame; type of house; the number of floors; cost/m² and the gross internal floor areas (GIFA).

Table 2: Statistical analysis table showing Cramer's v values and Spearman correlation for Building accreditation

Variables measured against building energy certification	N	Cramer's V	Spearman's rho coefficient	Significance (2-tailed, <0.05)
Procurement route	117	0.29	0.061	0.514
Building frame	117	0.496	0.142	0.126
Type of House	117	0.287	-0.186	0.045
Number of floors	117	0.296	0.185	0.045
Cost/m²	117	0.979	0.163	0.079
Gross Internal Floor Area (GIFA)	117	0.998	0.057	0.538

In table 2, the Cramer's V value only reflects the sizes of the effect of a variable on producing the Spearman's rho correlation. The Spearman's rho correlation was chosen over Pearson correlation because the type of data extracted from BCIS was primarily non-parametric in nature. However, the number of floors, cost/m² and GIFA are parametric data. Nonetheless, the 2 tailed asymptotic significance shows that the number of floors and the type of house both having $p<0.05$ at 0.45 respectively have significant effects on building accreditation. Consequently, there is a small correlation between the number of floors, type of house and building energy certification. A Spearman's rho coefficient of -0.186 with the minus sign exposing the direction of the relationship, confirm a correlation with the building accreditation. The number of floors and building accreditation has a correlation value of 0.185. This shows that varying building types and number of floors significantly influence the type of energy performance accreditation issued to buildings. This may be evident in a smaller correlation of 0.163 for the cost per meters squared variable. Procurement routes such as direct and design and build, partnering and traditional procurement routes have virtually no influence on the energy performance of a building and the accreditation process. This can be attested for the GIFA. The building frame, which is primarily bricks, concrete, timber, and steel, provides a small relationship with the energy performance certifications in UK buildings.

The findings, therefore, support hypotheses H2 and H3. Based on this premise, building energy accreditations are affected by the type of house and number of floors. Additionally, the building frame.

5. DISCUSSION AND IMPLICATIONS OF THIS RESULT

In the UK, energy performance certifications such as SAP ratings are very popular and is expected to increase significantly by the year 2050. This is based on BRE domestic energy (BREDEM) models for assessing energy performance in buildings (Crawford-Brown, 2012; Baker and Steemers, 2002). The U-values of buildings are measured for energy efficiency and the building fabric are evaluated for explored to detect embodied carbon (Murphy, Kummert, Anderson, 2009). Dwelling carbon emission ratings in buildings also contribute to the assessment criteria. Other criteria used in building assessment are water, pollution, waste generated, health and wellbeing (Eadie, Millar, Grant, 2013).

In this study, it was discovered that energy performance certifications such as the life compliant homes, code for sustainable homes 3 and 4 make up almost 80% of 117 residential buildings in the UK. The type of house, which may be semi-detached, detached houses and flats, bungalows, and the height of the building established by the number of floors grossly influence this percentage. Therefore, the number of floors in a house or flat reflects the code of sustainable homes 3 and 4 for most building in the UK. Code for sustainable homes 3 implies 0% percentage improvements in dwelling emission rate over targeted emission and a 105 litres human consumption of water per day. Code 4 is a 25% improvement in dwelling emission rate over targeted emission and similar human water consumption rate as code 3. The three and four-star ratings for most buildings in the UK reflect an average rating which can be improved. The implications of this result for further research may involve in-depth studies of building types and increment in storey height.

6. CONCLUSION AND LIMITATIONS OF THIS STUDY

Although this study superficially investigated the relationships between unexplored variables such a procurement; cost per meter squared; GIFA, building frame; type of building; number of floors; with energy performance certifications in buildings, further studies into the causalities of the relationship between the significant variables such as the type of house and number of floors may constitute additional studies into certification criteria. Notwithstanding, this study has applied a repository of UK building data in materializing relationships between residential building types and number of floors. Pertinent questions of procurement and floor area in building energy ratings reflect no dependencies. This small-scale study conceptualizes research into building components and energy performance certification and completely reflects the major dependencies considered during building accreditation in the UK.

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ENERGY STORAGE FOR INCREASING SELF-CONSUMPTION OF WIND ENERGY AND MARKET VALUE ON A DISTRIBUTION NETWORK

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Abstract: It is desirable to maximize the utilization of renewable energy resources. Wind energy, being a renewable resource, could be generated and stored within the customer premises while using the captured energy to provide various services. To demonstrate the benefits of adding an energy storage at a distribution network having a typical peak load of 1,000 kW and two wind turbines, a 2MW/4MWh storage is installed. All storage options that meet the performance characteristics required are selected for economic and technical analysis. The technical analysis is done through power flow techniques using the NEPLAN 360 modelling tool while an existing market pricing scheme is used in analysing the feasibility of project. To avoid the errors inherent in price quotes, hypothesised price ranges are used in estimating storage costs and a likely payback period of project. New integration possibilities and potential benefits of storage suggest how changes in market conditions could impact the profitability of the project. Self-consumption of wind energy increased by about 10% after introducing the storage. Using the storage to provide stacked market services makes the project more profitable. Policies that encourage the integration of storage in delivering more benefits across the electricity supply chain make storage project profitable.

Keywords: Energy storage, storage economics, storage services, wind energy, wind self-consumption.

1. INTRODUCTION

The quest for a low-carbon energy system leads to the development of cleaner methods of power generation using Distributed Energy Resources (DERs), notably renewable energy generation from wind and solar photovoltaics (PV). While the generation of power from wind is desirable for sustainable energy usage, the intermittent nature of renewables makes them less effective in meeting constant energy needs. To make the supply from renewables more utilizable, some solutions have been proposed – the use of storage options and energy demand control measures (*EPRI*, 2016) and (Olinsky-Paul, 2019). Now, integrating a renewable energy system into the conventional electricity grid brings considerable opportunities as well as new challenges. The opportunities include; increased generation of power from renewable sources – wind and PV, access to clean electricity in remote places, relatively cheap source of clean energy, less pollution from power generation, sustainable and secured energy system, elimination of constraints and curtailments of renewables (Pietrosanti et al., 2016), (Finn and Fitzpatrick, 2014), and (*EirGrid and SONI*, 2018). The challenges include; the complexity in ascertaining real storage benefits, location-dependent nature of storage benefits (Fine et al., 2015), inconsistent integration policies, and a dynamic storage economics. The diverse structure of the aggregate power network at a location – architecture of the power grid, the point on the grid where a DER is installed, the local load profile, the energy mix of the grid, the electricity market, and the availability of other complementary means of power generation at the location; make the net benefits of installing DERs vary substantially at different places. In this work, we examine how adding a suitable energy storage system could increase self-consumption of wind energy and provide other monetized services at a distribution network, using the NEPLAN 360 software as a modelling tool. The distribution network fits the load of a campus where the typical daily base load is 500 kW and the typical peak load is 1,000 kW. There are two wind turbines at the location, each rated 800KW. The campus network is linked to an Alternating Current (AC) grid supplying 3-phase voltage at 400V/50Hz through an 11kV substation. Currently, any excess power generated from wind turbines are fed to the grid at a flat rate – happens during the times of excess wind flow. To inform policies for the optimization of demand-side renewable energy generation, this study examines the net benefit attached to, rather than feeding the excess wind power to the grid, storing the locally produced excess wind energy for later consumption on-site. The potential benefits of installing the storage in providing other customer, utility, and ancillary services are also estimated with respect to a market structure. The economic implications of such storage substitution are analysed in terms of; the likely storage cost ranges and efficiencies, the electricity market structure, and the potential additional services of storage; to identify beneficial changes in market conditions and inform new policies.

2. METHODS

2.1 Description of Distribution Network

To ascertain the overall benefit of installing a storage at a distribution network – a model of the distribution network is developed using *NEPLAN 360* software. The site has ten substations feeding various buildings on-site and is connected to a High Voltage (HV) network through an 11 kV Feeder. From the data obtained for the site for a calendar year – with two 800KW wind turbine Generators; the site generates 3,042,075 kWh from wind while it imports 3,720,642 kWh from the electricity grid. With an annual energy consumption of 6,189,647 kWh, the average annual energy exported back to the grid is 601,780 kWh. The base load on-site is about 500 kW while typical daily peak load is around 1,000 kW, Figure 1. An HV connection agreement puts the Maximum Import Capacity – that is, the maximum amount of power that the site may draw from the grid – at 2,500 kW, and the Maximum Export Capacity – that is, the maximum power that may be supplied from the site to the grid – at 1,242 kW.

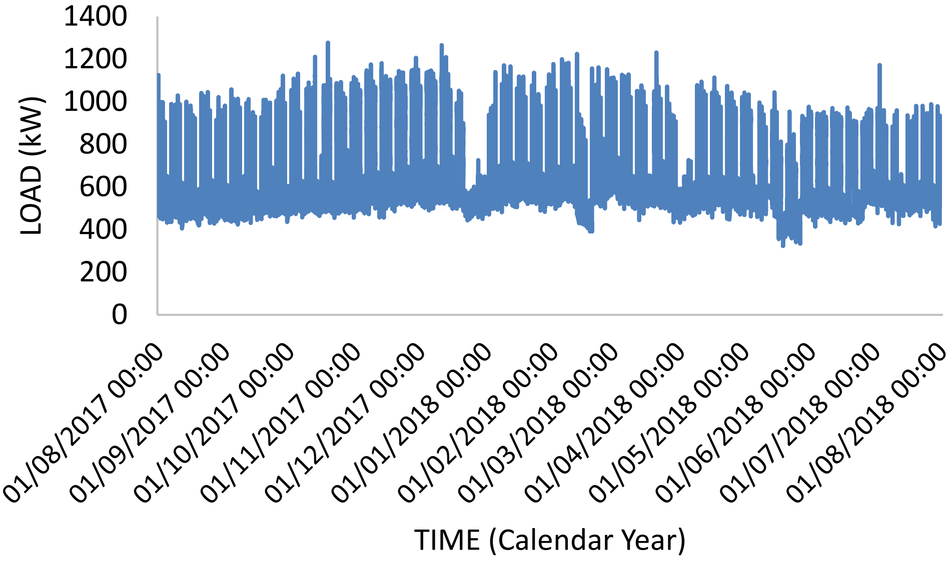


Figure 1: Site Calendar Year Load Profile

The initial setup of the distribution network is depicted by the line diagram of Figure 2.

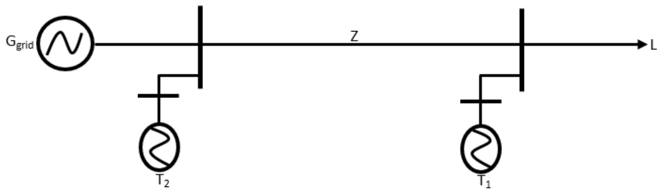


Figure 2: Initial Network Configuration

$$T_2 \pm G_{grid} = T_1 + Z + L \tag{1}$$

where G_{grid} is any instantaneous power supply from the grid, T_1 denotes the power supply from turbine number one, T_2 denotes the power supply from turbine number two, Z is a total power expended in system impedance, and L is the total power consumption in aggregated system load. Behind-the-meter storage is introduced to take up the excess generation from the wind turbines, Figure 3.

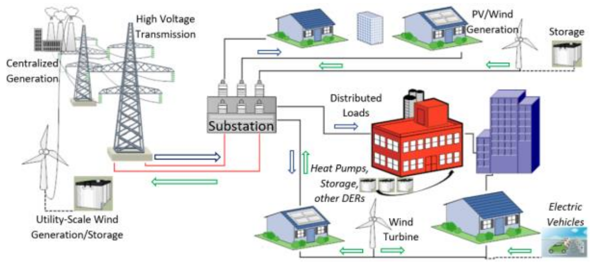


Figure 3: Layout of the Distribution Network

Here, the power from the roof-mounted PV is locally consumed for heating and not grid-connected. While the site network remains connected to the grid for continuous power supply, maximum self-consumption of power from on-site wind turbines is to be achieved by charging a storage equipment with any excess wind power generated rather than sending the excess wind power to the grid. The data of the maximum power demanded from site within the last calendar year and the combined maximum power produced from the wind turbines are used to estimate the likely energy profile of site. The peak load for the last calendar year was 1,376 kW while the base load was around 500 kW. The local load profile, the exported electricity data, and the wind generation profile; are used in selecting a suitable storage option that may effectively maximize the use of any locally generated energy from the wind turbines. The prices of the imported electricity and the exported electricity are taken from a typical unit value for imported electricity and exported electricity. Looking at the power generation and the power demand profiles of site, and the export power profile and the import power profile within a year; a suitable storage technology with a capability that can match the observed energy characteristics is selected. A cost analysis is performed on major suitable storage technologies.

2.2 Storage Technologies

To Some of the storage technologies described in (Aneke et al., 2016) and (Azzuni and Breyer, 2018) are applicable in behind-the-meter storage applications, especially batteries. Batteries are readily available and can be cascaded to form small, medium, or higher power banks. The modularity of batteries makes them suitable for customer-premise storage. The battery size may be chosen to meet the exact storage needs – optimizing resources and ensuring feasible economics. Some of the other important factors that should be considered when selecting storage for a behind-the-meter application include; service power requirement, charge-discharge cycle, length of service requirement, physical requirement, environmental conditions, unusual operation needs, maintenance needs, safety needs, and cost. Different applicable storage options are considered for the same project for a comparison of performance among the storage options. For example, the economics of including a Lithium-ion battery as a storage is compared to the economics of using a Flywheel storage. Usually, in several cases, it might be possible to use more than one storage option. The final choice of a storage used in any project may now depend on some specific utility, storage, or user requirements.

2.3 Determining Effect of Storage on Network through Power Flow Analysis

The overall effect of adding a storage to the power network is determined with a power flow analysis. The system is checked to ensure that the introduction of the storage to the power network has not compromised the stability and reliability of the network. The real and the reactive power for a *static load flow network analysis* can be expressed respectively as;

$$P_i = V_i \sum_{k=1}^{n} V_k Y_{ik} \cos(\theta_{ik} + \delta_k - \delta_i)$$
$$Q_i = -V_i \textstyle\sum_{k=1}^{n} V_k Y_{ik} \sin(\theta_{ik} + \delta_k - \delta_i) \quad (2)$$

The load flow equations are non-linear; they are solved using a numerical solution such as the *Extended Newton-Raphson*, the *Current Iteration*, or the *Voltage Drop* solutions. The numerical solutions are used in a power flow analysis in the *NEPLAN 360* modelling software.

2.4 Storage Power Management

With respect to Figure 4, a switch S_{w1} that links the distribution network to the grid is operated according to the control described by Equations (3a) and (3b) while a switch S_{w2} – that determines when the storage *E* is to be charged or discharged, is operated according to a C_{node} control described by Equation (4).

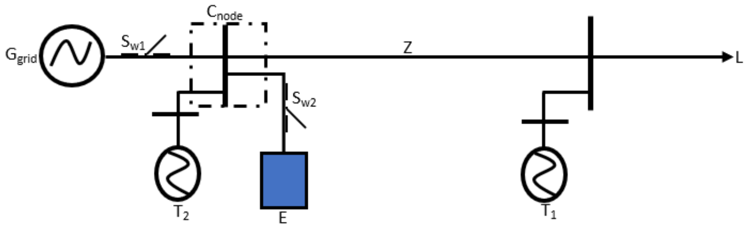


Figure 4: Addition of Storage to Initial Network

$$S_{w1} = 1, when\ L + Z > T_1 + T_2 + E_{(\min)} \quad (3a)$$
$$S_{w1} = 0, when\ L + Z < T_1 + T_2 + E_{(min)} \quad (3b)$$

where $E_{(\min)}$ is the implied energy discharge limit for storage, T_1 is the energy feed from turbine number *1*, T_2 is the energy feed from turbine number *2*, *L* is the energy demand of load, and *Z* is the energy expended in system impedance.

$$E_{(\min)} \propto \left[(E_{SOC})\ AND\ (E_{Services})\ AND\ (Time_{Tariff})\ AND\ (T_1)\ AND\ (T_2)\right]$$
$$S_{w2} \propto E_{(min)} = 1\ OR\ 0 \quad (4)$$

where E_{SOC} is any specified state of charge of storage, $E_{services}$ is the service demand on storage, $Time_{Tariff}$ is the net instantaneous amount charged for electricity, T_1 is the energy feed from turbine number *1*, and T_2 is the energy feed from turbine number *2*;

whereas, $E_{(\min)}(1)^+ = E_{(\min)}(0)^+ \pm E_{(\min)}(1)^-$

$$E_{(\min)}(2)^+ = E_{(\min)}(1)^+ \pm E_{(\min)}(2)^-$$

that is, $E_{(\min)}(t)^+ = E_{(\min)}(t-1)^+ \pm E_{(\min)}(t)^-$; *for every storage charge-limit instance t = 1, 2, 3, …, n*

The combined operations of switches *Sw₁* and *Sw₂* imply that the storage is to be charged with a power supply from the turbines only and it is to be discharged to maximize self-consumption of wind energy while retaining certain capacities for optimal discharging and specialized services.

2.5 Assessing the Storage Benefits

After matching a storage option with the technical details of the energy flexibility required on-site, a cost analysis is performed on major suitable storage technologies. An analysis on the performance of different suitable storage options is done to identify an optimal storage option that meets all essential requirements at the least cost.

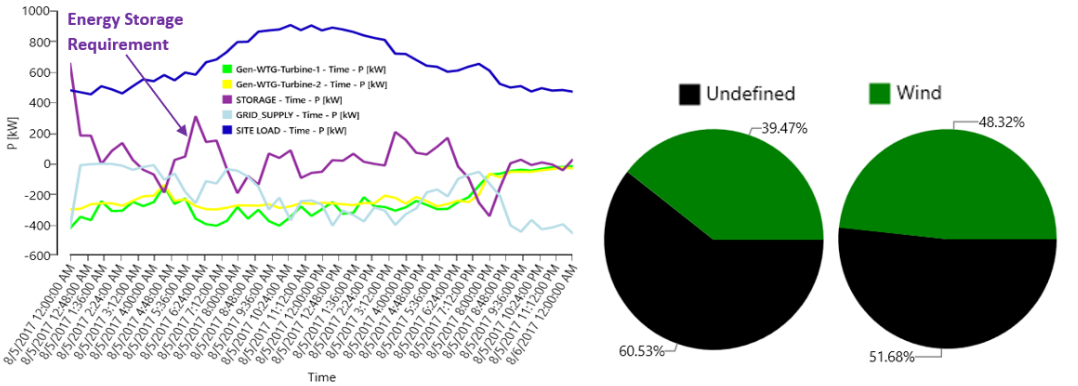
The overall benefit of increasing self-consumption of wind energy to the customer and to the power network is determined. The cost of having a storage system is hardly fixed; the cost changes and makes the economics of energy storage system dynamic – errors could arise when earlier quoted prices are used for analysis in a new economic dispensation. To avoid such errors; the costing of the energy storage here is done heuristically, choosing a most likely cost ranges of the storage types. The analysis, while not claiming that a storage type is currently economically feasible, is to reveal that cost point at which an identified storage option could be economically feasible with respect to the electricity market of the distribution network and suggests where changes – in storage characteristics and usage, market services, pricing, or policies – could create more values for the storage. The benefits are assessed using existing market prices – and including other hypothetical market values that could encourage demand-side generation in analysis. In the existing market, the imported electricity and the exported electricity prices vary but have predictable ranges. However, the imported electricity price is often higher than the exported electricity price, typically in a ratio of 7 to 3 (Invest Northern Ireland).

A proportion of the storage is presented to provide additional services to the grid for utility and ancillary services using *DS3/I-SEM* prices (*SONI*, 2018) – *DS3* is a programme developed to increase non-synchronous penetration on the grid at this location while *I-SEM* is a wholesale electricity market that was set up to permit trading bulk electricity across borders. Looking at the different additional ancillary services that a storage may provide to the grid, the applicable energy storage technologies are identified; and a new cost analysis is done to determine the new cost implications of presenting the storage for stacked services. The economic analysis is to indicate the economic feasibility of the project and suggest the likely payback period of investment on any applicable storage capacity.

A further potential benefit analysis is carried out to indicate how presenting a storage for other additional services across the electricity supply chain could impact the economics of introducing the storage at the distribution network. In estimating the potential benefits of such introduction of storage, the following assumptions are made: the storage used for calculation is 90% efficient – a typical Lithium Ion Battery or a Flywheel, storage capacity is 2MW/4MWh with 20% of capacity committed to providing additional services, price of electricity is £0.12/kWh, CO_2 factor of the grid supply is 0.2kgCO_2/kWh while a Carbon tax of £80/tonneCO_2 exists – required for ‘green’ generation estimation, cost of electricity distribution is £0.0312/kWh (26% of electricity price), cost of electricity transmission is £0.0372/kWh (31% of electricity price), and the total value of all ancillary services provided by storage through *DS3* is £10/MWh for 1 hour.

3. MAIN RESULTS

While a suitable storage takes on any excess wind power through the day – Figure 5(a), the percentage of energy consumption from wind rose from 39.47% in Figure 5(b) to 48.32% in Figure 5(c) – nearly a 10% increase. The other percentages of the energy mix came from a grid with an average energy mix including about 55% from fossil fuel. The introduction of storage creates market value by providing monetized benefits; through customer services – the 10% increase in wind energy consumption, demand charge reduction, and backup reserve; through utility services – more efficient transmission and distribution resource management; and through ancillary services – inertial and operating reserves, ramping margins, and active-reactive power services.



(a) Generation-Demand Profiles (b) Current Energy Mix (c) New Energy Mix with Storage

Figure 5: Energy Generation-Demand Profiles and Mix

Table 1: Result of Increase in Self-consumption and Market Gain

Storage System Efficiency (%)	Total Energy Recovered (kWh)	Market Value of Energy Recovered (£)	Gross Annual Gain (£)	New Self-consumption of Wind Energy (%)
95	572,867.71	68,744.13	37,085.65	48.82
90	542,716.78	65,126.01	33,467.53	48.33
85	512,565.84	61,507.90	29,849.42	47.83
80	482,414.91	57,889.79	26,231.31	47.34
75	452,267.50	54,271.62	22,613.14	46.85
70	422,113.05	50,653.57	18,995.09	46.36

Table 2: Results of Cost of Selected Storage Types and Payback Period on Investment

Selected Storage Systems with Average Ranges of Overall Costs through the Storage Life Span	Total Capacity Cost (£ Million) - 2MW/4MWh	Nominated Storage Efficiency (%)	Life Span (Years)	Gross Annual Gain (£)	Payback Period (Years)
Flywheel at £80/kWh; at £120/kW	0.56	90	20+	33,467.53	17
Flywheel at £1,715/kWh; at £1,880/kW	10.62	90	20+	33,467.53	317
Li-ion Battery at £70/kWh, at £110/kW	0.50	85	10-15	29,849.42	17
Li-ion Battery at £1,510/kWh, at £1,580/kW	9.20	85	10-15	29,849.42	308
Na-ion Battery at £60/kWh, at £90/kW	0.42	80	10-15	26,231.31	16
Na-ion Battery at £1,100/kWh, at £1,200/kW	6.80	80	10-15	26,231.31	259
*Zn-Br Flow Battery at £65/kWh, at £105/kW	0.47	75	5-10	22,613.14	21
*Zn-Br Flow Battery at £800/kWh, at £1,150/kW	5.50	75	5-10	22,613.14	243

*Zn-Br Flow Battery should be considered with caution as its lifespan may be less than 10 years – a minimum lifespan standard for storage technology, for easy comparison between storage and conventional power system components – usually lasting for 40 years.

In the last calendar year, the total electricity import from electricity grid was 3,713,900 kWh at a market value of 3,713,900 kWh * £0.12/kWh = £445,668; the total electricity export to the grid was 603,018.64 kWh at a market value of 603,018.64 kWh * £0.0525/kWh = £31,658.48. Typical storage efficiencies are chosen between 95% to 70%. The total energy recovered is obtained by multiplying the efficiencies by the export electricity – 603,018.64 kWh. The market value represents the equivalent value of the recovered energy at the market price of £0.12/kWh. The gain in market value is obtained from the difference between the recovered energy at a price of £0.12/kWh – export electricity price, and at a price of £0.0525/kWh – import electricity price, Table 1. The gross annual gain is more when the efficiency of the storage deployed is higher. The percentage of the wind energy consumed on-site increases with higher storage efficiency as less of the wind energy is wasted through the charge-discharge cycle of the storage.

The storage technologies considered here are the storage technologies that; could meet the technical discharge cycle required, typically have round-trip efficiencies higher than 65%, are applicable at the point of the on-site distribution network, have no unusual operating temperature requirements, are mature or demonstrated technologies, could act as load and electricity generator, and that have decreasing trends for overall system and life-cycle costs. Flywheel, Lithium Ion (Li-ion) battery, Sodium Ion (Na-ion) battery, and Zinc-bromide (Zn-br) Flow battery are found to meet these requirements. The average cost estimates in Table 2 include all costs – fixed, variable, initial, capital, complementary, and maintenance costs – over the average life of storage. The cost ranges are selected only as test cases to reveal how storage costs, efficiencies, and lifespans impact on the economic feasibility of project, using the payback period estimation of investment. The payback period is the ratio of the aggregate lifetime cost of a storage to the annual gain of the storage, Table 2. The typical lifespan of each of the storage technologies is included in Table 2 to reveal the storage technologies that make economic sense at the hypothesized prices. With the current market condition, the result suggests that this project becomes economically feasible when the total cost of the specified storage size is around £500,000. Given that each of the storage technologies have similar costs, Flywheel promises better return on investment because of its longer lifespan, its inherent almost unlimited number of discharge cycles, and its ability to respond effectively in providing other specialized services.

Table 3: Cost of Selected Storage Types, Ancillary Service Gain, Total Gain, and New Payback Period

Selected Energy Storage Systems with Average Ranges of Overall Costs through Storage Life Span	**20% Capacity for Ancillary Service (MWh/year)**	**Ancillary Services Gain (£)**	**Self-consumption Gain (£)**	**Total Annual Gain (£)**	**New Payback Period (Years)**
Flywheel at £80/kWh; at £120/kW	262.80	2,628.00	33,467.53	36,095.53	15.5
Flywheel at £1,715/kWh; at £1,880/kW	262.80	2,628.00	33,467.53	36,095.53	294.2
Li-ion Battery at £70/kWh, at £110/kW	223.38	2,233.80	29,849.42	32,083.22	15.6
Li-ion Battery at £1,510/kWh, at £1,580/kW	223.38	2,233.80	29,849.42	32,083.22	286.8
Na-ion Battery at £60/kWh, at £90/kW	178.70	1,787.00	26,231.31	28,018.31	15.0
Na-ion Battery at £1,100/kWh, at £1,200/kW	178.70	1,787.00	26,231.31	28,018.31	242.7
*Zn-Br Flow Battery at £65/kWh, at £105/kW	134.03	1,340.30	22,613.14	23,953.44	19.6
*Zn-Br Flow Battery at £800/kWh, at £1,150/kW	134.03	1,340.30	22,613.14	23,953.44	229.6

While the result obtained in Table 2 is for a scenario in which the storage has been deployed only for a singular service, namely self-consumption of wind energy; the results of Table 3 depict a bigger picture in which, in addition to increasing self-consumption of wind energy, the storage is deployed to provide grid services. A 20% capacity of storage is committed to providing ancillary services up to £10/MWh in value. The ancillary services and the self-consumption gains are combined to obtain a total annual gain and a new payback period is obtained, Table 3. The results indicate a shorter payback period for storage, suggesting that storage projects become more profitable when conditions permit a storage to be deployed for stacked services to the owner and to the grid. Here, the 20% capacity has been deployed for ancillary services for a short period; deploying that same capacity for a longer time could drastically reduce the payback period of this project.

An even more interesting picture is depicted in Figure 6, where the potential benefits of adding the storage to the distribution network is monetised and considered across the whole electricity supply chain – using the assumed values described in section 2.5. However, these potential benefits require favourable electricity market policies to become realizable. For example, the grid should permit storage projects to participate in providing ancillary services equitably, green energy generation should have economic reward – perhaps, through carbon credits, and the grid should be planned to admit more demand-side energy generation.

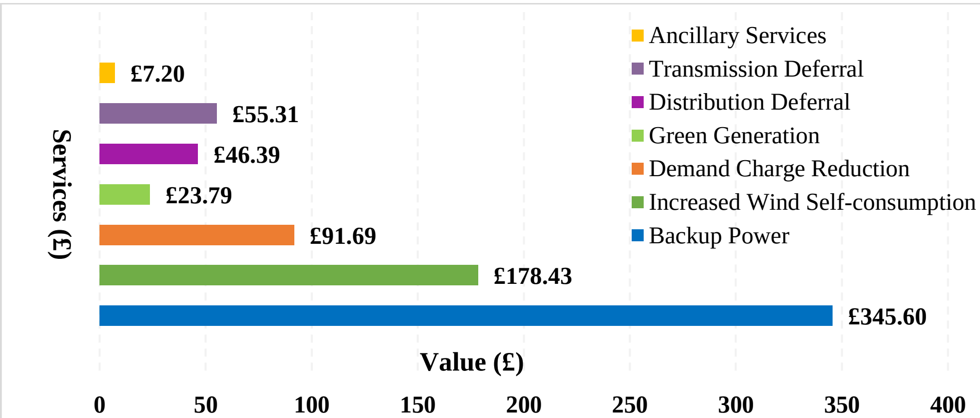


Figure 6: Potential Benefits of Storage in the Electricity Supply Chain

4. CONCLUSIONS

Demand-side energy storage could play a major role in the on-going effort of maximizing energy generation from renewables like wind. Energy users become key players in renewable energy generation when markets and policies allow customers to deploy more distributed energy resources to maximize own energy generation from renewables profitably. Deploying demand-side resources comes with benefits to electricity stakeholders. When a 2MW/4MWh storage was introduced to a distributed network having two grid-connected wind turbines and an aggregate on-site typical peak load of about 1,000 kW – using a storage with features that could effectively meet the supply-demand charge-discharge characteristics of loads – the percentage of on-site energy consumption from wind rose from 39.47% to 48.32%, improving self-consumption of wind energy while potentially relieving the grid of network capacities. The deployment of the storage becomes more profitable when the storage can provide ancillary services through electricity markets – suggesting a mechanism through which fossil fuel-based generations could be clamped down while promoting renewables using favourable market prices and policies, for a safe and sustainable energy system in a campus built environment. With environment-cautious market policies, energy storage could become a profitable tool; providing customer, utility, and ancillary service values to stakeholders across the electricity supply chain.

5. ACKNOWLEDGEMENTS

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APPENDIX

THE LOAD FLOW EQUATIONS FOR NON-LINEAR SOLUTION

If the net complex power injected into a bus *i* of a network is given as;

$$S_i = P_i + jQ_i = (P_{Gi} - P_{Di}) + j(Q_{Gi} - Q_{Di}) \quad (5)$$

with the real and the reactive power demanded (P_D and Q_D) and generated (P_G and Q_G) within the bus respectively;

$$P_i = P_{Gi} - P_{Di}$$

$$Q_i = Q_{Gi} - Q_{Di} \text{ ; for } i = 1, 2, 3, \dots, n;$$

n being the number of buses in the network; then, the current flowing through the bus *i* can be given as;

$$I_i = \sum_{k=1}^{n} Y_{ik} V_k \text{ ; for } i = 1, 2, 3, \dots, n \quad (6)$$

where Y_{ii} – the *self-admittance* – the driving-point admittance of *i*th node; is the sum of all admittances at the *i*th node, Y_{ik} – the *mutual admittance* – the transfer admittance between the *i*th and the *k*th nodes; is the negative of the sum of all admittances between the *i*th and the *k*th nodes, whereas $Y_{ik} = Y_{ki}$.

Similarly, the complex power injected into the bus *i* can be written as;

$$S_i = P_i + jQ_i = V_i I_i^* \text{ ; for } i = 1, 2, 3, \dots, n \quad (7)$$

where I_i^* is the complex conjugate of the current flowing through the *i*th bus and V_i is the voltage at the bus;

this implies, $S_i^* = P_i - jQ_i = V_i^* I_i$; for $i = 1, 2, 3, \dots, n$

$$S_i^* = P_i - jQ_i = V_i^* \left(\sum_{k=1}^{n} Y_{ik} V_k\right) \text{; for } i = 1, 2, 3, \dots, n \quad (8)$$

Equating the real and the imaginary parts of Equation (8) implies;

$$P_i = R_e\{V_i^* \sum_{k=1}^{n} Y_{ik} V_k\}; \; Q_i = -I_m\{V_i^* \sum_{k=1}^{n} Y_{ik} V_k\}; \text{ for } i = 1, 2, 3, \dots, n \quad (9)$$

In polar form, $\boldsymbol{V_i} = V_i \llcorner \delta_i$; $\boldsymbol{V_i^*} = V_i \llcorner -\delta_i$; and $\boldsymbol{Y_{ik}} = Y_{ik} \llcorner \theta_{ik}$; where δ is the power angle and θ is the current-voltage phase angle.

Substituting the polar forms of V_i^*, Y_{ik}, and V_k in Equation (9); the real and the reactive power for a *static load flow network analysis* can be expressed respectively as;

$$P_i = V_i \sum_{k=1}^{n} V_k Y_{ik} \cos(\theta_{ik} + \delta_k - \delta_i)$$

$$Q_i = -V_i \sum_{k=1}^{n} V_k Y_{ik} \sin(\theta_{ik} + \delta_k - \delta_i)$$

INTEGRATING H&S REGULATIONS INTO GREEN BUILDING RATING TOOLS FOR MORE SUSTAINABLE OUTCOMES: THE CASE OF THE PEARL RATING SYSTEM (ESTIDAMA) ADOPTED IN ABU DHABI, UAE

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Abstract: Safety needs to be a visceral element of construction processes in order for them to succeed. In that context, the United Arab Emirates (UAE) makes use of Estidama as a tool for building design so as to measure practices relating to sustainable building via its Pearl Rating System. To that end, in essence, it shares some similarities with UK BREEAM measures. Against this backdrop, the current research will evaluate the potential for using Estidama as a tool for implementing systems with a view to track construction workers' health and safety (H&S). It has been pointed out that there needs to be greater appraisal when it comes to these systems within GCC nations and, on a larger level, draw linkages between cultural, socioeconomic, institutional, environments, political, and safety-related elements across construction sites owing to poor levels of understanding. Notably, meaningful comparisons of H&S statistical data could help drive enhanced performance; however, greater degrees of transparency must be ensured and the ability to secure valid information. A systematic literature forms the cornerstone of this research, and exploratory interviews are then undertaken with UAE-based construction professional staff. According to the findings, a lot of work needs to be done in order to enhance H&S performance. Governments need to demonstrate greater commitment towards enforcement, whereas the perception of legislation leaves a lot to be desired. Put simply, the prospect of implementing tools such as Estidama is not impervious to challenge. In a similar vein, questions must be asked about implementing H&S regulations with building green buildings under the same guidelines, methods and structures of green building rating tools systems.

Keywords: Construction., Estidama programme, environments, sustainability, worker H&S.

1. INTRODUCTION

A review of the definitions of 'sustainability' in the context of the construction industry is typically inclusive of terms linked to health and safety (H&S) regulation structures in the construction industry guaranteeing that engineering entities put in suitable efforts to acquire minimum expected standards associated with H&S (Gurzawska, Mäkinction, & Brey, 2017). However, only a holistic perspective that factors in the effect of immediate surroundings of the environment is known to impact sustainability. The current challenge on hand is to straddle between worker H&S and environmental considerations. It can be inferred that under the existing system, the linkage between institutional environments, social environments, political, cultural, and H&S in the construction industry needs to be understood better. Under the purview of sustainability, site engineering and design professionals design tasks for providing production facilities, to make best use of resources in a safe and correct manner, so as to lower any adverse environmental impacts (Farr, 2011).

The significance of this study is underpinned from the current level of inappropriate understanding and performance of H&S in the UAE construction industry. It is important not to view H&S issues as a regulatory burden since it provides construction firms with a plethora of benefits and opportunities. In fact, the construction phase necessitates the presence of a large number of work people whereas their presence is the maintenance phase till the point of demolition (see Table 1). Benefits imparted to a significant number of workers entails the reduction of construction phase risks, thereby minimising risks of legal actions and injuries while increasing productivity, which augurs well for the industry at large. Thus, there exists a strong relationship between the commitment to regulations on H&S and implementing sustainability rating tools.

Table 1: Expected numbers of Professionals, Designers and Site engineers, as opposed to the number of workers expected throughout project.

		Professional Staff	Operators Staff
Planning	• Idea generation • Targeting expectations • Programming for specific features • Project promotion and fundraising	1	0
Design	• Idea generation • Performance modeling and prediction • System selection and configuration • Design optimization	3	0
Construction	• Project planning • Construction implementation • Implementation monitoring • Documentation	2	4
O & M	• Market recognition • Operational decision making • Performance assessment • Retrofit/upgrade decisions	1	2
Demolition	• End-of-life planning • Implementation monitoring • Recycle	1	4

0 - Small or nothing 1 - Minimum 2 - Normal
3 - Maximum 4 - High

1.1 Integration of H&S Within Sustainability Definitions

The overarching objective of sustainability is to lower the impact on the environmental ecosystem whilst reducing the consumption of water, energy and hazardous materials; for this reason, the word has a special resonance with environment preservation. This theme gets echoed in several research studies which are inclusive of sustainability-related definitions, as detailed below:

- "When organizations choose to invest in spreading the message that it is possible to prevent all accidents, they are explicitly conveying that they are mindful of the safety and well-being of their employees. They also imply that work must only commence if credible development and progress has been made on sustainability. By reinforcing the significance of collective yet individual responsibility, as well as by encouraging employees to feel strongly about the longer-term goals of their organisations, it is possible to transform a vague concept into something meaningful" (Nair, 2014).
- "Matters typically coming under the domain of social sustainability such as human rights, H&S and labour laws are relatively less deciphered on account of the reduced attention elicited by them. Therefore, a myopic emphasis on one or certain elements of sustainability could lead to adverse negative effects, such as causing danger to workers due to the efforts stemming from the intention to lower environmental challenges or disharmony between environmental sustainability and social sustainability" (OSHA, 2016).
- "It is impossible companies to remain sustainable without ensuring the health and safety of their workers. In the current day and age, it may be possible to acknowledge health in sustainability strategies; however, its importance tends to be neglected. For this reason, the integration of health and safety into proactive and novel strategies provides organizations with a compelling opportunity to ensure company-wide sustainability" (Michaels & Henshaw, 2017).
- Back in the 1980's, the Brundtland Commission defined sustainability as follows: "it is a simple concept that can often be difficult to put into practice". In addition, it entails both corporate and character commitment for making sure that outcomes, outputs as well as benefits are sustainable throughout the entire duration of their creation and development (Borowy, 2013).
- "It is important to view sustainability as a holistic concept encompassing a number of elements such as governance, social justice for all, business guidelines, safety and wellbeing of employees, philanthropy and diversity. When viewed in this manner, it becomes evident that sustainability must be an indispensable element of the strategy of any company" (Hankinson, 2005).

The importance of sustainable development arises from a well-rounded awareness that indiscreet use of natural and human resources for the myopic goal of economic profit that disregard environmental considerations or social ethics is becoming increasingly untenable. Therefore, not addressing H&S in planning stages is at variance with a calibrated strategic intervention about risk management, because nipping risks in the bud is the best way of dealing it, as opposed to indiscriminate use of non-renewable resources.

1.2 The Paradigm Transfer Need and Importance

The Abu Dhabi Urban Planning Council (UPC), which has taken a leadership position in enforcing the Estidama rating system of sustainable design, promulgates the globalization of environmentally-friendly construction practices, which was evidenced when it launched the Pearl Rating System (PRS) back in 2010. Due to the system's local promotion, it is important to revisit pre-existing assumption related to the H&S programs of construction workers in the UAE. In order to smoothly apply this concept in the nation's construction sector, this paper endeavours to undertake the development of a sustainable H&S (construction-related) as a mandatory requirement category in the rating tool system. This system would be unique in that it would imbibe elements of health and safety to ensure sustainable health of workers on all projects. In addition, it will facilitate projects' rating based on the significance accorded to the on-ground application of elements that promulgate H&S of workers (DPM Abu Dhabi, 2019). Despite the fact that a number of nations have reinforced their commitment towards creating an injury-proof work ecosystem across projects, there is an abject paucity of any recognition of companies (such as H&S certification), which have an exemplary track record in lowering workplace injuries and fatalities. It is possible to use this system as part of the Estidama program for rating projects depending on team members' commitment to H&S. Given that it would take the collective effort of members to make this rating system a success, improved team coordination would also be a related advantage that could make a useful contribution towards the achievement of this common objective in the construction sector.

Due to the fact that concepts of sustainability deal with social, environmental and financial betterment of the society at large, taking the H&S of workers who remain an integral aspect of the life-cycle of buildings will go a long way in fructifying the seemingly elusive goal of implementing green buildings at a large scale. This concept is also useful in that it would help offset these green buildings' negative consequences. The concept of sustainable H&S is emerging as an efficacious strategy to improve the performance and safety of workers because it takes a holistic perspective of construction workers' economic and social well-being. Worker H&S meaning and issues entail disseminating ideas pertaining to sustainable principles. Via the procedure of certification (Quinn & Dalton, 2009), Estidama proactively encourages a well-rounded understanding of environmental systems of sustainability competition, construction sites, and promulgation of green building results. In this context, the current study also examines this element's inclusion to all sustainable building rating structures. Potentially, estimate rating tools can be used across all phases of construction projects. To that end, scaling the protection as well as renovation of workers' H&S during the process of construction must be encompassed, in which cases there is a need to change strategies for evaluating H&S.

The UAE Urban Planning Council (UPC) strategy stresses the need to develop an overarching culture of sustainable safety premised on a number of pillars which help ensure the growth and development of the construction industry, and which is also consistent with the UAE Vision 2030 (Madden, 2010). The benefit of the Estidama system is its ability to meet international standards in sustainable information technology, which then contributes to the attainment of digital records and undertakes the development of practices that are needed to achieve the highest standards of worker H&S, all whilst implementing best practice specific to the construction sector's efficiency and effectiveness. To that end, commitment to occupational H&S and associated quality practices assumes significance for enhancing efficiency and contributing towards long-term progress (Estidama, 2016).

1.3 Existing Worker Protection and H&S Regulations in UAE

Currently, UAE-based stakeholders in the construction sector are unable to adhere to provisions of H&S. Despite the presence of well-defined obligations that these stakeholders are expected to comply with, they face problems in collating several aspects of guidelines, orders, regulations and legislation, as well as implementing them consistently. Thus, they are unable to recognize origins and ramifications of violations. According to stakeholders, there are as many as 170 divergent guidelines, orders and regulations regarding H&S in the nation; furthermore, each of them have their unique contours that are dissimilar to one another, which poses a challenge in collective implementation to avoid causing property damage or personal injury (Alali, 2016).

In the UAE, the legal system of HSE is mainly sourced from the following verdicts and laws (Paul, 2017):
Federal Law No (24) to protect and development the environment (1999);
Amended Federal Law No. (8) UAE Labour Law (1980);
Ministerial Decision No. (27/1) regarding remote areas (1981);
Ministerial Decision No. (4/1) relating to hazardous works (1981);
Ministerial Decision No. (32) related to methods of employee protection (1982);
Ministerial Decision No. (37/2) regarding quality of medical care concerning Employees (1982).

It is notable that there is no single legislation at the local or federal level that is specifically related to H&S in the UAE. In contrast, several laws are known to impact H&S, albeit often without outlining compliance standards of technical aspects. Despite the fact that Codes are yet to be drafted into law on a former level, it suggests that individuals are playing their part in making incremental improvements in this matter. However, owing to the discrepancy in H&S norms between the government and several stakeholders operating in the sector, there is a consensus that the time has come to specify a comprehensive set of legally enforceable provisions nationwide (McGeehan & Keane, 2008).

The UAE currently implements a two-tiered system. This includes local laws that are restricted to the Emirate where they get enforced; and federal laws, which are applicable to all Emirates (seven of them). However, single legislation is specifically aimed at H&S in the construction industry. To make matters worse, occupational regulations on H&S differ radically Emirate-wise, which leads to nebulousness. “Abu Dhabi and Dubai-based municipalities do implement a set of concise guidelines that are obligatory across all worksites. However, no details are shared at the federal level” (George, 2009). According to Schuster, companies would find it better to operate under a single entity.

At an official level, the Ministry of Labour is entrusted with the responsibility of implementing law on H&S. However, the fact remains that the police ends up probing accidents that occur on construction sides and it is they who take important decisions on prosecution. In addition to the fact that they lack training or experience in handing such cases, the involvement of police is viewed as a defensive mechanism to address the problem as opposed to a cooperative, proactive one.

1.4 The Existing Rating Tools System Estidama Pearl Rating (PRS)

In the past few decades, Abu Dhabi has witnessed a commendable transformation on the cultural, social and economic front, which is why it is not at par at some of the most well-developed cities worldwide that are also known for their openness towards innovation, foreign investment and diversity (Estidama, 2016). Abu Dhabi Vision 2030 emerged with the aim to achieve economic diversification as well as develop into an integrated capital without comprising on sustainable infrastructure at any level. This approach, in turn, enables people to enjoy a quality lifestyle by availing the best possible services, particularly in the domain of energy, health, transport and education, among others. Arguably, the most notable aspect of Abu Dhabi's commitment to achieving sustainability at all levels is the earnest desire on the part of all private and public-sector institutions to take proactive measures and do all that they can to achieve sustainability and continue to inspire one and all through their relentless emphasis on innovation. In this regard, their ability to contribute towards preserving natural resources for the future has also drawn praises for its holistic approach towards sustainable growths.

In 2010, the UPC (Abu Dhabi Urban Planning Council) launched 1,672 projects that were then assessed in 2018. The residential property's total area is a massive 22,124,089 square meters that occupies 1,728 buildings in addition to16,446 villas. Requirements of Estidama compliance are estimated to have lowered energy and water consumption by 55% and 45%, respectively, when it comes to new developments. At the same time, upwards of 1,900 urban planning specialists have been imparted training to implement the Estidama Pearl Rating System, as a result of which, they are now known as certified experts in implementing projects relating to urban development. The Council is also estimated to have delivered a series of training workshops on the Pearl Sustainability Assessment Program, wherein it trained as many as 13,000 people via 459 targeted training courses (UPC, 2016). The organization of the Pearl Rating System into seven categories has sharpened its focus towards ensuring sustainable development in Abu Dhabi (see Figure 1).

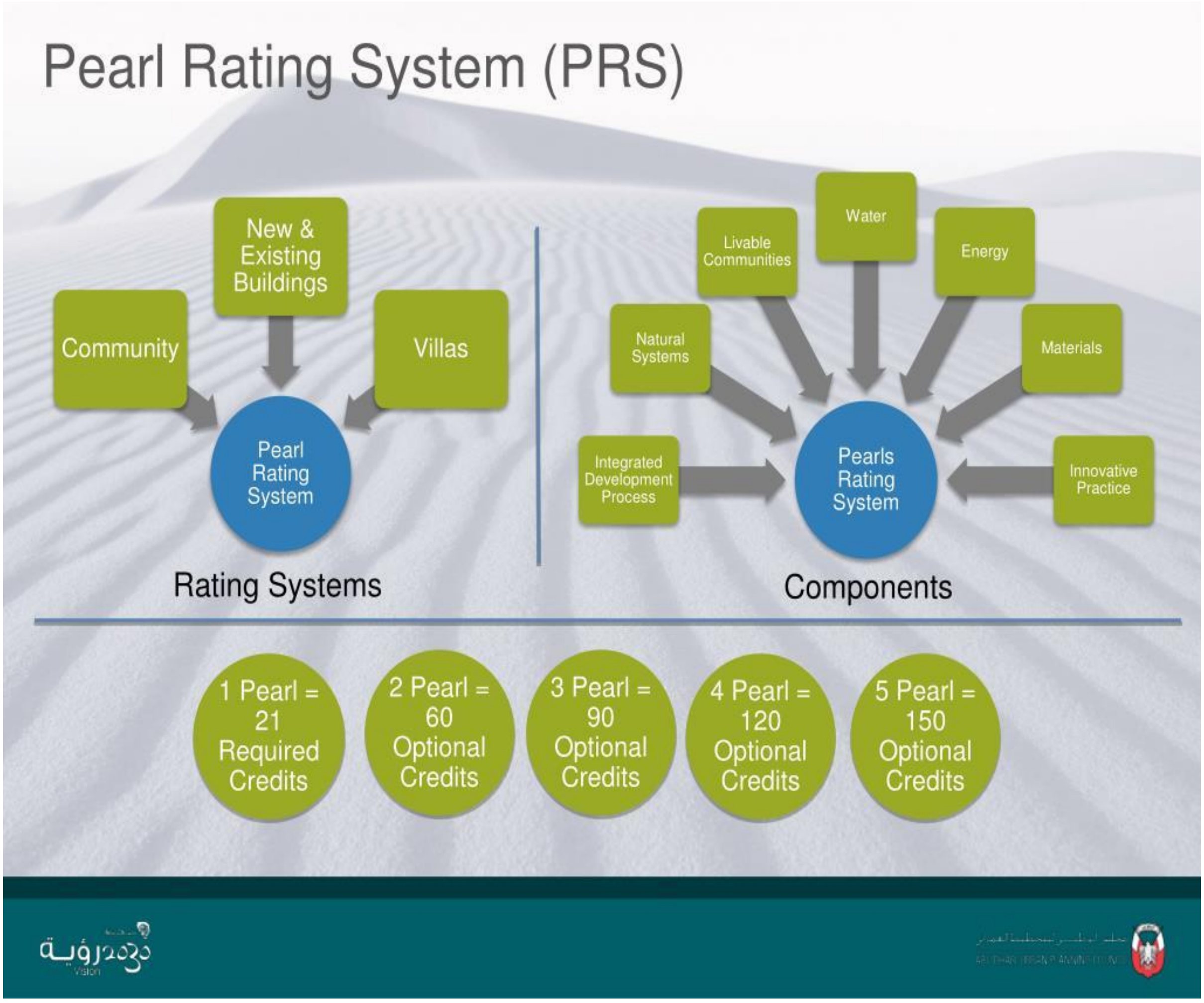

Figure 1: Abu Dhabi Urban Planning Council (UPC). Estidama Initiative. A mandated policy to create a new sustainable framework (PPT, 2019)

2. RESPONSIBILITY (AVOIDED LIABILITY CLAIMS BY HELPING TO AVERT INJURIES).

Companies as well as their shareholders tend to face many problems when reporting H&S. This is primarily due to the absence of an acceptable standards based on which information can be reported. In addition, some opine that reports pertaining to corporate social responsibility (CSR) as one feasible area of meaningful engagement. Some people may be apprehensive of stet integrating H&S into rating tools systems with green building will impose additional burden on all parties concerned. However, if integration does actually take place, the rationale for these concerns seems a little unreasonable. There is no precedent about anything in the past that suggests that this is likely to transpire. There are those who opine that addressing H&S as a vital element of green building rating systems would make people more accountable for workers' H&S. However, thus far, no linkage has been established between companies and stakeholders in an efficacious manner to that effect. Another predicament in this regard is the misalignment in the perspectives of companies sand their designers. In fact, several professions rue the fact that some firms refrain from maintaining transparency relating to their H&S-related operations. Similar problems have been observed during construction phases on many sites. Considering the number of cases that are being dragged into legal systems, it is evident that there is hardly any consensus between corporations and designers. In fact, it is pointed out that the best way to avoid responsibility is to evade accidents altogether, which is not a practical approach (Gambatese, 1998).

This clearly suggests that the focus must be to include workers actively in the sustainability goals of all organisations. Often, H&S responsibility is viewed as a necessary stepping stone towards sustainable development, which is why people are increasingly expecting companies to collectively work towards minimising negative ramifications on society. In this regard, the movement of green building rating tools can be immensely helpful in helping transmit relevant knowledge while enhancing trust and awareness about implementing H&S at a large scale to encompass a sizeable population (see Figure 2). This appears to be an effective and holistic approach towards implementing green construction in particular, and sustainability in general. Issuance of certificates on companies' H&S performance within green building rating tools is an important first step towards solving the pain points of civil society and consequently, helping facilitate a better understanding between communities and companies. Issuing certificates also allows organisations to feel encouraged to engage in environmental matters. Especially for developing nations, accountability and transparency in corporate risk management systems can encourage governments to formulate an effective way of dealing with implementation in the public and private sectors.

Figure 2: Green Building rating tools can be beneficial in helping construction H&S

2.1 Integrating Welfare of Workers on Construction Sites Within Rating Tool Systems

Sustainability is one of the most important concepts when it comes to green buildings. It has largely focused on combining resources in built ecosystem energy systems for the purpose of producing or installing materials. To that end, it would not be farfetched to say that construction workers must be regarded as the most significant component of the construction process because the entire premise of the industry depends on them. However, construction practices can have a wide range of impacts (direct and indirect) on their health. This is due to the fact that several toxic substances are frequently found on sites, such as pesticides, paints, adhesives, solvents and insulating ingredients. Moreover, in the absence of careful handling, emissions from such materials can volatize around construction sites, some of which are very dangerous for the health of workers and the lay public. This is a serious issue as injuries caused to construction workers were until recently considered to be an acceptable aspect of construction activities.

The overarching theme of sustainability can be succinctly described as diluting the effect of the built ecosystem on the natural environment, and making improvements in the efficacy of buildings to ensure a relevant, high quality life for future generations. However, there is a worrying but pervasive perception that it is inevitable for some workers to lose their lives during the construction of projects. A comprehensive evaluation of the number of fatalities and injuries in the sector reveal that the number is unacceptably high and that a lot more needs to be done to make tangible enhancements. No matter what, fatalities cannot be accepted as an inevitable eventuality and there is a dire need to bring about a mindset change to bring about long-term improvements. When designing construction projects, an endeavour must be to ensure no injuries.

Within that context, green buildings take into consideration respect for human life and other natural facets of life, which inexorably involves prioritizing designs that mitigate or minimize the negative impact of humans on natural resources and materials, not to mention the ramifications on worker’s lives. The development of the Green Building and Sustainability Movement can proceed further by adopting a no-comprising attitude towards H&S when it comes to construction workers. This is an aspect that has been neglected for a long period of time, but is a vital element of the construction process that deserves utmost importance. By doing so, it will increase the inclusiveness of sustainability and bolster projects that are able to meet criteria of sustainability by attaching importance to the safety of construction workers as a non-negotiable aspect of environmental conservation. The redesign of sustainable construction H&S should include the integration of design and evaluation of construction processes.

2.2 Estidama Certification Containing the H&S of Construction Workers

A lot of work must be done to develop a sustainable H&S assessment system to implement this concept in the construction industry (Marhani, Jaapar, & Bari, 2012). This classification, in turn, includes aspects of H&S that are necessary to maintain workers' H&S depending on the project they are a part of. The construction process involves a number of parties: architects, owners, subcontractors, engineers, contractors, and suppliers, amongst others. The creation of Estidama was intended to improve the quality of green buildings by setting standards of estimation and measurement. More precisely, Estidama aims to attain three basic objectives: (a) respecting the nuances of evolution without compromising natural resources or impacting future generations, (b) involving all parties during the construction process from design to delivery, and (c) exchanging ideas on developing and educating sustainable principles (Al Abbadi, 2015). The concept relating to the H&S concerns of construction workers comes under the mission of Estidama to develop principles of sustainability. By issuing certificates, the Estidama system encourages green competition, promulgates practices of integrated design, takes cognizance of environmental leadership and enhances awareness about advantages of green buildings. Seemingly, construction workers' H&S are integrated into the green construction and sustainability movement, and it is necessary to include this topic as a major requirement for implementation and is not optional as part of the Estidama certification standards, Estidama currently offers core credits which can be sent for clearance during phases of project submission, which in turn, address concerns that may have been left out by its guidelines and facilitates creativity.

It is proposed Estidama will be divided into many elements based on a combination of core credits in these categories to derive the projects' overall credit score the project, which is inclusive of several initiatives, including H&S. In turn, this results in the postulation of a classification system, as per which a higher number of total points (and Pearls) garnered by projects will indicate a lower likelihood of accidents on account of fewer risks. There will be several facets of sustainable H&S that form part of the classification system: this includes professionals, industry experts and literature specialists, among others. This assessment in turn helps maintain construction workers' H&S. It will coordinate the efforts of different parties in their participations in projects (see Figure 3).

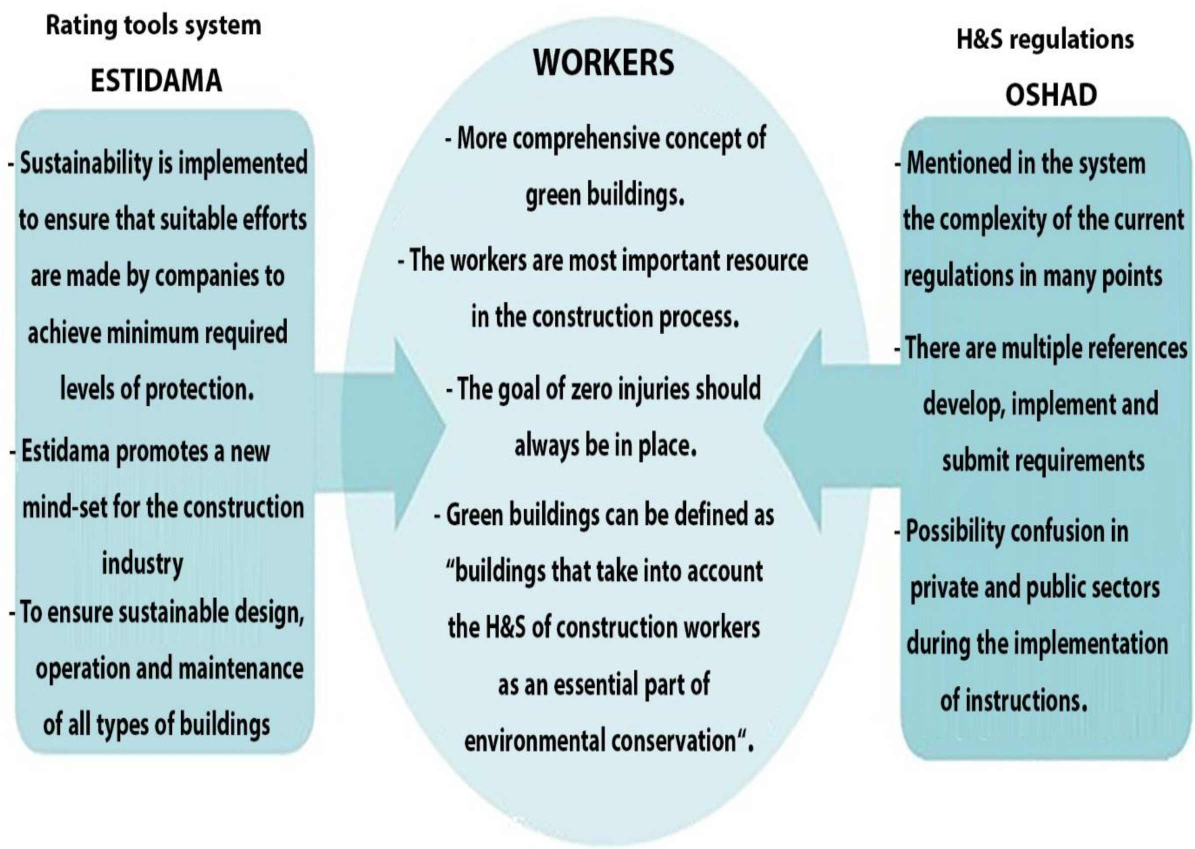

Figure 3: Figure showing positive points in the case of integrate

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2.3 The Role of Estidama Rating Tools System in Affecting the Safety of Construction Sites

According to Behm (2005), designers have a major role to play in determining building safety. In 1991, the European Foundation for the Improvement of Living and Working Conditions observed that about 60% of accidents (that turn fatal) in the construction sector are attributed to decisions made prior to the commencement of work on site. A study concerning the UK's construction sector in 1994 suggested a causal linkage between safe construction and decisions on designs. Behm referred to the works of Szympersky while outlining his findings. It was revealed that the best time for improving a building's safety is during the stage of ideating and designing. This is because the ability of influencing safety lowers as time goes by. Integration of Estidama and H&S denotes a formal system of undertaking risk analysis prior to commencing the design of buildings which starts with identifying risks. Meanwhile the design pyramid procedures commence by eradicating hazards via the conduit of design engineering upon the integration of H&S as a very important aspect of the Estidama rating tools system. If it is not possible to eliminate risks through design engineering or minimizing them introducing the H&S warnings, instructions, training and device tools, are considered to be the last resort, which is typically traditional and late (Lingard, 2013).

Traditionally, design specialists have been responsible for designing buildings or conceptualising structures which adhere to acceptable engineering practices that are deemed safe for the general public. Construction workers' safety is typically considered to be the responsibility of contractors. Nevertheless, the importance of Estidama rating tools system lies in the fact that it can enhance buildings' safety by making improved choices at the planning/design phases of projects. In turn, this would lead to fewer decisions that must be made by workers and contractors, which, in turn results in fewer accidents. It is important for the methodology of examining H&S to change for its inclusion in the criteria of Estidama certification. To that end, a conventional method to measure a project's safety performance is by ascertaining the number of injuries sustained for as many as 200,000 hours of exposure of workers (Hallowell, et al. 2013). However, this step would be unsuitable for Estidama certification, since it is paramount to establish criteria before beginning the construction. For this reason, a new approach is necessitated.

3. SUMMARY AND CONCLUSIONS

A key question to ask is whether or not Estidama must include H&S as an indicator of projects' sustainability. Given the lack of difference in terms of H&S performance, Estidama projects are unlikely to be sustainable when it comes to H&S, despite being environmentally compliant. Since occupants' safety is given due consideration in Estidama, proper attention must be paid to the welfare and H&S of construction workers for projects to be classified as sustainable. Research into the linkage between sustainable construction and workers' H&S is suggestive that the environment is accorded a higher priority than the H&S of construction workers. The National Institute of Occupational Safety and Health, National Institute of Occupational Safety and Health, Atlanta has initiated a new measure called `Prevention through Design` (Rajendran, Gambatese, & Behm, 2009).

H&S of construction workers should be fully integrated into existing sustainability rating tools systems such as Estidama, such that it is prominent in public awareness and behaviour. It is no longer acceptable to marginalize and neglect this all-important element. It is a known fact that construction workers are the most important resource used for building and developing facilities, which explains why their H&S must be guaranteed at all times. As a matter of fact, it must be the number one priority of all sustainable projects which aim to be taken seriously. The subsequent step entails examining the viability of a project through well-calibrated data gathering and analysis. In this regard, the proposed methodology involves the use of questionnaires as well as interviews with stakeholders, such as engineers and other professionals who are in possession of the Estidama certificate. Based on various research which failed to prove the success of existing H&S applications, it can be inferred that proper planning and integration of H&S into the Estidama program can yield the best results only when it is made mandatory for all projects.

- According to evidence of statistically important extant literature, green building projects are more dangerous for workers than their conventional counterparts (Dewlaney & Hallowell, 2012). Meanwhile, a study from Hwang et al (2017) pointed out a higher risk was posed to workers taking part in LEED projects owing to several roofing construction activities. Additionally, workers taking part in LEED construction projects were said to confront 36% more strains, wounds as well as sprains caused the recycling of materials related to construction, including solar panel; similarly, a 19% surge was observed in eye strain during the installation of reflective roof membranes, and a 14% higher exposure to hazardous substances during the installation of novel wastewater technologies (Walter & Ron, 2011). This gives an insight into the type of construction projects receiving the Estidama certification, which resulted in a higher number of registered injuries as compared to their non-Estidama counterparts.

- The predicament of multiple sources and discrepancies in health and safety laws in each Emirate is a serious issue. However, it can be obviated by unifying into one source of clarity and transparency of incident reports. In turn, this plays an important role in lowering the extent of damage to equipment, human lives, and other tools and paves the way for better morale and reputation for everyone involved in projects. By integrating H&S regulations into the Estidama program, it will be considered to be strongly enforceable across all construction sites.
- Through close association with all relevant stakeholders, Estidama has already transformed the mindset as well as enforcement practices as far as the construction industry is concerned (Kaftangui & Mohamed, 2015). When the H&S of workers becomes a key element of Estidama categories, it is possible to make sure that its enforced properly and it will increase awareness of their overall significance.
- A key justification of imbibing H&S into green building rating tools is to ensure greater transparency. In the absence of transparency, monitoring and implementing H&S on the part of clients becomes difficult. The problem of a lack of transparency in construction planning and control leads to communication issues on-site, poor process orientation and high levels of risk. The integration improves process transparency by making information related to system-wide processes more readily available to project participants. This enables them to foresee problems in a timely manner and to take necessary measures to resolve them or to adapt processes to current circumstances (Brady, B & et al 2019).

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SUSTAINABLE CONSTRUCTION AND SUSTAINABILITY EXPERTISE – UNDERLYING CONCEPTS: GETTING THE BALANCE RIGHT

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Abstract: There is a huge discussion on sustainability in literature and in practice but a disparity has been found between construction professionals' understanding of sustainability and how their perceptions of it are translated into practice. Having the requisite sustainability expertise/competencies have been posited to be a way to help bridge this gap. Using a literature review, this paper presents a discussion around what true sustainability is and how sustainability expertise can help achieve more sustainable outcomes in the Built Environment (BE). Sustainable development calls for people skilled at understanding and employing sustainability principles and concepts and thus, efforts to achieve more sustainable outcomes require an examination of the competencies of these technical personnel. This paper examines the very concepts of sustainability and what it is for the case of the BE. Some findings emerging from this research include achieving the right balance among the concepts of sustainability which governs three main pillars; environment, social and economy. True sustainability is not the attainment of any of these concepts in isolation but one that addresses all of these three fundamental pillars of sustainability at the same time.

Keywords: Built Environment, concepts, sustainability, sustainable construction, sustainability expertise.

1. INTRODUCTION

The mounting global concern for the negative impacts of human activities on the environment, climate change and sustainability in recent years has caused many industrial sectors to steer towards sustainable development (Bickel, 2013; Hwan and Ng, 2013) with sustainable construction seen as a way for the Built Environment to contribute to the effort to achieve sustainable development (Abidin, 2010). The BE is responsible for a large amount of the world's energy consumption and substantial carbon dioxide emissions, which plays a huge role in climate change (Yudelson, 2007). Sustainable construction is a way to mitigate these negative impacts on the environment. Despite the benefits sustainable construction presents, research has shown that clear gaps exist between predicted and actual performance (Lokman et al. 2017; Ng and Akasah, 2013). The aim of this paper, in an attempt to help bridge this research gap, explains what the right balance among the three fundamental concepts of sustainability is, which is termed as 'true sustainability' by this research taking place at the Technological University Dublin and how sustainability expertise can help.

2. RESEARCH METHODOLOGY AND METHOD

This study adopts a conceptual type of traditional literature review as its method. A traditional literature review presents summary of published research related to a particular topic of interest without a prescribed methodology in a way that contributes to a better understanding of issues (Gough et al., 2012; Jesson et al., 2011) which according to Jesson et al. (2011) can be considered a research method in its own right.

Traditional reviews are usually based on a personal selection of materials where the researcher believes that the original authors have some important contribution to current knowledge. What the researchers of traditional review do is to weave those contributions together in a logical way to tell a story or develop an argument which mostly provide useful insights that can be neglected in the steps towards exclusion and quality control that are required in the systematic review model. This notwithstanding, there may be great insight and knowledge transferred in both a traditional review and a systematic review (Jesson et al., 2011).

3. LITERATURE REVIEW

3.1 Background

As the built environment steers towards sustainable development, construction practitioners are confronted with new issues and must undertake roles that have not traditionally been part of their responsibility. The knowledge, skills and competencies of construction practitioners need to be supplemented to address sustainability (Hwang and Ng, 2013). Every built environment stakeholder with a focus on practitioners has a role to play in addressing sustainability. With the gap between predicted and actual sustainability performances, an investigation into what expertise or competencies built environment practitioners should have to achieve more sustainable outcomes to offset the general believe in sustainable construction amidst unsustainable results will help.

Several barriers have been identified by research to be hindering sustainable construction. Amongst them are the high initial cost of green products and the lack of interest from clients and developers. However, a significant barrier found is the lack of sustainability expertise. According to Brand and Karvonen (2007), sustainable development calls for people skilled at understanding and employing sustainability principles and concepts and thus, efforts to achieve more sustainable outcomes require an examination of the competencies of these technical personnel (Brand and Karvonen, 2007). Addis et al. (2016) emphasise that excellent performance is underpinned by expertise and plays a central role in a successful construction practice. That means if the Architecture, Engineering and Construction (AEC) practitioners do not have the requisite sustainability expertise, the efforts of the BE to achieving more sustainable outcomes will not be realized. There is a huge gap in literature and in practice as regarding what expertise AEC practitioners should have to address sustainability. Several studies such as (Jaafar et al., 2015; Dogbegah et al., 2011; Chen et al., 2008) have looked at competencies of construction practitioners but few have specifically examined in the context of addressing sustainability (Lokman et al. 2017; Hwang and Ng, 2013); hence a need for it in global industry and in literature. There is a clear need therefore to delve into the sustainability expertise of the AEC practitioners knowing the indispensable role they play in addressing sustainability issues in the AEC sector.

3.2 Sustainability Awareness in the Built Environment

There is a general awareness of sustainability issues in the AEC sector and among built environment practitioners, however there is little clarity as to what competencies facilitate the delivery of sustainable outcomes (Bickell, 2013). It is important for construction practitioners to understand sustainable construction sufficiently to be able to ensure that their individual actions, and the decisions they make that influence the actions of others, add as little as possible to the total burden on the environment (Bickell, 2013; Parkin, 2000). As stated by Ashley et al. (2003), a widespread agreement on sustainable construction does not mean a widespread implementation. Although many construction practitioners agreed with sustainability principles, many have still not grasped their meaning and even fewer have translated sustainability into action. The lack of clarity into what knowledge, skills and roles of AEC practitioners will address sustainability will in turn hinder people's ability to identify and acquire the skills they need to deliver sustainability solutions (Bickell, 2013).

3.3 Sustainability and Sustainable Construction – Underlying Concepts and Principles

Several actors in society have acknowledged that we are facing a global sustainability crisis that is likely to have major negative impacts on the natural, social and economic foundations of society. The global demand for ecosystem services is beyond what the planet can provide, and human activities in various domains are on the verge of profoundly altering the underlying earth systems (OECD, 2012). United Nations announced 17 Sustainable Development Goals (SDGs) in September 2015 by including no hunger, quality education and health, clean energy and economic growth, sustainable cities and communities, climate action, responsible consumption and production, and life on land (UN, 2015).

The awareness and knowledge of the individuals' roles in addressing sustainability is important. Although stakeholders agree to the need and relevance of sustainability in the AEC sector, they often ranked the involvement of government agencies in addressing sustainability issues with higher priority (Shi et al., 2013). The China Environmental Awareness Program (CEAP) report also revealed that the public perceived that responsibility for environmental protection belonged to local government and authorities (CEAP, 2007). According to Abidin (2010), the pace towards addressing sustainability in the construction sector will depend on knowledge and consciousness of individual actions and roles. There is a clear need therefore to delve into the sustainability expertise of the AEC practitioners knowing the indispensable role they play in addressing sustainability issues in the AEC sector.

Shi et al. (2013) in their study into critical factors for green construction identified ambiguity in the concept of sustainable construction by practitioners. The concept of sustainable construction governs three main pillars: environmental protection, social well-being and economic prosperity (Abidin, 2010; Brownhill and Rao, 2002; Addis and Talbot, 2001; Brundtland, 1987). This mirrors the study of Abidin (2010), which found practitioners understanding of sustainable construction to be mainly about protecting the environment. Many are still unaware that sustainability truly is about balancing environmental, social and economic aspects of construction. Achieving the right balance between these factors is what supports true sustainability. Hansmann (2010) writing about the development of sustainable education argued that sustainability literacy is key for professionals to recognise their role in its delivery and then to provide a stimulus for acquiring the necessary skills and appreciation of new technologies and techniques. Unless professionals are sufficiently literate in the holistic nature of its principles, view it through a multidisciplinary lens and can relate to its often specific language, they are going to struggle to be able to reflect on its implications for their own role within construction practice (Higham and Thomson, 2015). Schemes such as BREEAM play a significant role in raising sustainability profile and performance within the industry but that through its often prescriptive and checklist format that, it has been argued, fails to educate professionals beyond compliance (Fortune, 2008) as cited in Higham and Thomson (2015).

3.4 Getting the Balance Right – Fundamental Pillars of Sustainability

It is important to recognize that in order to implement sustainability measures we need to understand what knowledge and skills are required to achieve this. Different levels of knowledge and skills set will be required of different people in sustainability, however, a general awareness and understanding of the main themes of sustainability can help strengthen our attitudes towards the subject (Bickell, 2013; Abidan, 2010). It is vital for construction practitioners to have a sufficient understanding of the concept of sustainability to ensure that individual actions foster sustainability in the AEC sector (Parkin, 2000).

The concept of sustainable construction governs three main pillars: environmental protection, social well-being and economic prosperity (Abidin, 2010; Brownhill and Rao, 2002; Addis and Talbot, 2001; Brundtland, 1987), although other dimensions exist. Economic, social, and environmental dimensions are accepted as the “three pillars” model of sustainability to formulate methods of sustainable development (Dogruyol and Arayici, 2018; Eizenberg and Jabareen, 2017).

3.4.1 True Sustainability – Striking the Balance

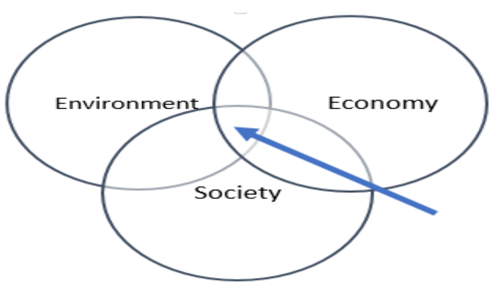

Figure 1: Diagram showing what true sustainability is.

Imagine a world where humans are not allowed to build, this may be good for environmental sustainability but society will probably not be able to function (social sustainability). True sustainability is not the attainment of any of these concepts in isolation but one that addresses all of these three fundamental pillars of sustainability at the same time (Barbier, 1987 as cited in Twumasi and Scott, 2018).

According to Barbie (1987), sustainability is about balance. The three sustainability key areas: 'Economic Sustainability', 'Social Sustainability' and 'Environmental Sustainability' should all be factored into consideration in the attainment of a single objective. It is about striking this right balance, which is described by this study as true sustainability. If we just focus on getting one circle right and do not think about how they affect each other we will not find the spot in the middle and will hence not create a sustainable outcome (see figure 1). Sustainable development isn't outstanding environmental performance at the cost of a company which goes out of business, nor is it outstanding financial performance at the cost of adverse effects on the local environment and communities. A sustainable approach is a balanced approach.

4. DISCUSSION

"I used to think that top environmental problems were biodiversity loss, ecosystem collapse and climate change. I thought that thirty years of good science could address these problems. I was wrong. The top environmental problems are selfishness, greed and apathy, and to deal with these we need a cultural and spiritual transformation. And we scientists don't know how to do that."

—James Gustave Speth, US advisor on climate change

"But astronomers will agree that since we are here, and know that we are here, we have important responsibilities to our planet, such as not destroying our atmosphere or depleting the available oxygen or polluting the oceans. They will agree that human greed, ignorance, and indifference are a greater threat to the planet than comets." —Neil Postman, media ecologist

The above two quotes aim to identify a common ground on how to provide a safe earth for future generations towards the achievement of sustainable development goals and the reason these quotes were chosen by this study is the human element required in addressing sustainability problems which is an ongoing PhD research investigating what role sustainability expertise can help . With respect, it is true that "selfishness, greed, and apathy" are major problems to be overcome to prevent future environmental catastrophes from materializing, which is not to say also that major environmental problems aren't biodiversity loss, ecosystem collapse and climate change. In minimizing the impending disaster of climate change, the question is not about avoidance, but how the impacts or effects of climate change on mankind can be reduced with this paper focusing on getting the balance right from the very concepts of sustainability principles. Logan (2018) believes that global warming and climate change is as much a threat to human survival on this planet as is the possibility of nuclear war. This study is also a step in the right direction for Ireland's built environment sector considering the shortage of skilled personnel in the sector as a result of its emergence from the depths of recession. Construction industry plays an important role in the economy of a country (Towey 2012) and outlooks reported by the Construction Industry Federation (CIF) Ireland, show pointers of significant growth for the AEC sector in Ireland; 'the construction industry has emerged from the depths of the recession in good shape but significant improvements are required to help the sector grow' (CIF, 2018).

This study also agrees with the study by Adidan (2010) which identified seven statements that best describes and encapsulate the concept of sustainable construction listed below.

Protection of the environment
Environmental planning, management and control
Prudent use of natural resources
Generating profit without compromising future needs
Maintaining economic growth
Customer satisfaction
Social progress for everyone

These seven statements is seen to be an outstanding breakdown of the three fundamental pillars of sustainability and hence when these statements are considered in sustainability goals, one would basically be on the right path towards a true sustainability attainment.

5. CONCLUSION

Research has shown how relevant the role expertise has in addressing a more sustainable AEC/BE sector. With the AEC sector employing the use of expertise at various levels with much intensity and in unique situations, a call for people skilled at understanding and employing sustainability principles/concepts and equipped with the requisite sustainability expertise is indispensable. With the lack of sustainability expertise identified by this research to be hampering the achievement of sustainable outcomes in the built environment, recognised and accredited construction sustainability performance is a key requisite which will help in maintaining a healthy built environment and will lead towards sustainable development. In the accomplishment of SDGs, the stakeholders implementing sustainable construction practices are key to a sustainable construction sector. The three dimensions of sustainable development called (economic, social and environment) cannot be approached without sustainability expertise. Any serious effort to thus achieve sustainable development and sustainable construction will need stakeholders who are equipped with the requisite sustainability competencies.

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SUSTAINABLE CONSTRUCTION IN WAR ZONES: PALESTINE AS A CASE STUDY

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Abstract: Palestinian construction sector suffers from prolonged conflict and numerous restrictions imposed by Israeli occupation; international funds have been focusing on sustainability, but it is not achieved yet. The aim of this paper is to appraise reconstruction in war zones, taking Palestine as a case study, it will discuss the political situation and its impact on construction sector in Palestine, it also attempts to prioritise procedures and tasks involved in reconstruction, trying to set a suitable framework for sustainable construction and trigger sustainability out of war rubble.

Collecting information about sustainable construction in conflict zones is challenging, since valid data is difficult to find. The main data collection instruments are a literature review and a group discussion, with ten construction professionals in Palestine. The debate structure was founded on issues in the literature; data reliability was also supported by interviewing five Palestinian experts in construction and an authoritative figure on green building in Palestine. Participants agreed that issues described in literature are applicable in the context of Palestine. Accordingly, a list of consequences of how war affected the construction industry in Palestine was agreed on, and how they hindered the development of sustainable construction. Methods both on private and public levels were discussed, which aim to create buildings to last, by designing structures that could stand against strikes; thus, using destruction to reconstruct in the right way. Sustainable construction in Palestine should be focusing on high resilience buildings and providing affordable homes. Socio-economic development and planning are needed as post-conflict countries suffer from destruction, poverty and lack of access to basic needs. It is recommended to build stronger institutions and municipal systems for cities to be able to anticipate, endure and rebound from crisis situations.

Keywords: Conflict zones, construction, Palestine, Palestinian construction, sustainable construction.

1. INTRODUCTION

The history of mankind consists of successive, endless armed conflicts; wars damage, reshape and change the social and physical fabric and urban design of cities (Hasic, 2004). On the one hand, it is difficult to prioritise sustainable construction practice in circumstances where day-to-day personal security is paramount, but on the other, it is particularly important to use carefully limited resources, such as water and energy, the Palestinian economy needs to have both a medium and long-term vision to support its needs (United Nations Conference on Trade and Development, UNCTAD, 2004). Although Palestine has a unique set of circumstances, comparisons with political conflicts in other countries are possible. In this context, the research questions that arise are ‘in which ways can the reconstruction process in post-conflict areas be improved to fulfil the needs of communities, and, at the same time, contribute to long-term stability and sustainability?’ and ‘which designs best fit culturally and socially in such communities?’

The misfortunes of war are often accompanied by misfortunes in reconstruction, usually neglecting sustainability prospects. Procedures, specifications and designs for reconstruction after war are often imposed by international communities that provide funds (Hasic, 2004). Some funds may serve political agenda, and, in the case of Palestine in return for aid, conditions have been imposed by many governments, using aid as a tool to achieve political ends (Oxfam, 2009). Unfortunately, there is no guarantee that objectives of donors harmonise with those of recipients in the short, medium or even long-term (UN, 2004). According to statistics from the Palestinian Monetary Authority, during the period 2000-2013, the total donation and assistance to the Palestinian Authority (PA) amounted to $14 billion, but clearly these donations were used as a tool to gain benefits (Saleh, 2015). In addition, there has been a lack of accurate need assessments when dealing with emergency circumstances, and there have been limitations imposed by Israel that have prevented sustainable development in Palestinian territories.

According to Panic (2005) "There have been more than one hundred and forty civil wars since 1945. Estimates put the number of casualties at around 20 million, with 67 million people displaced". In the case of Palestine, beside causalities and losses at all levels, Israeli occupation caused severe destruction for the built environment in Palestine, Table 1 shows the number of damaged buildings in the Palestinian Territories up to 2016.

Table 1: Destruction by the Israeli army in the Palestinian Territories. Source (PCBS, 2016)

Level of destruction and type → District ↓	Partially destroyed homes	Severely destroyed homes	Public amenities destroyed	Security and military amenities destroyed	Total
West Bank	42,752	2,855	155	83	45,845
Gaza	26,578	5,248	88	None	31,914
Total in Palestinian Authority areas	69,330	8,103	243	83	77,759

1.1 Post-conflict Environment

Rice *et al* (2010) stated "Architects do not heal trauma; they are complicit with its production". Wars and conflicts cause human loss and devastation, whilst the role of architects and engineers is to adapt to crises, and to challenge war-time conditions that are unpredictable and exceed systematic thinking and planning. Reychler and Langer (2006) state "post-conflict" scenarios are often characterised by "multiple transition processes," including the conversion from war to peace, accompanied by democracy, decentralisation, and liberalisation. Hence, reverting war-riven societies to peace and stability is a very complex task, often liable to risks of violence recurrence. "The destruction of one's environment –can mean a disorientating exile from the memories they have invoked" (Bevan, 2007). Re-constructing pre-war communities may sometimes be unambitious and frustrating; also, severe conflicts can affect socio-economic structures that may take generations to remedy – or may never be remedied at all (Brown et al., 2008). Wars are always associated with uncertainty, and that is why redevelopment is difficult in such contexts.

1.2 Characteristics of Development in Cities Located in Conflict Zones

Cities in fragile conflict zones may share the same features; conflict causes displacement and migration of people to refugee camps, which can cause sharp increases in fuel demand, construction materials and energy consumption (Harwell, 2010). In addition, conflict zones suffer from rapid population growth, putting extra responsibilities on governments, and more stress on municipal and governmental systems, which are likely to be already suffering from uncertain situations and lack of capacity (Smith, 2017). The same author stresses that, given limited capability for planning, finance and procuring sustainable development, donors prioritise short-term humanitarian assistance and basic needs provision rather than long-term planning. Harwell (2010) confirms that consequences of conflict are loss of management and oversight, and rising incidents of theft. Absence of security and protection for inhabitants often causes high increases in urban violence (Smith, 2017). In post-conflict periods there are often abrupt flows of workers into labour markets. Conflict causes unemployment and under-employment, and many young, unqualified, unskilled, and inexperienced ex-combatants may bring down already low wages of labour (Peschka, 2011). Smith (2017) demonstrates that private sector investment is risky in fragile areas, due to the impairment of the rule of law, political instability and potential long-term costs. Foreign and local investors are more likely to flee from such countries, taking with them longer-term capital, skills and jobs (Peschka, 2011).

1.3 Rebuilding After War

There are endless debates about what to do in the aftermath of wars. Some say: “we build to remember; others say: we also build to forget” (Crawford, 2015). It is debatable whether structures should be recreated just as they were, or something brand new be constructed. Crawford (2015) questions whether ruins should be preserved exactly as they have fallen, leaving rubble as a symbol of human fragility and as a lesson to future generations of the artistic and cultural cost of war and intolerance. This philosophical vision is applicable in countries with plenty of space for everyone and everything, but that is not the case in Palestine. On the contrary, the conflict has not only destroyed the country’s infrastructure, but it has also debilitated the economy, depleted natural resources and polluted the environment.

When buildings, sculptures, and monuments are destroyed, the character of cities and their identities are erased as well. “Cultural identity is a matter of ‘becoming’ as well as of ‘being’ and it belongs to the future as much as the past” (Emmons, 2012). Therefore, when cultural and political legacies of nations are destroyed, it is almost like destroying identities and it consequently risks regenerated conflicts and long-term tensions (Pilav, 2012). Although conflict seems to de-escalate at times, it is often questionable de-escalation, as unexpected incidents could trigger conflicts again. In the case of Palestine, there has been more than 70 years of conflict. Communities suffer from the legacy of previous violence, which leads to high unemployment, poverty and many restraints on development. The history of Palestine is one of successive wars and conflicts with Israel, and each conflict becomes a precedent for future tensions, related to boundaries and identities (Pilav, 2012). The Palestinian Authority has been undergoing reconstruction and rehabilitation process since being established by Oslo Accord in 1994, which was predicted to be the end of a long conflict between Palestinians and Israelis, and the start of an era of peace (Damen, 2016).

2. ABOUT ARCHITECTURE IN PALESTINE

Sir Roger Scruton (2014) stated that when Edward Lear travelled to the Holy Land in the early 1900s, painting towns and villages on his way, he left a record of the most beautiful human settlements the world has ever known. Many of these cities remained unchanged until the twentieth century. According to the Palestinian News and Information Agency, WAFA (2011), in subsequent years the historical heritage of Palestine has been threatened with destruction for several reasons. The policy of the Israeli occupation authorities to confiscate, demolish or 'Judaise' buildings is considered by many as an attempt to falsify historical facts, and to attach various Jewish biblical accounts to these buildings to justify confiscation.

2.1 Historical Map

Historical Palestine is positioned in the eastern Mediterranean region, comprising parts of modern Israel and the Palestinian territories of the Gaza Strip, located along the coast of the Mediterranean Sea, and the West Bank, located west of the Jordan River (Britannica, 2018). Palestinian history in the twentieth century could be described as politically unstable after Israel was established in the ancient land of Palestine. On November 2, 1917, Foreign Secretary, Arthur James Balfour, wrote a letter to Britain's most eminent Jewish citizen, Baron Lionel Walter Rothschild, expressing the British Government's support for a Jewish homeland in Palestine. The letter became ultimately known as the "Balfour Declaration" (History, 2009). Although most parts of Palestine are now under Israeli occupation, Palestine declared itself an independent country in 1988, and, with its territory in the West Bank and Gaza Strip, it is recognised by more than 100 countries around the world; however, it still strives to have its own state recognised at the United Nations (UN) (Hadid, 2002). On November 29, 2012, the United Nations General Assembly voted by an overwhelming majority to accord Palestine 'Non-Member Observer State' status, 138 in favour to 9 against (Canada, the Czech Republic, Israel, the Marshall Islands, Micronesia, Nauru, Panama, Palau and the United States of America), with 41 abstentions (United Nations, UN, 2012). The recognition was considered a symbolic victory in the Palestinian quest for statehood.

2.2 War Architecture in Palestine

Weizman (2014) asserted that the Israeli army destroyed deliberately cities and towns during the second Intifada. Cities in the West Bank such as Jenin and Nablus dramatically changed. When Israel tried to capture these cities, its army used D9 bulldozers to construct new roads, flattening homes in their way. He added that when Jenin was rebuilt after the army had left, the residents built roads wide enough for tanks to be able to go through. They did not want the tanks to destroy their homes again and again, but at the same time they lost the protection the densely- packed neighbourhoods had given them.

Alongside the urban and rural communities that already existed in Palestine before the war, conflict has brought Palestine new styles of communities to Palestine in the form of Israeli settlements and Palestinian refugee camps.

• **Israeli Settlements**
Located on the hilltops of the West Bank, they are positioned strategically, so that they look out over Palestinian valleys and towns below in order "to dominate" (Weizman, 2014). Settlements can be defined as Israeli cities, towns and villages constructed in the West Bank and the Golan Heights. They tend to be gated communities with armed guards at the entrances. These settlements cannot be considered as simply Israeli residential areas, because Israel is an occupying force in Palestinian territories. It is land that Palestinians, along with the international community, view as territory of the Palestinian state (Liebermann, 2017). According to the Palestinian Central Bureau (PCBS, 2018), the number of Israeli settlers in the West Bank has reached 636,452. Israeli settlements expanded following the Oslo Accord, leading to the breakdown of the peace process (Sharif, 2009).

Settlements are uniform-looking houses – all have red roof tiles, and Weizman (2014) explains that these roofs are optical instruments, as they were recommended by the military so that the Israeli Air Force can avoid targeting them. A tragic irony is that roads connect settlements with each other, but these same roads separate Palestinian land, towns and cities from each other.

• **Palestinian Refugee Camps**
Palestinian refugees are distributed over 19 camps in the West Bank and eight in the Gaza Strip. The residents of the camps are people who were forced to leave their homes. At the beginning of displacement, many Palestinians refused to convert their temporary tents into buildings, but long-term suffering forced them to adapt to their situation by building small homes. The camps took the form of simple, overcrowded buildings, lacking civil organisation, infrastructure and services, thus becoming a new source of daily suffering. For economic reasons, instead of stone, concrete hollow blocks and low-price building materials were used in refugee camps. This affected the durability of the buildings, maintenance and the quality of living and spaces (Hadid, 2002).

• **New Urban Expressions Appeared e.g. Bypass Roads, Separation Walls, Seam Zones, Buffer Zones and Checkpoints**
The combination of the 1993 Oslo Accord, the expansion of Israeli settlements in the West Bank, security checkpoints, bypass roads, and the building of the 'apartheid wall', have created even greater fragmentation and deformation in the Palestinian-Israeli topography (Sharif, 2009). Palestinian movement and mobility are severely restricted, and short-distance trips can take many hours. There are checkpoints everywhere, manned by armed Israeli soldiers and some guarded with tanks. Others are made up of gates, which are locked when soldiers are not on duty. In addition, there are hundreds of earth mounds, created from excavated material and concrete roadblocks. This affects the daily life of Palestinians, and their life styles.

2.3 Difficulties Facing Sustainable Construction Related to Conflict

According to the Oxford Dictionary 'sustainable' means "Able to be maintained and conserved at a certain rate or level". Sustainability is a broad term to describe a desire to perform activities avoiding resource depletion and having damaging impacts, according with the Brundtland Report (1987) as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". Conceptually, the term sustainable construction was proposed to describe the responsibility of the construction industry in attaining sustainability (Hill and Bowen, 1997).

In conflict zones context, on the one hand, development have to be sustainable, not politicised for the short-term (United Nations, 2016). On the other hand, long-term development in conflict-affected areas is a challenging task (Soelen, 2014). Pilav (2012) stressed that the long-term effects of conflict and violence on people are inextricably linked to the physical damage to the country, its landscape and the resulting psychological impairment. Hadid (2002) reported that political instability in the West Bank and Gaza Strip disturbed building processes by affecting the social and economic situation of Palestinians. Conflict did not prevent people from building for natural growth purposes, but altered investment in construction sectors and the quality of buildings and quality of life, which prioritised the need for just somewhere to live over the need for quality homes. He added that the development of communities was based on everyday needs, with an absence of careful planning. Conflict can thus damage or wipe out the value and purpose of infrastructure for a population.

The resources of occupied territories are supposed to be used to benefit local populations, and not to be used by the occupying authorities; this is not the case with Palestinian land and resources. The consequences of this conflict on sustainable construction are directly linked with the following main factors:

• **Energy**

Palestine has limited fossil-fuel resources. The Palestinian Authority has to import 100% of its petroleum products and around 92% of its the electrical energy from the Israeli market. This costs Palestine around $430 million per year (Yaseen, 2008). Israel controls energy imports into the West Bank and Gaza, and prevents open trade in electricity and petroleum products between Palestine and other countries (Yamin, 2015).

According to the Palestinian Ministry of National Economy (2011), the main constraints facing the development of the Palestinian energy sector are restrictions imposed by Israeli policies and actions. These constraints are:

1. Israeli control over parts of the West Bank (Area C), which presents serious challenges to constructing power networks given that Israeli co-operation and coordination is not forthcoming;

2. Israeli control of Palestinian territorial borders, particularly in the West Bank, which can effectively deny or limit trade across international borders, including importation of electricity and petroleum products;

3. Israeli destruction of Palestinian power system facilities by military action, such as the June 2006 attack on the Gaza power plant, which created a serious short-term crisis for consumers; also, Israeli-related impediments to the exploitation of the marine gas field off the coast of Gaza.

• **Water**

In both International Humanitarian Law and International Human Rights Law, it is not appropriate for occupying power to restrict the exploitation of natural resources located within occupied territories (Tignino, 2009). Despite this, Israel controls Palestinian water resources. Since 1967 the Israeli authorities have passed dozens of laws to control natural resources and underground water in Palestine. Palestinians have limited access to the water within their own territory, including underground aquifers and water from the Jordan River. Palestinians only have access to about 10% of the annual recharge capacity of the West Bank's water system (Haddad, 2009). The Israeli Government does not issue Palestinians with permits to dig new wells on their own land. This is an old practice, that means once a well is dry, there is no more water. Inside Israeli settlements drilling is free-flowing, as can be seen from the greenery of the landscape in those settlements (IMEMC, 2007). Abu Kishek (2007) stated that Israel destroyed large parts of the water utilities in the West Bank, by demolishing wells, irrigation systems, reservoirs and water lines. All this results in a major deficit in underground reservoirs, and an increase in the suffering of the Palestinian population, who have limited access to drinking water on a daily basis. There is clear inequality in water allocation between Israeli and Palestinian sites, and Jewish and non-Jewish areas, which creates feelings of injustice (Issac *et al,* 2004).

• **Quarrying and Mining**

According to the Palestinian Ministry of National Economy (2011), the West Bank is rich in gravel, stone and marble. These materials are Palestine's major exports. Most of the mines and quarries, from which these materials are extracted, are located in Area C under direct Israeli control. In 2009 the Israeli human rights organisation, Yesh Din, presented a petition to the Israeli High Court, to stop all mining and quarry activities in the West Bank, stating that Area C inappropriately produces a large amount of mining and quarrying materials for Israel. The majority of mines and quarries in West Bank are owned by Israeli companies and are operated under the auspices of the Civil Administration in Judea and Samaria. The petition stated that Israeli policy constitutes the ruthless exploitation of occupied territory for the economic benefit of the State of Israel, thus blatantly violating international law (Yesh Din, 2017).

• **Land**

According to the Oslo Accord, Palestinian territories are divided into three zones: A, B and C. B'Tselem (2017) explained that zones A and B are built environment areas, which are officially under Palestinian Authority control. The remaining 61% is considered Area C, which is the land surrounding Areas A and B, where Israel exercises full control over security and civil affairs, such as: planning; building; laying infrastructure and development. The potential for urban, agricultural and economic development remains in Area C. Most of the West Bank is considered as Area C. From a construction perspective, this means that Israel governs new buildings and authorisations, in addition to building materials and natural stone production by controlling the stone quarries, which are all located in Area C.

The harmony of the built and social environments have arguably been brutally destroyed by the elements of conflict and modernity. This is evident in unfinished concrete block buildings, destruction everywhere, neglect and dereliction of the aesthetic elements due to financial constraints, and the division of urban areas according to class and wealth. The sense of belonging to communities has become weak. From a sociological point of view, the architecture of war became a means of differentiation. Societies began to separate themselves from the fabric which had united them in the past, and from the spirit of places that had represented their common existence. Towns, cities and refugee camps became residential areas for distinct social classes.

The construction sector in the Palestinian Territories has undergone many complex changes since the start of the occupation in 1948. It can be said that this sector is the one most affected by Israeli policies. The Palestinian-Israeli conflict is a conflict on the ground, leading to restrictive security and economic policies: building permits, confiscation of land and restricting the work of organisations such as housing associations. All of these halt construction developments. In addition, Israeli policies attract low-paid Palestinian labour to work on risky, dangerous and difficult construction tasks.

The main effects and consequences of conflict on construction processes could be summarised as follows:

1. The Palestinian Ministry of National Economy (2011) stated that Israel imposes particularly burdensome procedures on Palestinian imports and exports in the name of security. These procedures directly raise the costs of trading for Palestinian businesses. Supplying building materials is not easy, as Israel enforces limits on importing construction materials for building and renovating homes. Such control is on the pretext of preventing Palestine from constructing tunnels, which Israel perceives as a threat to its security.

2. The provision of local materials such as building stone are limited, since all quarries are in Area C, where the Palestinian authorities are not allowed to open up new quarries without Israeli permission.

3. Israeli authorities control building permits in Palestinian zone, Area C.

4. Checkpoints and blockades disturb field trips and restrict access to some villages and cities (Hadid, 2002).

5. Poverty, fragility and weakness in communities due to war leads people to settle for the cheapest build solutions with the worst quality, as sustainability in crisis situations is not priority.

6. Destruction of buildings and other infrastructure creates rubble that is not easy to dispose of or recycle

3. METHODOLOGY AND GROUP DISCUSSION OUTCOMES

The research ethics were taken from Farrell *et al.* (2016), the paper's structure was founded on issues arising from the literature; data reliability was also supported by interviewing five Palestinian construction and an authoritative figure on green building in Palestine. A focus group discussion took place at Tulkarem branch of the Palestinian Engineers' Association. Attendees were engineers and practitioners in the public and private sectors. They were invited either by telephone or email. The discussion lasted for two hours; participants gave their opinion on the issues raised and digital voice recordings were made to document the discussion. The data were carefully transcribed *verbatim*. These data were shared with the group by email to ensure validity. The critique method was adopted, whereby participants were asked a series of questions, with one or two minutes given to reply, followed by free debate within the group to confirm the outcome.

4. THE FINDINGS OF FOCUS GROUP DISCUSSION AND INTERVIEWS WERE AS FOLLOWS:

Unexpected debate and important feedback arose from the focus group discussion, which clarified many vague issues, and revealed information that was little-known hitherto.

1. The participants agreed that since the Palestinian-Israeli conflict has lasted for so long, due to its complexity, it has become more a way of life than a temporary crisis.

2. Excluding the work of the Ministry of Education and its premises and schools, it was assumed that no specific architectural elements are designed in Palestine as energy-saving and thermal-loss-reducing, except solar heating for water, which is widely used.

3. Donors and beneficiaries have different agendas due to different cultural backgrounds, or weaknesses and immaturity in need assessment strategies.

4. A lack of financial resources imposes on most people a need to construct their own houses without advice from professional architects. In addition, most architects pay very little attention to climate change issues.

5. Historical buildings offer developers live examples of how to adapt to climate change, and provide them with a “do’s and don’ts” list, as such buildings have been used for generations, with lessons learned by trial and error.

6. Despite the fact that historical buildings were designed to suit and respect the climate, it is strongly argued that these buildings should be studied, evaluated and improved, rather than copied, since they are ‘accidentally’ and ‘unintentionally’ sustainable. According to one of the research interviewees, traditional buildings have a high thermal mass, due to the type of materials used and the thickness of walls and roofs.

7. The war in Palestine started over 70 years ago; unfortunately, it has become a way of life. Incidents should be predicted all the time; hence, all buildings should have the resilience to survive unexpected strikes. Moreover, Palestine is located in a seismically-active location, which should be considered in construction designs.

8. When the Palestinian Authority was established following the Oslo Accord in 1994, new buildings with odd styles were created that did not respect the identity and cultural heritage of Palestinian architecture, which traditionally conserve buildings with historic value.

9. The availability of affordable housing is a problem. The average price per square metere for an apartment in Ramallah city is $1120; such prices cannot be afforded by middle-class families whose average annual income is $7370. Residential places should be sustainable as part of a Palestinian culture that is based on strong connections with places,

which means homes do not usually sell or change ownership, but are inherited and move from one generation to another.

5. RECOMMENDATIONS:

1. Social and economic development is necessary in war-torn areas. Conflict in Palestine has left social and financial catastrophes, lives lost, damaged assets (including infrastructure, roads and facilities), unemployment, poverty, corruption and poor access to healthcare, education and good nutrition. Everyone should have access to these basics, followed then by raising awareness of environmental issues.

2. The aim of sustainable post-war architecture is the provision of affordable homes for the population, schools, hospitals and other basic infrastructure. Available resources should be used in co-ordination with planners and designers.

3. Note should be taken of Arnold (1988) who stated that "The use of catastrophes as an engine for 'historical transformation". It should trigger new starts with better planning out of destruction. Some schools consider architecture as casualty of war and destruction and as a tragic loss of nations' heritage, whilst others see destruction as an opportunity to rebuild better planned cities.

4. Building to last should be the core of sustainability, designing structures that can withstand military strikes.

5. On the public level, whether there are political, environmental or social crises, there is a need to build stronger institutions and municipal systems in order for cities to be able to anticipate, endure and rebound from difficult situations, with long-term planning agendas that are flexible and adaptable to continuously changing contexts (Smith, 2017).

6. The private sector role is as important as the public one. However, attracting private partners to contribute to projects in fragile, risky and challenging locations is not an easy task. It is necessary to identify risks and prepare suitable plans to mitigate and manage them (Smith, 2017). Moreover, encouraging international and political institutions to provide guarantees for private sector investment is necessary.

6. CONCLUSION

Architecture creates heritage, culture and memories, and part of Israeli policies appears to aim to empty Palestine of its civilised content and its link to Biblical verses and texts. In the current context it is clear that one place is not enough for two conflicting nations with memories, that deny each other. The Palestinian memory is carved in the place; in the houses of the people, in the minarets and domes that rise in the city spaces of Jerusalem, Jaffa, Haifa and Acre and the other cities and villages of Palestine. The Israeli Jewish memory lies in the Old Testament of the Bible as stories of events and battles as Jews looked for their place in the Holy Land. Since history is often written by the victors, it has seemed necessary for the stronger nation to resort to various methods to remove features that does not want, to steal the memory of the place, and to reshape the country as it wishes.

According to the World Bank, 40% of former conflict zones return to a state of conflict within a decade. That is the case in Palestine, where there is a series of peak tensions and lags of relatively quiet periods. As the Palestine crisis has been going on for over a hundred years, it has become a life style rather than an emergency. Increasingly efforts should come together to produce long-term sustainable development plans. There is a need to create buildings with a high resilience and function, that are able to withstand conflict.

Palestine needs to change its development goals from emergency humanitarian responses to war to long-term sustainable development, which can support stability in such a fragile area. Both the public and private sectors should work together to achieve this kind of development. The impact of occupation and the uncertainty and humanitarian crises associated with it affect the implementation of new projects and ideas, which make the situation seem to be an endless negative circle. The solution is to create a more certain environment, to access freedom, and to be granted political sovereignty over its resources and borders.

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COMPRESSIVE STRENGTH ANALYSIS OF CONCRETE FLOOR USING A NON-DESTRUCTIVE TEST

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Abstract: A non-destructive test (NDT) using a Schmidt rebound hammer is used in testing an existing structure because of its ability to access and test strength of concrete components in any part of a building with less labour stress or causes damage to the building structure. This study analyzed the rebound value (R) of an existing concrete floor with 150mm2 thickness. The rebound values (R) were taken at three (3) different points of the concrete floor of an existing building to determine the relatively compressive strength of the concrete floor area. The standard experimental procedure for the non-destructive test (NDT) using the impact method was followed and the analysis of the result was presented through figures and tables. The result shows that the Rebound value (R) of the concrete floor taken at different points was 24.21N/mm2 (CF1), 27.51 N/mm2 (CF2) and 26.18N/mm2 (CF3). The result further indicates that the average rebound value (R) of the concrete floor area sampled in relation to the compressive strength (MPa) of in-situ concrete is 25.97N/mm2. The result shows that the strength of the concrete floor is within the stipulated minimum compressive strength of between 21N/mm2- 25N/mm2 for load-bearing concrete floor in accordance to BS EN 197-1, and this shows that the concrete floor tested is suitable for habitation and can perform its required functions. The study concluded that NDT using Schmidt hammer with its relative simplicity and economy is a suitable test that can be used to determine the strength of existing building structures and its components, where its performance and quality will not be compromised.

Keywords: Compressive strength test, Non-destructive test; rebound value; Schmidt rebound hammer.

1. INTRODUCTION

Over the years, concrete is used in developed and developing countries to build modern structures. It is a suitable material of construction that has a very good compressive strength but poor tensile strength (Ede and Agbede, 2015). Its strength and service life most time is affected by various varieties of environmental degrading factors which shows in its texture and quality during usage (Ojerinde, Ajao, Ogunbayo, Stevenson, and Latif, 2018). Agunwamba and Adagba (2012) observed that it is of importance to measure the performance of the in-use properties of concrete to know its existing conditions and quality assurance. They further suggest that a non- destructive (NDT) will not impair the function of concrete and allow for evaluation through testing and retesting of the concrete component in a building. Aydin and Saribiyik (2010) state that the NDT is carried out on concrete components through the use of an apparatus called Schmidt rebound hammer that does not compromise the anticipated performance of concrete components being examined and it's quality especially during usage. Equally, Leshchinsky (1991) states that NDT causes less damage to concrete components of the building structure. Yüksel (1995) opined that NDT is an ideal test for testing the strength of an existing concrete component because of its easiness. The finding of the study of

Agunwamba et al (2012) further shows that standard processes need to be followed to attain better results using the NDT to determine the concrete strength. The compressive strength of building components such as block and concrete was usually done through the destructive method of testing that involves the use of different expensive heavy equipment (Ogunbayo et al, 2018). Roknuzzaman, Hossain, Mostazid, and Haque (2017) opined that NDT help in the preservation of the concrete component even if the estimated rebound values are approximate or empirical. The study of Sanchez and Tarranza (2014) revealed that NDT is fairly reliable test used in a swift strength test of existing concrete components with a good safety assessment. Agunwamba and Adagba (2012) further opined that NDT's are those tests applied to concrete that does not change the quality of the concrete testing. The need for quality strength evaluation of existing buildings produced with in-situ or pre-cast concrete makes NDT a great scientific and practical importance (Ogunbayo, Ajao, Alagbe, Ogundipe, Tunji-Olayeni, and Ogunde 2018). Conversely, Villemeur (1992) states that assessment of risk performance of concrete should not be limited to construction stage only, but rather extended to usage stage in order to avoid failure and collapsing of components of the building structures. The finding of the study of Shariati, Ramli-Sulong, Kh, Shafigh, and Sinaei (2011) revealed that NDT using the Schmidt rebound hammer is an improvement towards concrete strength evaluation. Conversely, Turgut (2004) states that these improvements are of no importance if the obtained values are not reliable. The report of Camex USA Technical Bulleting (2008) and Yilmax (2009) shows that readings of rebound values for NDT are influenced by rebound hammer calibration, temperature, presence of steel reinforcement and air voids, presence of aggregates, carbonation, moisture content, age of concrete and surface smoothness. The study of Turgut (2004) further revealed that testing of concrete strength using NDT is of no importance if its results are not meeting the expected result from any part tested. This study investigates the compressive strength of the concrete floor in relation to the rebound value (R) using the NDT impact method (Schmidt rebound hammer).

From the above literature, it clear that there were different studies on NDT that shows that it can be carried out on component of building most especially concrete without impairing the function or causes damage to it. However, there exist dearths of study on the use of NDT to evaluate the strength of in-use building concrete floors. It is on this bases, that this study aimed to determine the compressive strength of an in-use concrete floor of a building (public building) using the NDT without causing any defect to the physical appearance of the floor. Conversely, the study will help to show if the concrete floor area to be tested is suitable for habitation and can perform its required functions.

2. METHOD

2.1 Testing Preparation

The load-bearing floor point areas to be tested were identified and prepare for testing. For stability and accuracy of the result to be obtained through the apparatus used for the test, the load-bearing concrete floor points to be tested that were carefully selected, and prepared were smoothened using a grindstone to avoid undulating of the floor surface area to be tested. All obstacle materials within the testing area that could affect the result to be obtained were removed and effort was made to monitor and curtail other activities around the testing area such as use of heavy machines that could lead to vibration which might affect the calibration of the NDT apparatus in obtaining an accurate result. The NDT apparatus to be used was checked and re-calibrated to avoid parallel errors during the testing stage of concrete floor area to be tested.

2.2 Apparatus

The main apparatus used in evaluating the strength of the concrete floor within the study area is called a Schmidt hammer. The Schmidt hammer or rebound hammer is a device that is used to measure the elastic properties or strength of concrete, mainly surface hardness, and penetration resistance. The Schmidt hammer is described in ASTM C 805 (1997).

2.3 Procedure for the Test

The procedure for the NDT was carried out in accordance with the Czech Standards Institute on non-destructive testing (2013). The load-bearing concrete floor points to be tested as stated earlier were carefully selected, prepared and smoothened using a grindstone. The apparatus (Schmidt hammer) before usage was checked to be at an accurate point to avoid errors in result reading. The Schmidt hammer was pushed at a reasonable speed against the test surface with a fixed amount of energy against the concrete floor points. The test apparatus was positioned horizontally to and against the test surface and until an impact is initiated. After impact, the rebound hammer readings were recorded for the individual concrete floor are tested.

2.4 Compressive Test Analysis

For each concrete floor area tested twenty-five (25) impacts values were recorded and the highest twelve (12 impacts) values minimum requires for NDT was taking from total impact values for each tested concrete floor area. The average rebound value (ARV) for the three concrete floors tested point of the total concrete floor area in accordance with ASTM C 805-85(1993) and BS EN 197-1(2011) was calculated and the rebound value (R) determined. The rebound value (R) for the floor area tested was analyzed in relation to the compressive strength (MPa) of concrete in order to determine the stability and suitability of the area tested.

2.5 Equipment and Apparatus

In carrying out the NDT test for this study, the following equipment, apparatus, and tools were used: Schmidt rebound Hammer, grinding stone and measuring tape.

2.6 Safety Procedure

The safety procedure for the research was based on the finding of Ogundipe et al. (2018) which state that laid down safety arrangements should be strictly followed in carrying out any building process including material testing to avoid accidents or any other form of hazard on production site or testing area.

3. RESULTS

Table 1 shows NDT test that was carried out on CF1 of 150mm with screed and ceramic tiles of 25mm thickness. The rebound values after impact were recorded taking at least 12 readings out of 25 impacts that were carried out on the tested concrete floor. For accuracy, the lowest (21.98 N/mm2) and the highest rebound value (27.12 N/mm2) were deducted base on ASTM C 805-85 standard and the average rebound value (ARV) for the 10 rebound values was calculated. The result shows that the Rebound value (R) for CF1 is 24.41N/mm2.

Table 1: Analysis of Rebound value for the CF1

S/N	Sample tested	No of Impact	Rebound Value (N/mm^2)	Deductions (N/mm^2)
1	Concrete floor of 150mm	1	24.21	24.21
	thickness with screed and	2	25.09	25.09
	ceramic tiles finish of	3	23.02	23.02
	25mm	4	21.98	Lowest value
		5	25.97	25.97
		6	27.12	Highest value
		7	23.68	23.68
		8	24.78	24.78
		9	22.99	22.99
		10	23.72	23.72
		11	24.41	24.41
		12	26.21	26.21
			Total	244.08

$$\text{Average rebound value (ARV)} = \frac{\text{Sum of the total value}}{\text{Number of Impacts}}$$

$$R = \frac{244.08}{10} = 24.41\text{N/mm}^2$$

Table 2 described NDT test that was carried out on CF2 of 150mm with screed and ceramic tiles of 25mm thickness. The rebound values after impact were recorded taking at least 12 readings out of 25 impacts that were carried out on the tested concrete floor. For accuracy, the lowest (23.72 N/mm2) and the highest rebound value (27.15 N/mm2) were deducted base on ASTM C 805-85 standard and the average rebound value (ARV) for the 10 rebound values was calculated. The result shows that the Rebound value (R) for CF2 is 26.01N/mm2.

Table 2: Analysis of Rebound value for the CF2

S/N	Sample tested	No of Impact	Rebound Value (N/mm^2)	Deductions (N/mm^2)
2	Concrete floor of 150mm	1	26.71	26.71
	thickness with screed and	2	25.62	25.62
	ceramic tiles finish of	3	24.92	24.92
	25mm	4	26.98	26.98
		5	25.97	25.97
		6	27.15	Highest value
		7	25.61	25.61
		8	27.08	27.08
		9	25.81	25.81
		10	23.72	Lowest value
		11	24.41	24.41
		12	27.01	27.01
			Total	260.12

$$\text{Average rebound value (ARV)} = \frac{\text{Sum of the total value}}{\text{Number of Impacts}}$$

$$R = \frac{260.12}{10} = 26.01 N/mm^2$$

Table 3 analyzed NDT test that was carried out on CF3 of 150mm with screed and ceramic tiles of 25mm thickness. The rebound values after impact were recorded taking at least 12 readings out of 25 impacts that were carried out on the tested concrete floor. For accuracy, the lowest (23.87 N/mm^2) and the highest rebound value (26.97 N/mm^2) were deducted base on ASTM C 805-85 standard and the average rebound value (ARV) for the 10 rebound values was calculated. The result shows that the Rebound value (R) for CF3 is 26.01N/mm^2.

Table 3: Analysis of Rebound value for the CF 3

S/N	Sample tested	No of Impact	Rebound Value (N/mm^2)	Deductions (N/mm^2)
3	Concrete floor of 150mm	1	25.01	25.01
	thickness with screed and	2	23.93	23.93
	ceramic tiles finish of	3	26.78	26.78
	25mm	4	24.92	24.92
		5	26.97	Highest value
		6	28.03	28.03
		7	24.73	24.73
		8	25.84	25.84
		9	23.87	Lowest value
		10	25.79	25.79
		11	25.34	25.34
		12	26.23	26.23
			Total	256.6

Average rebound value (ARV) = <u>Sum of the total value</u>

Number of Impacts

$$R = \frac{256.6}{10} = 25.66 \text{ N/mm}^2$$

Figure 1 analyzed the average rebound value(R) of each of the three tested points of the floor area in specific relation to the compressive strength of concrete is shown in figure 1. The result showed compressive strengths of 24.41N/mm² (CF1), 26.01N/mm² (CF2), and 26.45N/mm² (CF3), and average compressive strength in relation to the rebound value (R) is 25.35N/mm² for all CF's tested using the NDT.

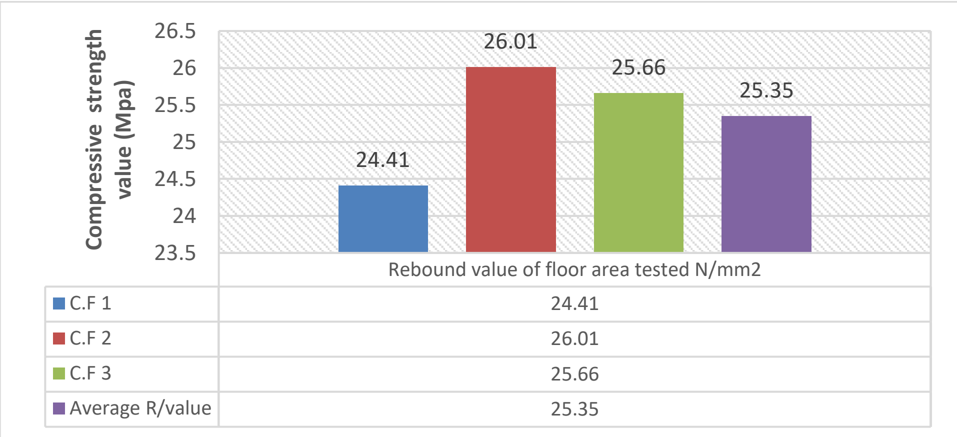

Figure 1: Analysis of CF average rebound values(R) in relation to the Compressive strength (MPa) of concrete.

4. DISCUSSIONS

The analysis of NDT carried out on CF1 (see table 1) showed highest rebound value of 27.12 N/mm^2 and lowest rebound value of 21.998 N/mm^2, while the ARV for CF1 is 24.41N/mm^2. The ARV of the NDT carried out on the CF1 within the floor area tested is similar to the finding of Sule (2011) that shows the ARV on an existing concrete slab was found to be between 19 N/mm^2 to 24 N/mm^2.

The analysis of NDT carried out on CF2 (see table 2) showed highest rebound value of 27.15 N/mm^2 and lowest rebound value of 23.72 N/mm^2, while the ARV for CF2 is 26.01N/mm^2. The ARV of the NDT carried out on the CF2 within the floor area tested is in line with the finding of Roknuzzaman et al (2017) and Sule (2011), which shows ARV of concrete in use to be between 23N/mm^2 to 25.34 N/mm^2.

The analysis of NDT carried out on CF3 (see table 3) showed highest rebound value of 26.97 N/mm2 and lowest rebound value of 23.87N/mm^2, while the ARV for CF3 is 26.01N/mm^2. The ARV of the NDT carried out on the CF3 within the floor area tested is in conformity with the finding of Agunwamba and Adagba (2012), which shows ARV of a concrete slab with mix design of 1:2:4 to be between 25N/mm^2 to 30 N/mm^2.

One important evaluation that is vital in NDT is the Compressive strength (MPa) analysis of components of building tested.The compressive analysis is carried to analyzed the average rebound value (R) of each of the three tested points of the floor area tested in specific relation to the compressive strength of concrete (see figure 1). However, base on the ARV result obtained from the NDT carried out on all the tested floor areas with AVR of 24.41N/mm2 (CF1), 26.01(CF2) and 26.01 N/mm (CF3) and incomparable with the compressive strength of concrete as stated by BS EN 197-1(2011) falls within the minimum strength required of concrete for an in-use building or structure.

5. CONCLUSIONS

This study investigates the rebound value (R) of an existing concrete floor in relation to the compressive strength (MPa) of concrete using the NDT. The result of the study indicated that the average compressive strength for the concrete floor tested in relation to the rebound value (R) of 24.41N/mm2 (CF1), 26.01(CF2) and 26.01 N/mm (CF3) is in alignment with BS EN 197-1(2011) that stipulated that the minimum compressive strength of an existing load-bearing floor above the damp-proof course should be between 21N/mm2 to 25N/mm2. The result shows that the strength of the concrete floor is within the stipulated minimum compressive strength for load-bearing concrete floor in accordance with BS EN 197-1. Base on the result of this study, it can be deduced that the concrete floor tested is suitable for habitation and can perform its required functions. The study concluded that NDT using Schmidt hammer with its relative simplicity and economy is a suitable test that can be used to determine the strength of existing building structures and its components, where its performance and quality will not be compromised. The study suggested that further research could be carried out to determine the strength of other existing in-use building components such as columns, beams, and others, through NDT using the Schmidt hammer for further comparison in the area of strength, quality, and performance of the Schmidt hammer.

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PROPERTIES AND EFFECT OF DORMANT RIVER SAND USED FOR SANDCRETE BLOCK PRODUCTION IN NIGERIA

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Abstract: River sand used as an aggregate for sandcrete block production is cheap and readily available aggregate materials that are sometimes abandoned on production sites and make dormant for prolonged periods of time before utilization. This study investigates the effect of Dormant river sand (DRS) used as an aggregate material for sandcrete block production in order to determine its suitability in the production of quality and affordable sandcrete block. Data for the study were collected from two different sandcrete block production locations in Ota, Ogun State Nigeria. Silt content, water absorption, specific gravity, sieve analysis, and the compressive strength test was conducted on the DRS to determine its efficiency, quality, suitability, and strength on sandcrete block produced through it. The analysis of the performed experiment on the dormant aggregates was presented through tables and figures. The analysis result of the study revealed that DRS used for block moulding in Nigeria is of quality and suitable for block production and it meets the specified requirement as stipulated by NIS 2007 for sandcrete block quality and strength parameters. The study concluded that the DRS used as aggregate materials for block production is suitable and has no effect on its quality and strength.

Keywords: Bulk density, compressive strength, dormant river sand, sandcrete block, sieve analysis.

1. INTRODUCTION

Different aggregates materials such as roadside sand, drainage sand, earth sand, retained sand from flood, river sand etc. were used in the production of different sizes of sandcrete blocks in many different locations in Nigeria without resort to the minimum quality standard expected of the block (Oyekan and Kamiyo, 2011). Anosike and Oyebade (2012) posited that the swift in population and economy growth of the country through rapid growth necessitate further expansion in infrastructures. Ko, (2011) states that these physical infrastructures comprise both commercial buildings, private residential buildings and other institutional buildings that require quality and affordable sandcrete blocks for their construction. Presently, majority of the houses in Nigeria were built using sandcrete block produced from cement, sand (river sand) and water why others were produced from the mixture of cement, crushed stone, and water (Ajao, Ogunbayo, Ogundipe, Bamigboye, Ogunde, and Tunji-Olayeni 2018). Abdullahi (2005) posited that sandcrete blocks are building components used in the construction of solid walls and partitions. Equally, Abdullahi (2005) further postulated that the sandcrete blocks were of different weight, sizes and are available in the construction of both non-load and load-bearing structures. Odeyemi, Otunola, Adeyemi, Oyeniyan, Olawuyi (2015) posit that sandcrete blocks are manufactured both manually and mechanically to meet the requirement of building with the discovery of an adhesive material called cement. However, Anosike, et al. (2012) posit that the most sandcrete blocks were produced without putting into consideration durability, suitability and strength of the blocks. However, Odeyemi et al. (2015) further positioned that due to differences in method and material usage in the production of the sandcrete blocks, the quality of blocks produced differs from each block industry or production location. Production of these blocks as observed by Ogunbayo, Ajao, Ogundipe, Joshua, Durotoye, and Bamigboye (2018) was done in an unprepared environment and due to economic factors, most of the aggregate material used for its production was abandoned and remain dormant before further production could take place. Thus, due to poorly produced blocks, most building external appearance lost their aesthetic fixtures due to cracks and other defects caused by the type of aggregate used (Ewa and Ukpata, 2013). The use of these different locally sourced building materials (fine aggregate) for sandcrete block production without any form of quality control has led to the loss of lives and properties due to persistent building collapses (Fakere, Fadairo, and Fakere, 2012). However, Sholanke, Fagbenle, Aderonmu, and Ajagbe, (2015) observed that inappropriate and poorly used locally sourced materials are a leading factor in building collapse in Nigeria. Contrariwise, Ogunbayo, et al. (2018) opined that government and other regulatory bodies need to control the use of locally sourced aggregate material by setting up a production standard guidelines.

Ojerinde, Ajao, Ogunbayo, Stevenson, and Latif (2018) in their study concluded that standard wall material for building needs to meet some standard requirements in terms of durability and mechanical properties. Ogunde, Ayodele, Joshua,Nduka, Ogunde, Ogundipe, Ogunbayo, and Ajao (2018) state that cost implications affect the quality of material used in building components productions. Baiden and Tuuli (2004) observed that over 90% of Masonry walling units of housing structure provided within the developing countries were constructed using sandcrete blocks produced with a locally sourced aggregate material such as river sand and others. This makes sandcrete blocks a vital building component in construction works. Although, Anosike and Oyebade (2012) noted that sandcrete block is majorly produced through mechanical vibrating moulding machine or manually process of production. The finding of the study of Ogunbayo et al. (2018) shows that properties and durability of aggregate material use for sandcrete block production are not considered before and during its usage. The Nigerian Industrial Standard (2000) stipulates different regulatory guide to standardized block production in Nigeria. It's specified bulk density of 1920 kg/m3 for individual blocks and 2020 kg/m3 for a mean of three or more blocks and a minimum compressive strength of 2.5 N/mm2 for individual block and 3.45 N/mm2 for an average of five blocks (Ajao et al 2018). All these measures were enacted to guide the use of locally sourced material in the production of quality and suitable blocks for housing production by following quality control as stipulated in the NIS 87: 2000.

From the above review, there appeared to be numerous studies on engineering properties of aggregate in block production and usage. However, there exist dearths of study on the use of DRS as an aggregate material in block production. It is on this note that the study aimed to investigate the effects of locally sourced DRS (sharp sand) together with its evolving physical properties over time and its effect(s) on quality, suitability, and affordability of sandcrete block produced.

2. METHOD

2.1 Material Consideration

Eighteen (18) blocks of size 450mmx225mmx225mm (9 sandcrete blocks each from each site) produced with DRS were randomly selected from two commercial sandcrete block production sites in Ota community area of Ogun State, Nigeria, for this study.

2.2 Material Analysis

DRS samples were collected from block production sites to determine the property quality of the DRS in accordance with BS EN 933- 1: 1997. Material analysis such as sieve analysis was carried out to determine the particle sizes of the DRS aggregate material; bulk density was performed to measures the volume of the graded DRS aggregate material in the block produced; silt analysis was carried out to determine the percentage of silt present in DRS aggregate material; water absorption was also carried out to evaluate the DRS water absorption rate.

2.3 Mixing

As specified by BS 6073 – 1:1981 and NIS 87:2000. Sandcrete block selected at the production locations was produced with vibrated block moulding machine with cement and DRS aggregate material of cement-sand ratio of (1:8). The cement and DRS aggregate material were mixed proportionally and water added gradually in spray to allow the adhesive (cement) to hydrate and to avoid shrinkage in block produced and to maintain stability during the setting period of the produced blocks. As specified by BS 6073 – 1:1981, 0.5 water-cement ratios were used in the production of the blocks

2.4 Curing

Curing was done manually to maintain suitable moisture content and provide appropriate hydration and hardening of the sandcrete blocks. The selected sandcrete blocks were cured in accordance with BSI 2009.

2.5 Compressive Strength Analysis

Sampled blocks selected within the block production sites were subjected to compressive test using compression testing machine Model YES-2000, Maximum Capacity: 2000KN, at concrete laboratory of Covenant University Ota, Ogun State, Nigeria, to determine the strength of the blocks produced for 7days,14 days and 28 days in accordance with BS EN 12390-2:2009. A total number of 18 blocks was tested.

2.6 Cement

42.5R type of Ordinary Portland Cement (OPC) delivered in good condition produced in accordance with BS EN 197-1: 2011 was used in the mixing and production of the sandcrete blocks.

2.7 Water

Clean water from the same waterbed level of drilled borehole was used by the producers of the sandcrete blocks sampled for their production as specified by NIS 87:2000.

2.8 Safety Procedure

The safety procedure for the research was based on the finding of Ogundipe et al. (2018) which state that construction workers should strictly adhere to laid down safety arrangements in the production process of component of building to avoid accidents or any other form of hazard on production site or location.

3. RESULTS AND DISCUSSION

Figure 1 shows the particle size distribution for DRS. The result in Figure 1 showed that the DRS samples gotten from the two production sites of sandcrete blocks within the study area have Coefficient of uniformity (CU) of 4.18 and 4.21, while the coefficient of curvature (CC) are 1.52 and 1.61.

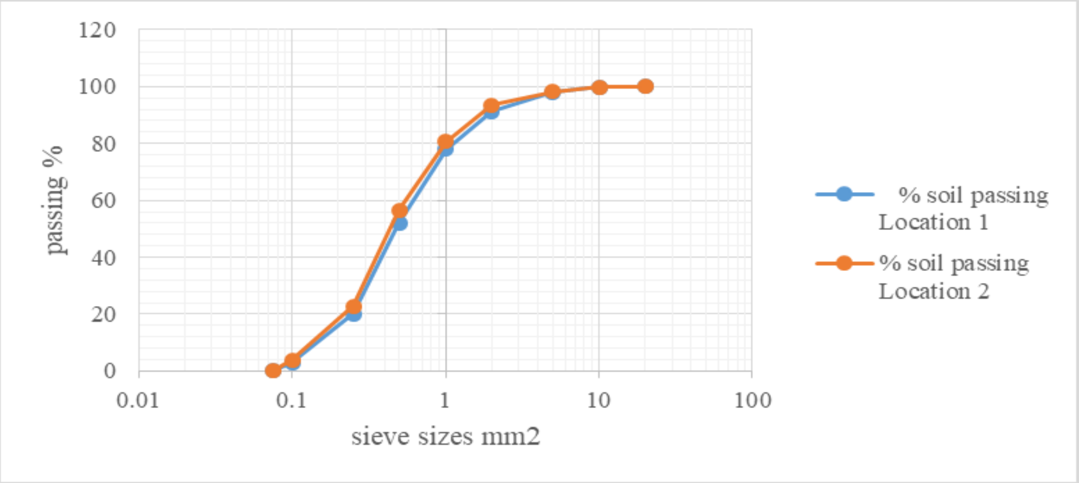

Figure 1: sieve analysis result of DRS

Figure 2 shows the analysis of the bulk density of sandcrete block produced with DRS from the two production sites within the study area. The result showed that location1 sandcrete blocks have density values of 200.18Kg/mm3, while location2 sandcrete blocks have a density of 2023.8kg/mm3 and relatively average density value of 2012.8kg/mm3 for sandcrete blocks for the study area.

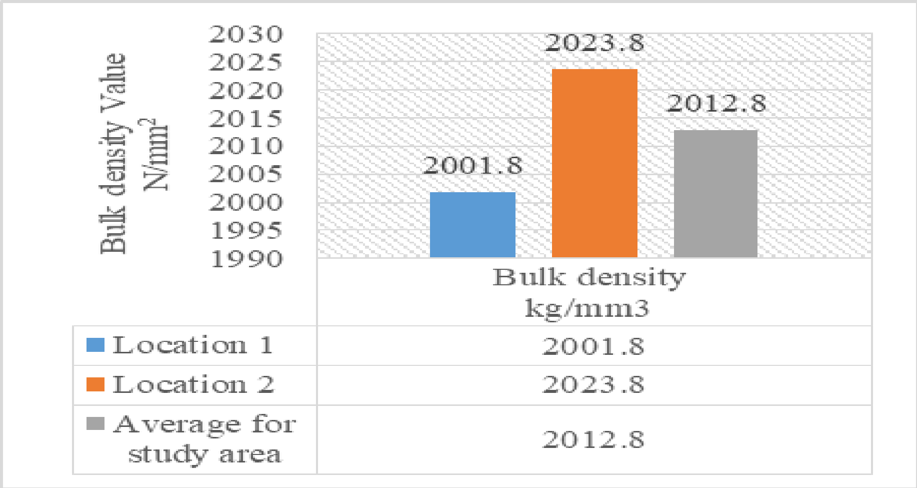

Figure 2: Bulk Density of DRS blocks

Figure 3 shows the analysis of the silt content test carried out on the DRS for the block production sites within the study area. The result showed silt content value of 2.22 % (location 1) and 2.35% (location 2), and relatively average silt content of 2.28% present in the DRS aggregate material within the study area.

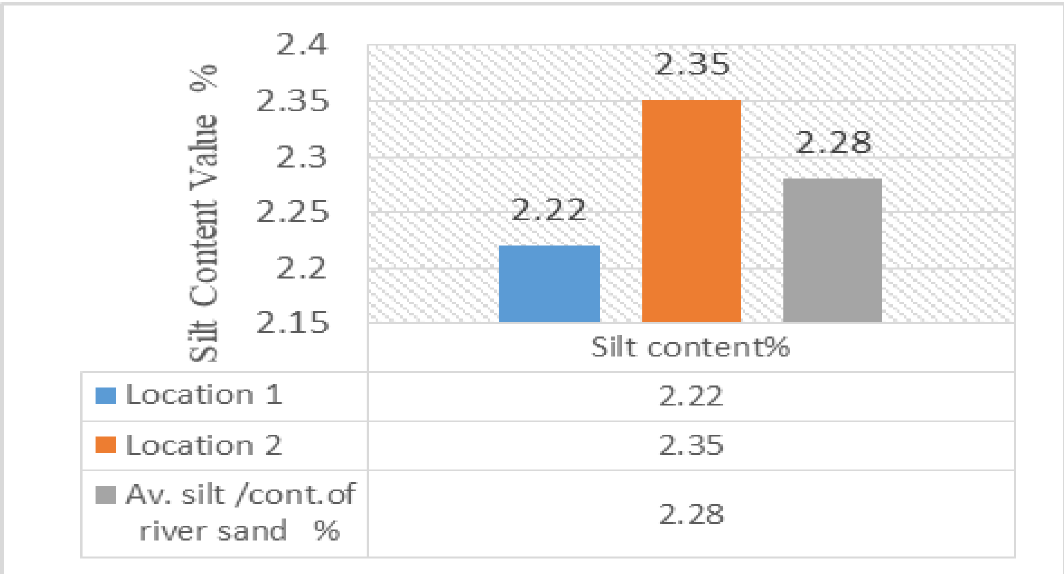

Figure 3: Silt content of sampled DRS

In Figure 4 water absorption of DRS blocks within the study area was analyzed. The result showed DRS water absorption rate of 2.01% (location1) and 1.92% (location 2), with a relatively average water absorption rate of 1.97% for blocks produced with DRS within the study area.

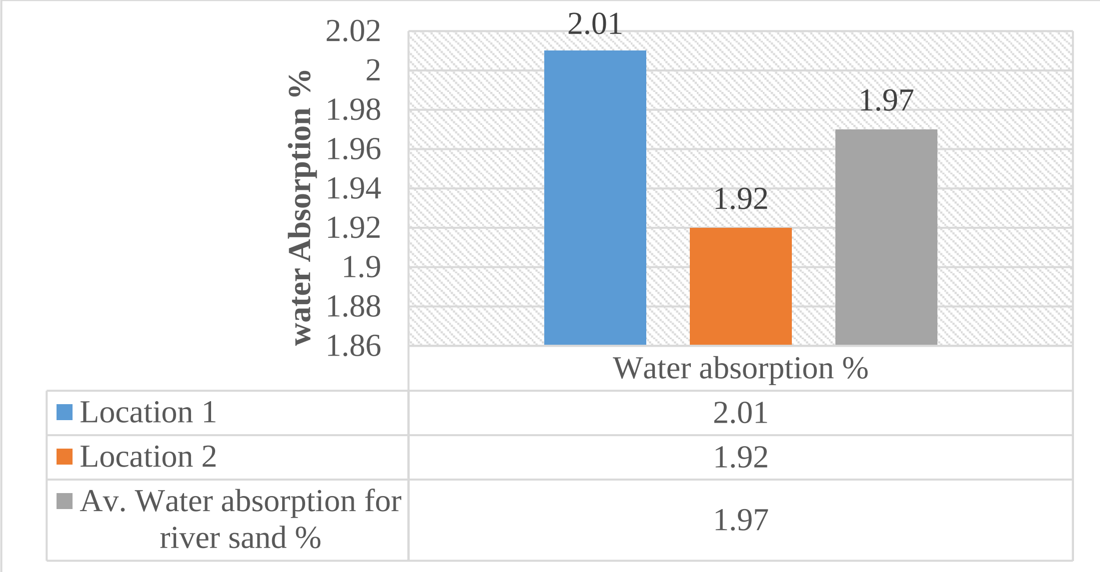

Figure 4: Water absorption of DRS blocks

Table 1 shows the analysis of compressive strength test carried out on sandcrete blocks produced with DRS from location1 and location 2 of the study area. The result showed average compressive strength of 0.94N/mm2 (7days), 1.94 N/mm2 (14days) and 2.48N/mm2 (28days) for sandcrete block produced in location 1, while location2 have average compressive strength of 0.90N/mm2 (7days), 1.69N/mm2 (14days), and 2.47N/mm2 (28days).

Table 1. Strength of blocks produced with DRS

	Location 1. Compressive strength of blocks produced with DRS (N/mm^2)			**Location 2. Compressive strength of blocks Produced DRS (N/mm^2)**		
Days	**7**	**14**	**21**	**7**	**14**	**28**
Test 1	1.02	1.92	2.41	0.83	1.51	2.39
Test 2	0.89	2.01	2.53	0.99	1.89	2.59
Test 3	0.91	1.89	2.49	0.89	1.67	2.42
Average strength N/mm^2	0.94	1.94	2.48	0.90	1.69	2.47

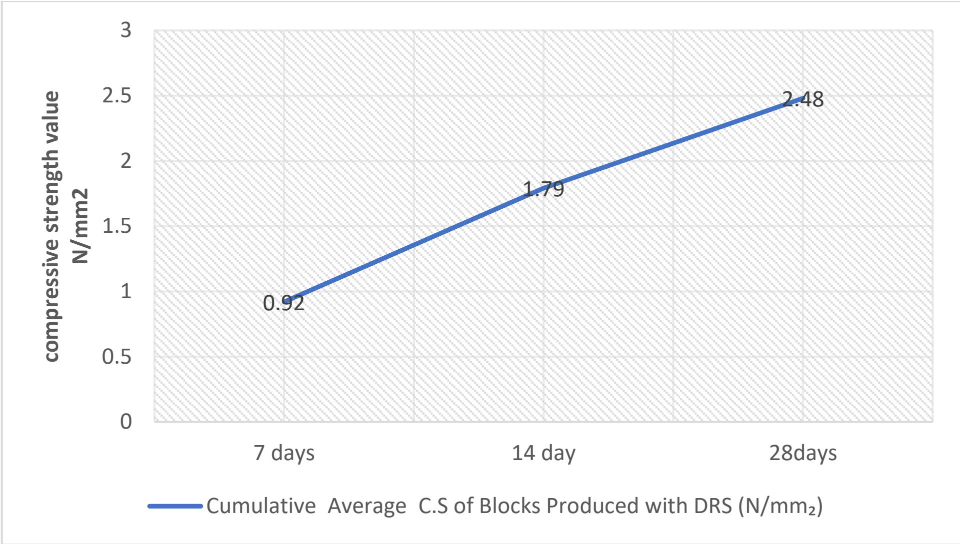

Figure 5: Cumulative Analysis of Compressive strength of blocks produced with DRS

4. DISCUSSION

The analysis of the result of the sieve analysis (figure 1) for the DRS sampled shows that cu>4 and cc for both samples are between 1 and 3. They both relatively meet the united soil classification (USC) and satisfied the particle size requirements of BS EN 933- 1: 1997. they could be adjudged base on the result of the analysis as a uniformly graded soil. The result is in line with the findings of Aginam, Chidolue, and Nwakire (2013); Ede and Agbede (2015) and also related to the finding of Nduka, Fagbenle, Joshua, Ogunde, and Omuh (2018); Ajamu and Ige (2015) that shows that river sand used as an aggregate material for concrete work including sandcrete block production must be uniformly graded.

The result of the bulk density (see figure 2) carried out on the blocks produced with DRS within the study area satisfied the required mean values of 2010kg/mm3 for two or more blocks as specified by NIS 87: 2000. The findings of the study were in conformity with the minimum standard requirement for two or more sandcrete blocks of size 450x250x250mm as prescribed by NIS 87: 2000 and it is also in line with the finding of Ajao et al (2018); Aginam (2013), and Abdullahi 2005.

To evaluate the amount of silt present in the DRS aggregate material, silt content test (see figure 3) was carried out on the sample. The result of the test showed that the presence of silt in the DRS aggregate material within the study area is between 2.22% to 2.35% with an average of 2.28% present in DRS material used for block production within the study area. This result shows that the DRS is an aggregate material that contains fewer impurities with more paste for lubrication and this makes the mixing process easy among components of block in the production process. The result of the study is in line with the findings of Mindless, Young, and Darwin, (2003) and Ogunbayo et al (2018).

To determine the level of water absorption of the block produced with DRS aggregate material. The water absorption test (see figure 4) was carried out on the blocks produced from the two production locations within the study area. The result showed that water absorption for block produced with DRS aggregate together with other adhesive material is between 1.92% and

2.01% with an average of 1.97% water absorption rate within the study area. The result implicates that the water absorption rate of the blocks is adequate. The effect of this result is that the set period of sandcrete blocks produced with the DRS will be timely and this will boost the commercial purpose of the sandcrete block produced. The finding of the study is in alignment with the finding of Neville (2002) and Anosike et al (2011).

One important test that is vital in block production is the Compressive strength test, which is used to determine the durability of sandcrete block in terms of strength and this guides its commercial value in terms of price. In building construction, the strength of block is determined by the method of mixing and nature of materials used or its material compositions. For this study, the strength of blocks produced with DRS aggregate material and other adhesive materials was tested after it was carefully cured between 7days, 14days and 21 days. The compressive result (see Table 1) showed an average compressive strength of 0.94N/mm2 (7days), 1.94 N/mm2 (14days) and 2.48N/mm2 (28days) for sandcrete block produced in location 1, while location 2 have average compressive strength of 0.90N/mm2 (7days), 1.69N/mm2 (14days), and 2.47N/mm2 (28days). The result from Table1 indicated that average compressive strength values for sandcrete blocks after 28days is 2.48N/mm2 for location1 and 2.47N/mm2 for loaction2. Conversely, the cumulative strength analysis (see figure 4) of the compressive values of the tested blocks produced with the DRS aggregate material showed 0.92N/mm^2 (7days),1.79 N/mm^2 (14days) and 2.48 N/mm^2. The finding of this result is comparable to Ajao et al. (2018); Anosike and Oyebade (2012); Odeyemi et al (2015) and Abdullahi (2005).

5. CONCLUSIONS

This study examined the effect of dormant river sand (DRS) on the quality of sandcrete blocks produced and its strength. The sieve analysis result shows that the dormant river sand satisfied the grain size distribution requirements of BS EN 933- 1: 1997 for mortar mix suitable for sandcrete block in housing production. The result shows that the average bulk density result of 2012.8Kg/m3 for block produced with DRS within the study area meet the required specified values of 1920kg/m3 as stated by NIS87: 2000 for blocks used in housing and other construction works. The result further shows that the DRS material sampled with an average silt content of 2.28% contain less amount of mud and other sludge deposit that can affect the quality and strength of blocks produced. Additionally, the result of the study shows that the DRS aggregate material water absorption rate is minimum with an average absorption of 1.97%, and this will boost the setting period during curing for sandcrete blocks produced. The result of the compressive strength of the block produced with river sand shows an average compressive strength of 2.48N/mm^2 (28days) for location1 and 2.47N/mm^2 (28days) for location 2, which shows that the strength of the produced blocks with DRS is in alignment with NIS 87:2000 requirement of 2.5N/mm2 for compressive strength of sandcrete blocks required for housing and other construction work. Therefore the study concluded that DRS aggregate material used in the production of sandcrete block production is suitable and has no effect on its quality and strength. The study suggested that further research could be conducted on partial replacement of the DRS with dormant crushed stone (DCS) together with other adhesive material in block production for further comparison in the area of quality, strength, and suitability.

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GEO-EXPERIMENTAL INVESTIGATION OF NSUKKA SANDY SAND: AN EVALUATION OF ITS ELECTROCHEMICAL PROPERTIES AND ANGLE OF REPOSE USING THE FIXED FUNNEL METHOD

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Abstract: Sand remains an integral part of engineering construction for both building foundation work, road construction work and other engineering construction works. To ensure the safety and durability of engineering construction, it is important to always carry out relevant tests on the materials to be used for the construction. The aim of this study is to determine the electrochemical properties of Nsukka sandy sand and evaluate its angle of repose using the fixed funnel method. The investigation ascertained that Nsukka sand has low salt content and electrical conductivity which ranges from 1090 – 1950 µS/cm. The pH values fluctuate between 6.6 and 7.1 which signifies that the sand is slightly acidic or basic in nature while the chloride content of the sands was 98.5ppm which satisfies FHWA (2009) specifications, however, two samples out of the eight samples investigated were found to have chloride content slightly above 100. The angles of repose of the samples were measured using the fixed funnel method, the results obtained established that the angle of repose of Nsukka sands varies from 24.9^0 – 32.2^0, meanwhile there was a slight variation on its specific gravity which ranged from 2.55 – 2.72, these values represent the typical values for sands. From the results obtained from the analysis, it can be said that Nsukka sandy sand is a good material for engineering construction which can involve concreting, backfilling, etc. It is recommended also that this study be repeated with larger sample points from various locations in South East, Nigeria to enable construction Engineers to make better decisions in material selections during construction. Further studies with larger sample points from various locations will also help in performing a good comparative study.

Keywords: Angle-of-repose, electrochemical-properties, geotechnical-engineering, highway-construction, sandy-soil, cohesionless-soil.

1. INTRODUCTION

Sand is an important construction material as it is one of the major constituents of concrete. Some Sand may contain chemical properties that can trigger certain reactions when it comes in contact with other construction materials. One of the major chemical properties of soil that needs to be known is the acidity of the soil (P^H) level. For road construction, highly acidic soil usually affects the bitumen solidity of the roads, it also causes serious adverse influence on the durability of concrete. Soil salinity which is the salt content in the soil greatly increases the maintenance cost of the infrastructure Geol (2012).

Chemical effects on the structural integrity of most Engineering construction work has become a cause for concern for construction Engineers worldwide. There are many other ways by which undesirable chemicals can affect the structural integrity of engineering construction works which can be via chemical attack from groundwater with a high constituent of sulfate, chloride and high P^H level. These chemicals attack the foundation of a structure when the groundwater comes in contact with the concrete foundation. The resultant effect could be the reduction in strength of the concrete foundation and in extreme cases the collapse of the entire superstructure.

There have been several reported cases of a chemical attack on structures, according to Tulliani, Laura, Alfredo & Mario (2002), he gave an account of how chemical attack deteriorated a concrete foundation of a concrete building in Italy. From the data gathered and analyzed it was clear that the foundation experienced sulfate attack which was caused by sulfate acid. Hobbs (2002) also gave an account of a case of the chemical attack which affected the foundation of a concrete bridge in the United Kingdom. According to the analysis conducted it was discovered that during the backfill there was oxidation of pyrites which led to the formation of sulfuric acid thereby reducing the P^H of the groundwater which resulted in a chemical attack on the foundation. There have been several other reported cases of chemical attacks on concrete and the damages caused.

According to several works of literature Nsukka area lies within the Anambra basin in South East, Nigeria. Several authors Nwajide and Reijer (1996), Agagu, Fayose & Peters (1985) and Ladipo, (1987) opined that this basin was formed during the Santonian and tectonism which happened about 8million years ago and this caused the folding and uplifting of the Abakaliki - Benue trough and subsidence of Anambra platform a neighboring state. There have been several studies regarding the sand formation and the several geotechnical tests which can be conducted to ascertain the geotechnical characteristics of the sand. Nwajide and Hoque (1976), opined that the textural properties of the Ajali sandstone are made up of medium-coarse grained sandstone, sub-angular to sub-rounded quartz arenites. Ladipo (1986) conducted a study on the Tidal shelf depositional model for Ajali sandstone and concluded that the creation was deposited in an environmental spectrum that ranged from marine via transitional to continental. In further studies, Egboka (1983) researched on the groundwater resources of the Nsukka area and her environed. Egboke, Nwankwor, Orajaka & Ejiofor (1989) further assessed the hydraulic conductivity of sandy aquifers situated in Nsukka area using the new statistical grained-sized method, their findings concluded that the hydraulic conductivity (k) of the Ajali sandstone is in the order of 1×10^{-2}cm/s, while the permeability is between 2.0cm^2 to 2.0cm^2 to 20.7×10^{-10} cm^2.

Therefore, it has become important to study the electrochemical properties of sandy sand from Nsukka, a small town in Enugu state, South East, Nigeria to ascertain the level of chemical presence within the sandy soil and also to ascertain its suitability for engineering construction. This paper will showcase the P^H value, electrical conductivity and chloride content of various samples of sandy soil from Nsukka and in addition, this paper will also ascertain the angle of repose of the sample using the fixed funnel method.

1.1 Justification of the Study

To further justify this study, it's imperative to obtain the electrochemical properties and other geotechnical characteristics of the Nsukka sandy sand as this result will provide highway construction Engineers the needed geotechnical information regarding this sand and aid them in making a better-informed decision regarding how best to use this sand for engineering construction work.

1.2 A Brief Review on the Determination of the Electrochemical Properties of Soil.

The electrochemical characteristics as referred to by BS 1377-3:1990 to be considered in this study are pH, electrical conductivity and chloride content (water-soluble). Electrochemical properties form part of the requirements to be met by granular backfill material in Federal Highway Administration stipulations Edil and Benson, (2001); FHWA (2009). See Table 1 below.

Soil can be regarded as the core of the terrestrial ecosystem, and in this regard studies on electrochemical characteristics of soil and the collaboration between charged particles in soil system have practical merits and benefits for environmental production.

Grisso (2009) defined Electrical conductivity (EC) as “the ability of a material to conduct an electrical current and is commonly expressed in units of milliSiemens per centimeter (mS/cm)”. Sands have low electrical conductivity compared to clay, and coupled with their volume stability; they are most preferred in structural backfills Jayawickrama, Amarasiri & Regino (2001).

The amount of chemical substances in soil and soil water is important to geotechnical engineers. Chloride and sulfate bearing soils have implications on the design and choice of soil materials Jayawickrama, Amarasiri & Regino (2001). Chloride (Cl^-) in the soil is soluble and shows little tendency or affinity to its absorption to other soil components. "Its movement within the soil is largely determined by water flows” White and Broadley (2001).

1.3 A Brief Review on the Determination of Angle of Repose of Soil.

A conical heap of sand is formed whenever sands or granular materials are allowed to fall at the same point. If the deposition of the granular materials continues the cone would form a slope as the particles of the material roll over to rest. The angle made with the horizontal when the particles have reached the peak value is what is termed angle of repose. This angle is constant and different for different granular materials. "Since this angle is the steepest stable slope for very loosely packed sand, the angle of repose represents the angle of internal friction of the granular material at loosest state". The angle of repose depends on types of materials and other factors, and it represents the angle of internal friction or shearing resistance at its loosest state Holtz, Konvacs & Sheahan (2011). The angle of repose is used in the design of the storage and transportation machinery of granular material and it can also be used in the determination of several geotechnical factors, for instance, the angle of repose can be used to indicate the flow-ability of granules. The angle of repose can be used in the design of barriers, rock collectors and in cases where the slope angle of soil is more than the angle of repose than a retaining wall needed, therefore, the angle of repose of soil helps to determine where a retaining wall is needed.

To properly understand the behavior of granular materials, Hamzah (2018) opined that the angle of repose of granular material is an important parameter which should be determined in other to understand the micro-behavior of granular materials and connect it with the macro-behavior.

Granular materials can be referred to as a mixture of unique materials which lose energy when they get in contact with other materials, granular materials is commonly known to have a minimum size of 1µm, sand, coarse and cohesionless aggregate are regarded as granular materials when more than 50% of the soil is sand and gravel and they weigh from 0.07 to 5mm and 5 to 75mm respectively. Furthermore, granular materials are usually unique and it's non-plastic as it does not form coherent material when it comes in contact with water, it is important to note that the permeability of granular material is high and this is because of the presence of voids which allows the movement of water across the materials.

In geotechnical engineering, Karl Terzaghi defined an angle of repose as a unique internal friction angle that is attained under extreme conditions. Day (2010) defined angle of repose as the angle of maximum slope inclination at which the soil is hardly steady. In geotechnics, the application of the angle of repose is usually in the design of retaining walls and in the determination of slope stability.

The angle of repose can be affected by many influences such as the angle of internal friction, the shape and grain size, moisture content, density, stratification, interface friction angle, the mass of the material, the pouring height and so many other factors.

The angle of repose can be determined using several methods which are, fixed funnel method, the tilting box method, revolving cylinder/ drum method, hollow cylinder method, and the tilting cylinder method. Each of these methods have its unique characteristics and mode of operation, comparing the various methods of ascertaining the angle of repose poses a challenge because the various methods have unique roles for instance, the tilting box method is utilized based on the assumption that the angle of repose and friction angle are equal which isn't accurate most time. The fixed funnel method is utilized in an area where bulk material handling needed and also in areas where the granular particles are congested or experiencing congestion.

1.4 The Geological Nature of Nsukka Sand.

This section discussed the geological nature of Nsukka sand with regards to its lectostratotype. A lectostratotype can be referred to as a stratotype selected after the main formation of stratigraphic unit, that is planned to serve as the standard in the absence of an acceptable original stratotype.

In conclusion, “Nsukka - Formation can be matched with the lower part of Kerri-Kerri Formation which is in the Upper Benue Trough and the Patti Formation which is found in the mid-Niger Basin. Thus, the lectostratotype of Nsukka formation is here represented as asserted by Uzoegbu et al.

Location - Akpugo Eze, Enugu near Oji River.

Thickness - 214 m (After Federal Department of Water Resources, Enugu)

The section encountered at Akpugo Eze village at Enugu near Oji River is proposed as a lectostratotype for the Nsukka Formation.

Table 1. Lectostratotype for the Nsukka Formation (Uzoegbu et al., 2013)

From (m)	To (m)	Lectostratotype
0	9.1	Lateritic sand
9.1	15.9	Medium – coarse brownish sand
15.9	27.4	Brownish red sandy clay
27.4	33.5	Blackish shales
33.5	38.1	Coarse pebbly blackish sand
38.1	45.7	Hard blackish shales
45.7	54.9	Brownish white sand
54.9	64.0	Sand blackish coarse-grained
64.0	79.9	Shale blackish
79.9	87.5	Sand coarse
87.5	99.1	Shale blackish, organic soft
99.1	117.3	Sandy clay, greenish black
117.3	125	Shales, soft blackish
125	129.5	Sand medium – coarse blackish
129.5	140.2	Shales, soft blackish grey
140.2	186.0	Sand, blackish, medium – coarse
186.0	191.1	Shales, soft blackish grey
191.1	214.0	Sand, blackish, medium - coarse

Table 2: Recommended limits of electrochemical properties for reinforced fills (FHWA (2009)

Property	Criteria	Test Method
Resistivity	>3000ohm-cm	AASHTO T-288
pH	>5 and < 10	AASHTO T-289
Chlorides	<100ppm	ASTM D4327
Sulfates	<200ppm	ASTM D4327
Organic Content	1% max	AASHTO T-267

2. RESEARCH METHODOLOGY

The main materials used for this work are sand samples obtained from different locations at Nsukka. These materials are backfill grade sand samples. Also, reagents used include the solution of pure grade $K_2Cr_2O_7$ (0.1M, BΔH), solution of pure grades AgNO3 (0.1 M) and distilled water. List of equipment used includes pH/EC/TDS meter (HANNA type), set of sieves and sieve shaker, electronic weighing balance, sensitive weighing balance, measuring cylinders, burettes, conical flask, pipette, auger, shovel, conductivity meter, pycnometer, beakers, and density bottles.

A total of eight sand samples were collected at Opi, Obimo and Nkpologu communities of Nsukka. These locations are situated outside the township of Nsukka where settlements are sparse. The borrow pits are located outside the various communities with tough access roads.

The site at Opi spans over a wide area that stretches for many kilometers with various borrow pits. At opi, the sands are generally brown in color and were collected at approximate depths of 1.5 m to 2.5 m at a distance of about 300 m apart. The sand samples were scrapped down from the exposed strata to the floor and about 25kg of the sample was packaged into each polythene bag with the aid of a shovel. Accordingly, the samples were labeled as Opi-I, Opi-II, and Opi-III.

Three samples were collected at Obimo at three different borrow pits. In those locations, samples were taken from the surplus on the floor of the pits using bare hands. The depths of the pits vary approximately from 3 m to 5 m. However, the same quantity of 25 kg (approximately) was collected at each location. The specimens' colors vary from light brown to white. For proper identification, the samples were designated as Obimo-I, Obimo-II, and Obimo-III. Two samples were collected at Nkpologwu borrow pits in a similar way to that of Obimo, except that the color of the sands is reddish-brown. They were labeled as Nkpo.-I and Nkpo.-II. The samples collected were transported to the Civil Engineering Department laboratory, University of Nigeria where they were tested to determine their electrochemical properties.

2.1 Determination of Electrochemical Properties of Soil

About 300 g of the air-dried soil sample was sieved through 2 mm sieve. 150 g of the sieved portion was placed into a beaker and soaked with water in a soil-water ration of 1:2. The mixture was stirred continuously with a spatula for one minute. The mixture was covered with polythene and allowed to soak for 24 hrs. A standard buffer solution of pH 7.0 was prepared and used to calibrate the pH/EC/TDS meter. The electrode of the pH/EC/TDS meter was transferred from a distilled water into a buffer solution and allowed to stabilize to pH 7.0. If the reading does not stabilize to pH 7.0, the meter was manually adjusted until it reads 7.0. The electrode was then transferred to the beaker containing the mixture of soil samples to record the pH. Each reading was taken only after the pH/EC/TDS meter stabilizes. The electrical conductivity (EC) reading was also recorded after pressing the “EC” button to activate the measurement of electrical conductivity mode. Accordingly, the results of pH and EC for all the samples were recorded and tabulated.

For the determination of chloride content, 50 ml of clear water was filtered and measured into a conical flask from the soaked sample as was prepared for the determination of pH above with the aid of the measuring cylinder. Three drops of potassium chromate ($K2Cr2O7$) was added to the soil mixture in the conical flask. A solution of silver nitrate ($AgNO3$) which was prepared at a concentration of 0.1 M was poured into a burette. The initial reading on the burette was recorded as R1. The content in the conical flask was then titrated with $AgNO3$ in the burette until there was a color change to brick red. Titration was then stopped and the reading on the burette was recorded as R2. The results were computed as follows:
Chloride ion (Cl^-) = "ml of titrant X N X 35.5" /"ml of sample" X 1000 (ppm)

Where:
ml of titrant = R2 – R1
ml of sample = 50 ml
N = Normality of silver nitrate in mole = 0.1

2.2 Determination of Angle of Repose – Fixed Funnel Method

The method employed to measure the angle of repose of the samples is the fixed funnel method. The sand sample is air-dried for 24 hrs and carefully broken down into individual particles. A white plain paper was placed on a flat surface of a table. The air-dried sand is poured into a funnel that is held above the paper to form a conic heap. The tip of the funnel was held closer to the growing cone and slowly raised as the pile grows to minimize the impact of falling particles. The same point was maintained for the falling particles from the funnel. After building a cone in this way, the falling sand sample was stopped when the pile reaches an appreciable height. The height of the sand cone, h was measured. The diameter of the cone base was then marked off in the opposite direction and carefully measured with a ruler as "a" and "b". The angle of repose is computed as follows:

The average width of the base of the sand cone, $W = \frac{a+b}{2}$**,** where a and b are values of the diameter of sand cone measured in the opposite direction.

Height, h = height of the sand cone

$$\text{Angle of repose, } \varphi = \tan\varphi = \left(\frac{h}{W/2}\right) = \frac{2h}{W} \qquad (3.7)$$

$$\varphi = \tan^{-1}\left(\frac{2h}{W}\right) \qquad (3.8)$$

2.3 Results and Discussion

Table 3: Table below shows the electrochemical properties and angle of repose of Nsukka sand

Sample No	**Electrical conductivity (µS/cm)**	**PH**	**Chloride (ppm)**	**The angle of Repose (φ^0)**	**Specific gravity (Gs)**
OPI-I	1090	6.9	85.2	24.9	2.65
OPI-II	1320	6.7	99.4	26.3	2.55
OPI-III	1950	6.8	120.7	25.6	2.62
NKPO.-I	1590	6.9	92.3	28.5	2.61
NKPO.-II	1240	7.1	106.5	31.6	2.60
OBIMO-I	1300	6.6	113.6	31.0	2.66
OBIMO-II	1600	6.9	92.3	32.2	2.72
OBIMO-III	1390	6.8	78.1	31.4	2.59

The table above gives the electrical conductivity, the angle of repose, the chloride values and the pH values of Nsukka sandy sands. The values of electrical conductivity are generally low and vary from 1240 – 1950 µS/cm. This indicates that the sands have a low content of salt. This is expected since Nsukka lies on deposits of continental fluvial sands, Ladipo, Nwajide & Akande (1992). The salty content might have been washed out by water during transportation and deposition.

The pH value fluctuates between 6.6 – 7.1 which means that the sands are slightly acidic or basic. The chloride content varies between 78.1 – 113.6 ppm. This implies that all the samples have met the recommended limits for chloride as specified by FHWA except two samples with values slightly above the limit of 100 FHWA (2009). Furthermore, the angle of repose of Nsukka sands varies from 24.9^0 – 32.2^0 and these are accurate due to the fact that they are typical values for sand.

3. CONCLUSIONS

Eight samples of Nsukka sandy sand were tested to determine their electrochemical properties, it was discovered that the samples tested have mean fineness modulus of 2.12 and low electrical conductivity ranging between 1090 – 1950 µS/cm. It was also discovered that all the samples but two met the specified chloride content by FHWA with a mean chloride content of 98.5ppm while the two had a mean chloride content which was found to be slightly above 100. The salt content is low with pH values between 6.6 – 7.1, with this pH value it can be said that the samples are slightly acidic and basic in nature, the angle of repose of Nsukka sands varied from 24.9^0 – 32.2^0 and this was observed to be typical values for sand. From the above results, it showed that Nsukka sandy sand is good for engineering construction works like concreting, backfilling and road construction, however, it is recommended that this study should be repeated with large sample points across the South-Eastern region of Nigeria for better understanding and comparative study.

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NUMERICAL STUDY ON EFFECT OF FIRE ON STRENGTH OF BLAST WAVE AFTER STAND-ALONE HYDROGEN TANK RUPTURE

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Abstract: Using hydrogen as fuel to power vehicles requires it being stored under high pressures, up to 70 MPa. Such storage conditions present detrimental consequences following a tank rupture due to fire, such as blast wave and fireball. Prior to rupture, a high-pressure hydrogen tank rupture surrounded by fire will experience less chemical reaction due to the limited amount of oxidizer available. This reduces the initial combustion of hydrogen, and less chemical energy contribution to the generated blast wave. The purpose of this study is to numerically simulate a high-pressure hydrogen tank rupture and observe the effect of fire, of areas 2 m2 and 21 m2, on the blast wave. Compared to when rupture occurs without fire present, the starting shock wave pressure in the near field is found to be reduced by half, the effect diminishing outside the fire zone area. The relationship between blast wave pressure, concentrations of hydrogen and oxygen and combustion mechanisms are analysed. These results will aid in creating more accurate consequence analysis and harmful criteria within hydrogen safety, taking into regards the effect of fire prior to rupture.

Keywords: Blast wave, combustion, fire, hydrogen, rupture.

1. INTRODUCTION

The introduction of hydrogen (H_2) and fuel cell technologies are targeted towards the aim to enable a sustainable low carbon society. In Europe, the number of fuel cell vehicles are expected to reach 500 000 by year 2020, following increased solutions of technological and safety hurdles (New Energy World Industrial Grouping (NEW-IG), 2011). From a safety aspect, concern of explosion risks associated to vehicle fires on hydrogen-powered vehicles are considered of low probability, albeit with high consequence. The low probability is given partly due to the mandatory installation of a thermally-activated pressure relief device (TRPD). Following an event whereby the tank is exposed to excessive temperature (over 110 Celsius), this relief valve allows the tank to depressurise, which proportionally reduces the risk of rupture and explosions. Due to the very limited data set for high-pressure hydrogen installations weighted against failure rates reported for a broad range of industries, the low sample size is all too decisive (Dadashzadeh et al., 2018). From the relatively extensive experience of compressed natural gas vehicles and information on its failure sources, a large percentage in conjunction with a faulty TPRD is in combination with a fire (Tschirschwitz et al., 2019). In fact, it is mostly due to fire that exposes the biggest weakness of the TPRD, as a localised fire (i.e. when only a portion of the tank is exposed to flames) towards cylinder could avoid the activation of the TPRD and induce a tank burst.

It is now of current knowledge the blast wave is not only of the mechanical energy contained in the tank prior to rupture, but also fed energy from combustion often corresponding to an similar amount of energy (Molkov and Kashkarov, 2015). Observed in high-pressure hydrogen rupture simulations also conducted at Ulster, the period of which the blast wave is fed energy from combustion predominately occurs in the beginning stages of hydrogen release (Molkov et al., 2018). More specifically, where the contact surface between the expanding hydrogen and air where combustion takes place and the shock wave are still conformed. This contribution may be reduced by the presence of flame; a direct visible result of fire consists of combustion products created such as water vapour (H_2O) and carbon dioxide (CO_2) depending on the fuel. This displaced area around the flame with combustion products will reduce the quantity of oxidiser such as oxygen in the air, causing less combustion and therefore energy contribution to the blast wave pressure generated. The presence of fire as it may enhance the process towards a conceivable tank rupture, may be found to have an adverse effect on its consequences. The aim in this study is to further explore the effect of fire prior to high-pressure hydrogen tank rupture with regards to generated blast wave pressure and fireball dynamics. Using computational fluid dynamics (CFD), the use of two fire areas will be simulated engulfing the tank before it ruptures.

2. PROBLEM FORMULATION

2.1. Heat Release Rate and Fire Area

The heat release rate (HRR) of fuel is usually established by testing, as it is not a fundamental property of a fuel and depends on its configuration and thermal conditions; it is often determined by first measuring the burning rate and basing it on the effective heat of combustion. The HHR in vehicle fire from a fuel spill vary depending on vehicle, ranging from 2 megawatt (MW) for a passenger car to well over 200 MW in heavy goods vehicles (Gottuk and White, 2016). To narrow it down to fuel spills of gasoline, the determined value found in the literature lists a HRR of 2.5 MW, determined from a burning of 1 metre $(m)^2$ (Regulat, 2015). This maximum burning rate is derived from burning dynamics of fuels at steady state. Nevertheless, this is close to the value found in an experiment conducted with the objective to examine the HRR of a fire starting in an engine bay of a modern family car (Department for Communities and Local Government et al., 2010). Here, a sudden peak of 2.8 MW was observed, associated with a spillage of gasoline fuel. Using this peak, a correlation that relates the rate of heat release to the pool diameter for various fuels can be used given by Dyrsdale (Drysdale, 2011), a calculated diameter of close to 2 MW/m^2. For fuel spills, experiments show rates reduced by up to 60 %, as spills has much lower fuel layer depth (1-2 millimetres (mm)) compared to fire pools, up to 1 centimetres (cm) (Ingason and Li, 2017). For a propane fire, this would reduce the HRR from 2.5 MW to 1 MW for fuel spill of propane used in this study. A quasi-steady state continuously fed spill fire is envisioned, assumed from a nearby vehicle after a collision. Propane gas is used as surrogate fuel to simulate fire. Attaining the same combustion products of that produced by fossil fuel i.e. CO_2 and H_2O, the HRR for propane is calculated to be the same to that of gasoline. This was done by calculating the corresponding mass flow rate for the desired HRR of 1 MW/m^2 using: $\dot{Q} = \dot{m}\Delta H_{\mathrm{c}}\,,_{\mathrm{eff}}$, where $\dot{Q}$ is the HRR, $\dot{m}$ is the mass flow rate and $\Delta\dot{H}_{\mathrm{c}}\,,_{\mathrm{eff}}$ is the effect heat of combustion (lower heat value), 46.35 MJ/kg for propane. The HRR together with the two fire spill areas selected are listed according to

Table *3*, "small fire" and "big fire" referring to fire of areas 2 m^2 and 21 m^2 respectively, both chosen to enclose the entire stand-alone tank and an envisioned vehicle (sedan) surface area.

Table 3. Calculated spill area sizes and heat release rates.

Size	**Mass flow rate of propane, kg/s**	**Total HRR, MW**	**Fuel spill area, m^2**	**Length x width, m**
Small fire	0.042	2	2	2x1
Big fire	0.453	21	21	7x3

2.2. Computational Domain

The computational domain consists of an unstructured hexahedral mesh with a total size of 311.1k control volumes. The hemispherical domain of 50 m in diameter was divided into three sub-zones, with different degrees of mesh resolution to cater for zones for the initial shock wave, fireball zone and outer boundary zone. The near tank hemisphere was 2 m, containing the most refined mesh ranging 3 – 5 cm. The fireball zone was 8 m in diameter, with mesh sizes between 9 – 25 cm, the remaining domain containing sizes up to a maximum of 1300 cm. The tank was placed 30 cm above the ground, with an internal surface volume of 72.2 litres. Further details of computational domain and mesh can be found elsewhere (Molkov et al., 2018).

2.3. Numerical Details of Fire Simulation

The large eddy simulation (LES) approach was applied with the constant Smagorinsky-Lilly model resolving the sub-grid scale turbulence. A fixed time step size was set at 0.005 seconds (s), ensuring the local convective Courant-Friedrichs-Lewy (CFL) number below 5 always. Convergence level of 1e-06 was set for continuity and species, with 20 iterations per time step inferred. Combustion was applied using the eddy dissipation model (EDM), using a single-step infinitely fast irreversible global reaction of propane and air given in the Fluent material database. Based on the extended Arrhenius equation, values of activation energy and pre-exponential factor for the reaction rate used by Fluent are listed elsewhere (Westbrook and Dryer, 1981). Using EDM however, it has a products limiter term that will prevent combustion occurring when the products fraction is zero ("ANSYS FLUENT 12.0 User's Guide," 2009). Therefore, an iteratively determined mass fraction of 0.01 for CO_2 and H_2O were set as initial conditions in the domain during fire simulation, including air with mass fraction 0.23 for O_2 and 0.75 for N_2.

Simulation of fire was initiated by the fuel supply from an assigned spill area normal to the floor boundary. The inlet boundary for fire spill was presumed already evaporated, and therefore has a constant temperature and mass flow rate according to the determined mass burning rate and heat release rate. To ensure that the effect of heat transfer mechanism in fire was upheld, thermal radiation was applied by the discrete ordinate radiation model, solving the radiative transfer equations for radiation intensities propagation. An important feature to consider for accurate fire simulations of propane, the absorption coefficient was evaluated as a constant of 5 above a temperature of 399 Kelvin (K), determined elsewhere (Kashkarov et al., 2017). Emissivity for all floors mimicking asphalt surface properties was kept constant at 1, assumed opaque and without any absorption of energy.

2.4. Numerical Details for Tank Rupture Simulation

A validated model consisting of LES for turbulence and eddy dissipation concept for combustion was used, details found in validation paper (Molkov et al., 2018), using ideal gas and omitting energy dissipation by structure deformation. Initial conditions of the tank are set to pressure of 70 megapascals (MPa) and temperature of 300 K, attaining an initial hydrogen mass of 4 kilograms (kg). Keeping the same computation domain for rupture simulation, the boundary condition of the tank was changed from wall to that of interior. Correspondingly, the area dedicated as the mass inlet was reverted to wall boundary. In switching the mixture properties from propane-air mixture to hydrogen-air mixture in Fluent, species of propane and carbon dioxide were included to ensure the domain species properties were kept unchanged.

The inclusion of radiation is essential and the discrete ordinates model was modified using data from Yan et al. (Yan et al., 2015) for the calculation of the water vapor mean absorption coefficient. To enforce numerical stability and accurate description of the resolved scales of motion, the CFL number of 0.1 was super-imposed, ensuring an averaging time-step of around 1e-06 s throughout simulation. In simulating the fireball, the methodology of determining the CFL number was altered to encourage less computational time, as a lower CFL number was first and foremost to accommodate for the initial shock wave propagation. Once the shock had left the domain and out of relevancy, the CFL number was increased gradually up to 20, while ensuring that the mass imbalance was ± 1 %.

3. FIRE SPILL SIMULATION AND HRR

In both cases, the simulations were initiated by the fuel released into the quiescent air. To ensure that a pseudo-steady-state fire was achieved before rupture, three sensors were placed 25 mm under the tank to observe the stability of the fire by the temperature profile, as usually required for fire test in experiments (Makarov et al., 2016). Figure 9 shows the transient fluctuations of temperature for all sensors, including the measurement of total heat released rate for both “small fire” (left) and “big fire” (right) simulations. The temperature profile for “small fire” is seen quite steady at 1100 K, and for a given mass flow rate of 0.0415 kg/s of propane the calculated HRR of 2 MW is attained quite accurately in the simulation. The “big fire” temperature profile shows larger oscillations focalised around 1100 K, due to the increase mass flow induced turbulence and mixing within the flame. The calculated HRR of 21 MW is in this case also accurately attained for a given mass flow rate of 0.453 kg/s. With a maximum temperature well below the adiabatic flame temperature of propane (~2300 K), this was expected due to the high radiative heat loss from the flame to the surroundings during simulation.

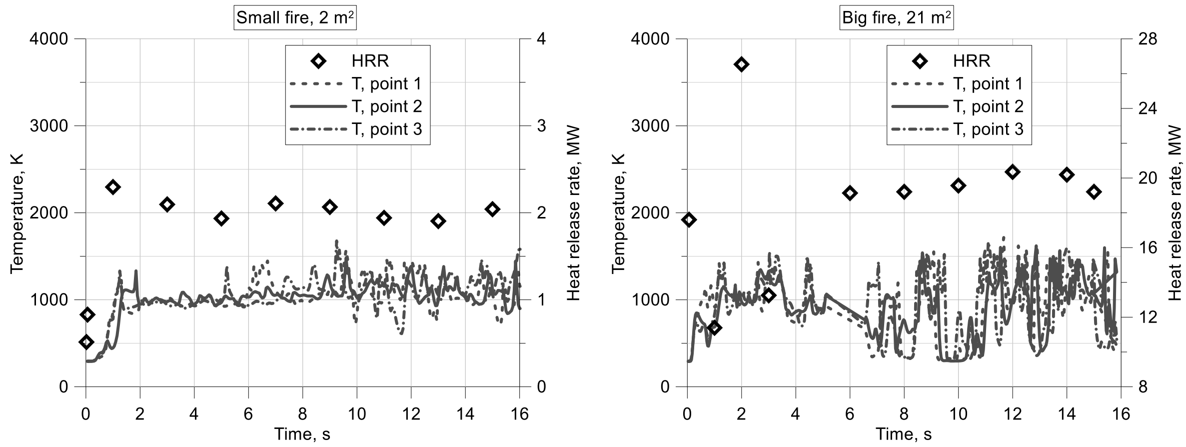

Figure 9. Temperature profiles for three temperature sensors and total heat released during fuel spill fire simulation. Points 1, 2 and 3 are placed 25 mm under tank right, centre and left axially to the tank axis.

To show the intensity of fire, the oxygen molar concentration in both “small fire” and “big fire” are shown in Figure 10. Due to the nature of flames intermittency and turbulence in the reactive flow surrounding the tank, the intensity of fire is seen not occupying the area entirely and narrows inwards in both directions. In perpendicular direction especially, the momentum of entrainment is seen to minimize the extent of width of “big fire” being 3 m, showing minimal difference to “small fire” width of 1 m. Length wise, the differences between “small fire” and “big fire” are more distinctive, for lengths 3 m and 7 m respectively. As the fire area is not equilateral, its influence on the blast wave pressure will likely be different. In addition, within the fire some concentrations of oxygen are seen in pocket areas around the tank likely to induce fire will within its zone. For this reason, the effect of fire on the blast wave is mostly focused in axial direction.

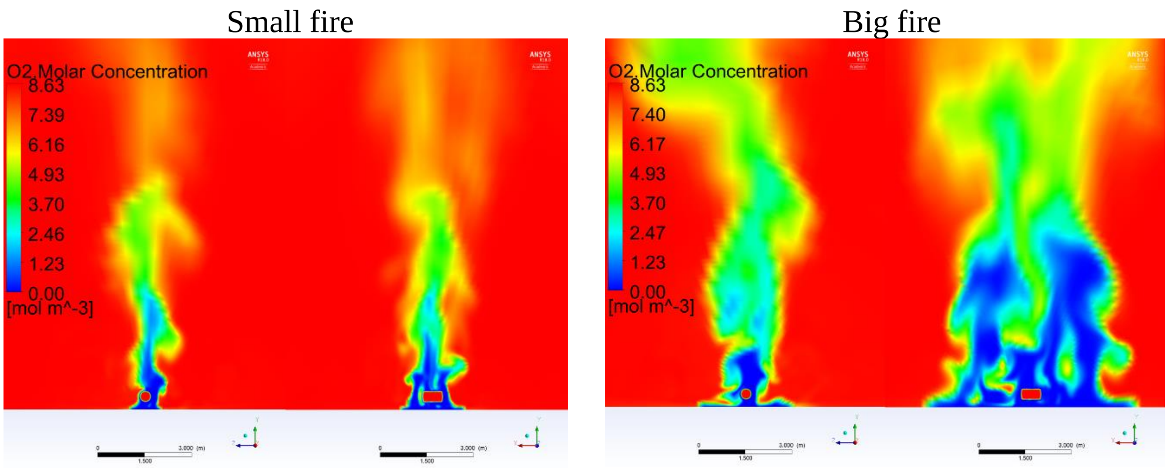

Figure 10. Contour of oxygen molar concentration shown for both fire simulations prior to rupture; directions shown are perpendicular (left half) and axial (right half) to the tank axis. Bottom ruler length is 3 m.

4. INITIAL TANK RUPTURE DYNAMICS

The Mach number profile generated by the pressure discontinuity, a ratio between speed of sound in air and pressurised hydrogen gas, echoes the development of the initial blast wave propagation after rupture. The local speed of sound (i.e. air speed of sound) vary with the various fire cases, it being inversely proportional to the density. In fires, the density of gas in the flame is usually reduced by ¾, inversely proportional to the fire temperature which is quadrupled from ambient temperature. With the expected lower density of air within the fire, the effect shown by the Mach number is visible within the first transient 5 milliseconds (ms) shown in Figure 11. Here, at 0.2 ms and 0.8 ms the Mach number profile is seen more pronounced when fire is present prior to rupture. As the primary shock wave is formed and propagates outwardly, the propagated distance is seen furthest and mort disruptive for "big fire" rupture, followed by "small fire" rupture case. In the case of rupture without fire present, the propagation of blast wave is seen highly hemispherical due to lack of density perturbations in ambient air. In addition, the absence of fire may contribute to a more uniform distribution of energy of combustion to the blast wave.

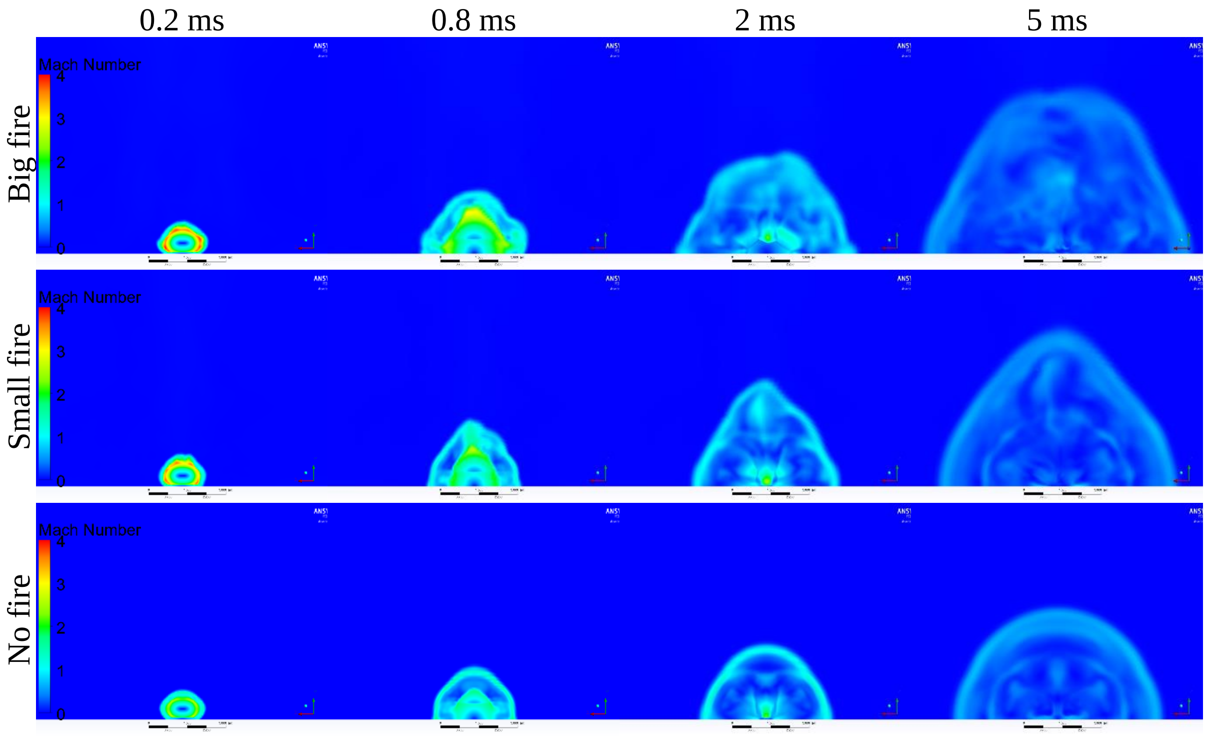

Figure 11. Dynamics of Mach number after tank rupture simulation at various times, in direction axial to the tank axis of. Length of bottom ruler in contour is 4 m.

The thermal energy during a hydrogen release is converted to kinetic energy as the gas is being accelerated and causes temperatures to decrease as low as 50 K for all cases, see Figure 12. However, the effect of fire present prior to rupture reduces the concentration of low temperature region significantly during the first 5 ms depending on the size of fire. The generated fireball of "big fire" rupture is seen more intertwined in all directions, compared to the two other cases of rupture. At 5 ms, a cone like display of the growing fireball is seen for "small fire" rupture, enhancing the fireball growth vertically due to the fire plume established before rupture. "No fire” rupture is seen more like a mushroom form with slight mixing at its core, the higher temperature areas mostly around the edges pertaining the contact surface. The temperature of the adiabatically compressed air is seen above that of the fire from 0.2 ms, around 2200 K across all cases of rupture implying that auto-ignition of hydrogen has been initiated.

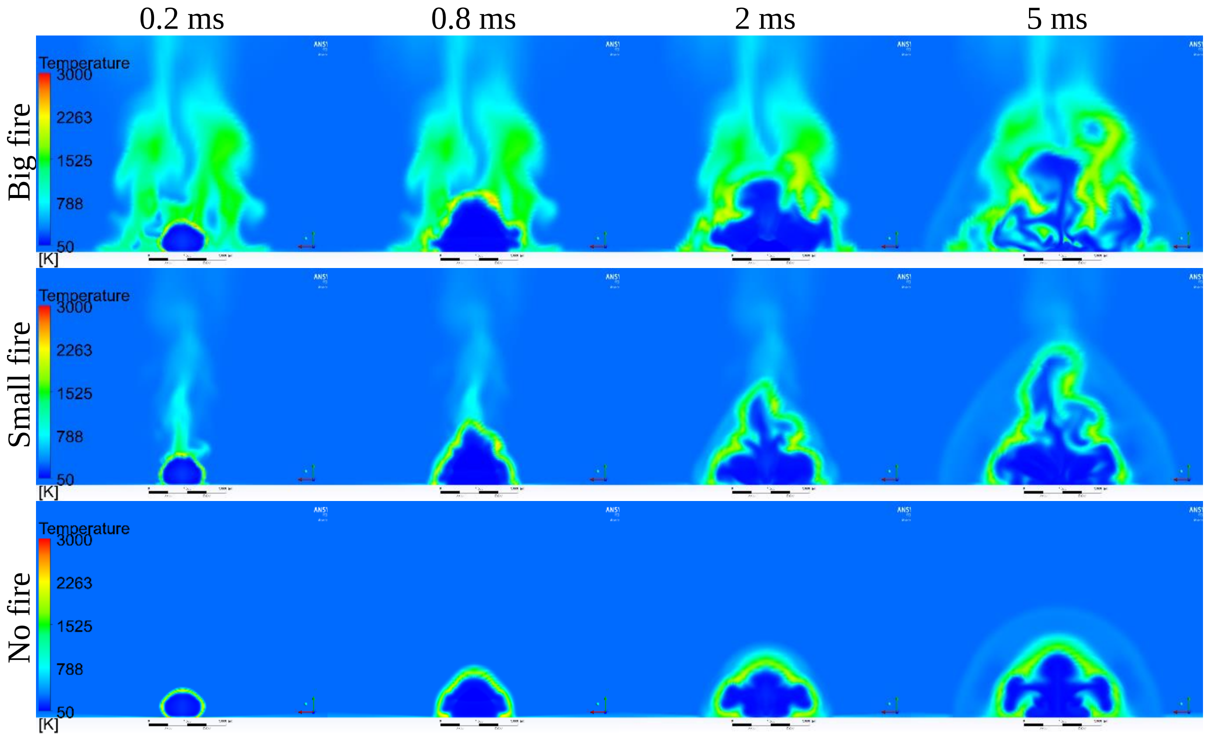

Figure 12. Dynamics of temperature after tank rupture simulation at various times, in direction axial to the tank axis of. Length of bottom ruler in contour is 4 m.

The dynamics of hydrogen mass is shown by its mass fraction in Figure 13. Up to 2 ms as hydrogen expands, the contact surface is seen intact and connected for all three cases with minimal swirls and twists. At 5 ms similar to the temperature profile, hydrogen distribution is highly affected by initial conditions of fire prior to rupture. The presence of fire clearly enhances the turbulence diffusion of the contact surface between hydrogen and its surroundings. For “big fire” rupture especially, the hydrogen is seen intensely diffused and spread out more which assumes a larger percentage of hydrogen burned. “No fire” experiences the least amount of scattering relatively, the mass of hydrogen still aplenty concentrated at around its rupture point.

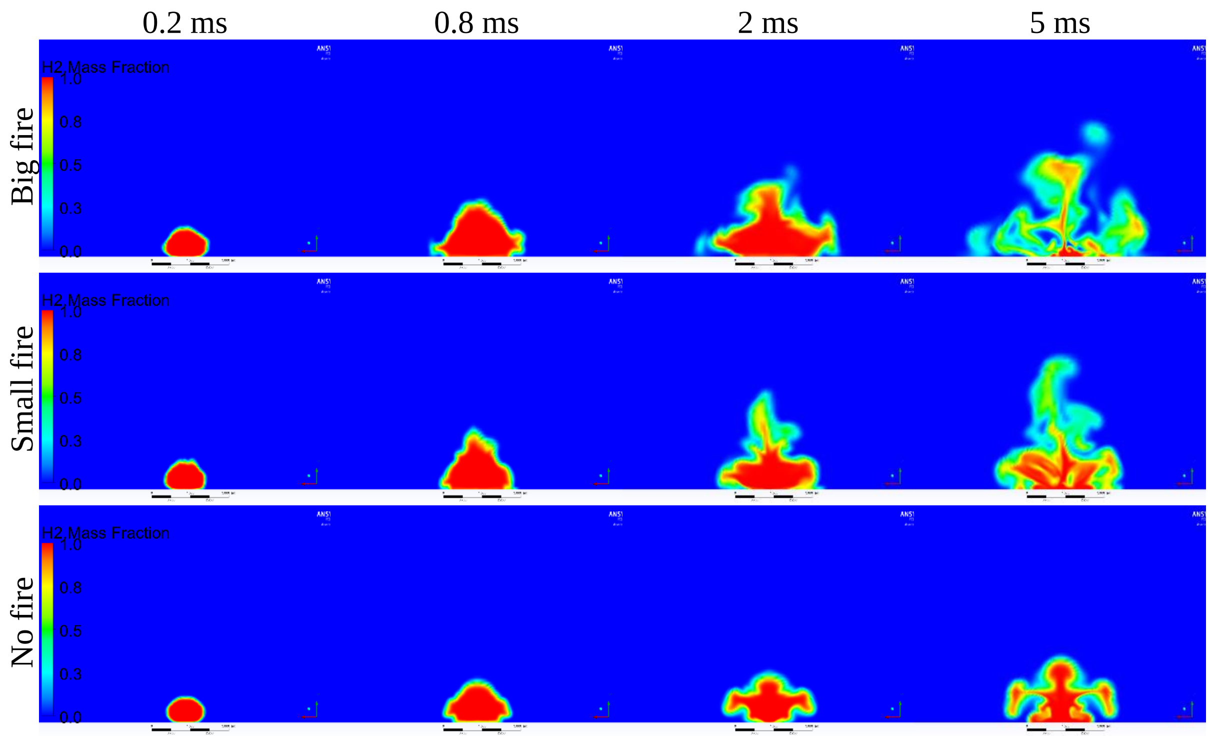

Figure 13. Dynamics of mass fraction of hydrogen after tank rupture simulation after various times, in direction axial to the tank axis of. Length of bottom ruler in contour is 4 m.

Figure 14 shows the amount of hydrogen mass burned for all three cases of tank rupture within the first 10 ms. Within the first millisecond, already over 3 % (0.15 kg) of hydrogen is burned of "big fire" rupture, compared to "no fire" rupture close to 2 % (0.8 kg). Afterwards there is a significant decrease in the rate of hydrogen combustion for all three cases established at 2 ms, more pronounced for "no fire" and "small fire" ruptures. Furthermore, they interchange whereby "big fire" rupture precedes in hydrogen combustion compared with "no fire" rupture. In the following section, the decrease of rate of hydrogen burned found in all three cases will be explored. (Spoiler alert: the dilution of mixtures by combustion products, temperature decrease due to flow divergence and gradual mass and heat diffusion may only partially explain it.)

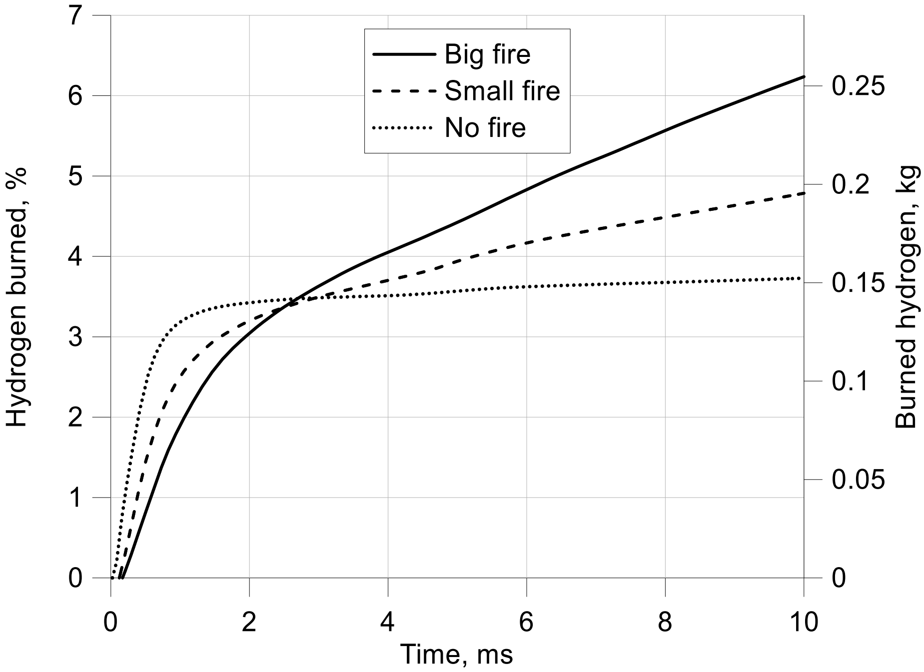

Figure 14. Amount of hydrogen burned as a function of time for all three initial conditions prior to rupture.

5. EFFECT OF FIRE ON BLAST WAVE STRENGTH IN NEAR FIELD

The connection between blast wave pressure, concentrations of hydrogen and oxygen and the chemical reaction rate for production of water vapour spatially distributed at various times during the initial stages rupture is analysed hereafter. For "no fire" rupture seen below in Figure 15, while the expansion of pressure happens together with hydrogen, the reaction rate at the contact surface is seen very pronounced during early stages of hydrogen release at 0.2 ms and 0.8 ms. At 3 ms as the pressure propagates ahead of the reaction zone, the reaction rate subsequently is reduced substantially, from 1e+04 kg/(m^3 s) to around 50 kg/(m^3 s). Also, the reflected secondary blast wave seen around 1 m is seen in conjunction with a higher reaction rate. The reaction rate constant expressed by the Arrhenius equation is proportional to the molar concentrations of reactants, which is again proportional to the partial pressure of a species in the gas phase according to the equation of state. Accordingly, during initial expansion phase where the blast wave and contact surface are linked, two things occur; the high pressure causes a reaction rate of water vapour of several magnitudes higher compared to later stages when the blast wave is well ahead of the reaction zone. Second, the species concentrations, also pressure dependent, increase equally providing concentrations high enough to initiate ignition and sustain combustion even within a fire. For "small fire" rupture (see Figure 16) at 0.2 ms, the expanded hydrogen has reached the 2 m^2 fire area, and the molar concentrations of oxygen compressed air ahead above that found in ambient air (i.e. 9 mol/m^3). Thereafter, the following development of pressure, species concentrations and reaction rate are quite similar to "no fire" rupture. For "big fire" rupture, the reaction rate is seen significantly lower at 0.8 ms, compared to the two other cases at 0.2 ms and 0.8 ms as seen in Figure 17. However, at 3 ms contrarily to the reaction rate reducing as the blast wave propagates ahead of the contact surface, there is an increase. Indeed, the contact surface of hydrogen has expanded beyond the fire zone and the sudden availability of oxygen concentration intensifies the reaction rate with values up to 1000 kg/(m^3 s), despite the blast wave well ahead of the contact surface. A higher "plateau" in blast wave pressure in distance between 1 and 4 m is observed, a direct result of the sustained high reaction rate, the chemical energy contributing to a higher pressure.

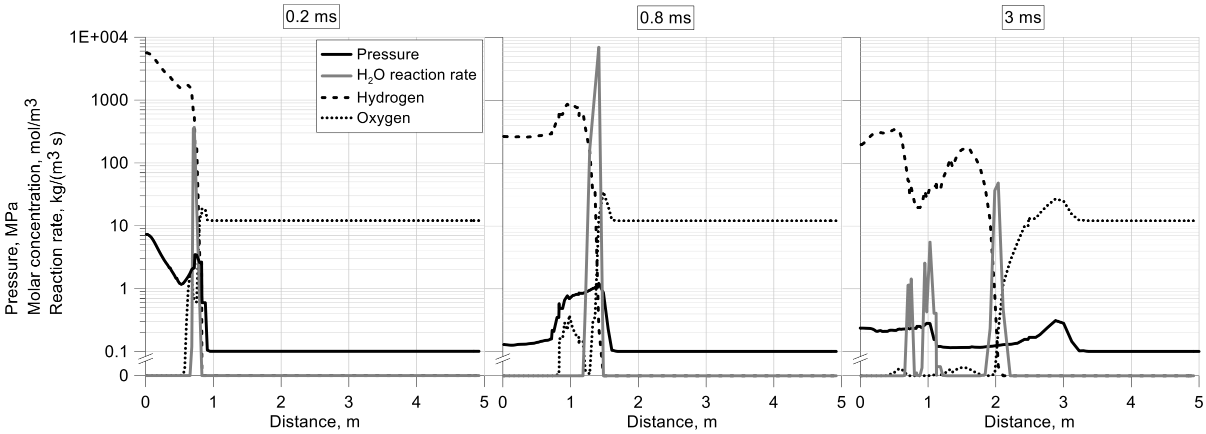

Figure 15. Pressure, molar concentrations of H_2 and O_2 and reaction rate of H_2O of "no fire" rupture, measured axial to the tank axis at various times.

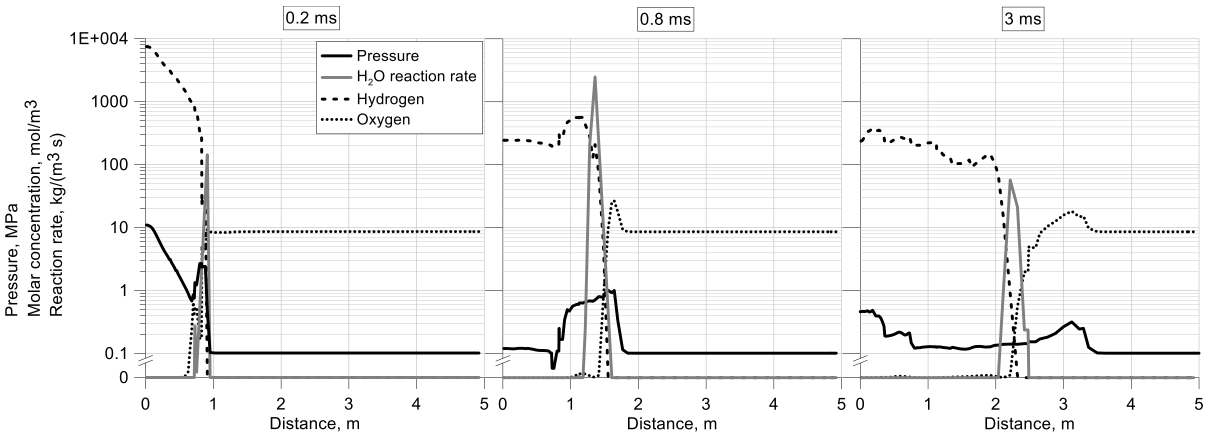

Figure 16. Pressure, molar concentrations of H_2 and O_2 and reaction rate of H_2O of "small fire" rupture, measured axial to the tank axis at various times.

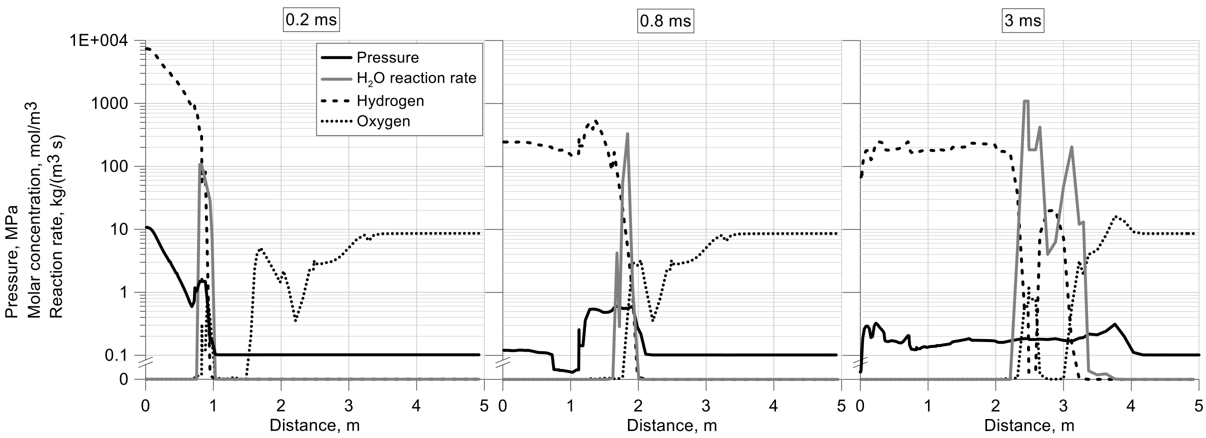

Figure 17. Pressure, molar concentrations of H_2 and O_2 and reaction rate of H_2O of "big fire" rupture, measured axial to the tank axis at various times.

The shock wave overpressure assumed at its maximum right after rupture at the contact surface between the tank gas and surrounding air after rupture can be calculated from equations found elsewhere (Bragin et al., 2013). With the initial stored tank pressure of 70 MPa considered in this study, the starting shock is calculated to be 6.3 MPa. The peak blast wave pressure is shown in Figure 18 (upper graph) for both directions (axial and perpendicular to the tank axis), the lower graph illustrates the difference in blast wave pressure of “big fire” and “small fire” ruptures from “no fire” rupture. It shows that the starting shock wave generated by “no fire” rupture seen at 0.5 m is around 6 MPa in both directions, closely matched with the calculated value. For “small fire” and “big fire” ruptures however, the values for starting shock are reduced by half, 3 MPa lower for “big fire” rupture in both directions, seen in Figure 18 (lower graph). At the respective boarders of “small fire” areas in length and width, the pressure quickly aligns with that of “no fire”. For “big fire” rupture, the effect of fire diminishes apparently before the blast reaches the beyond its borders. As previously observed in Figure 10, the varying intensity of fire prior to ignition influences the blast wave overpressure differently outside the fire core, more noticeable for “big fire” rupture.

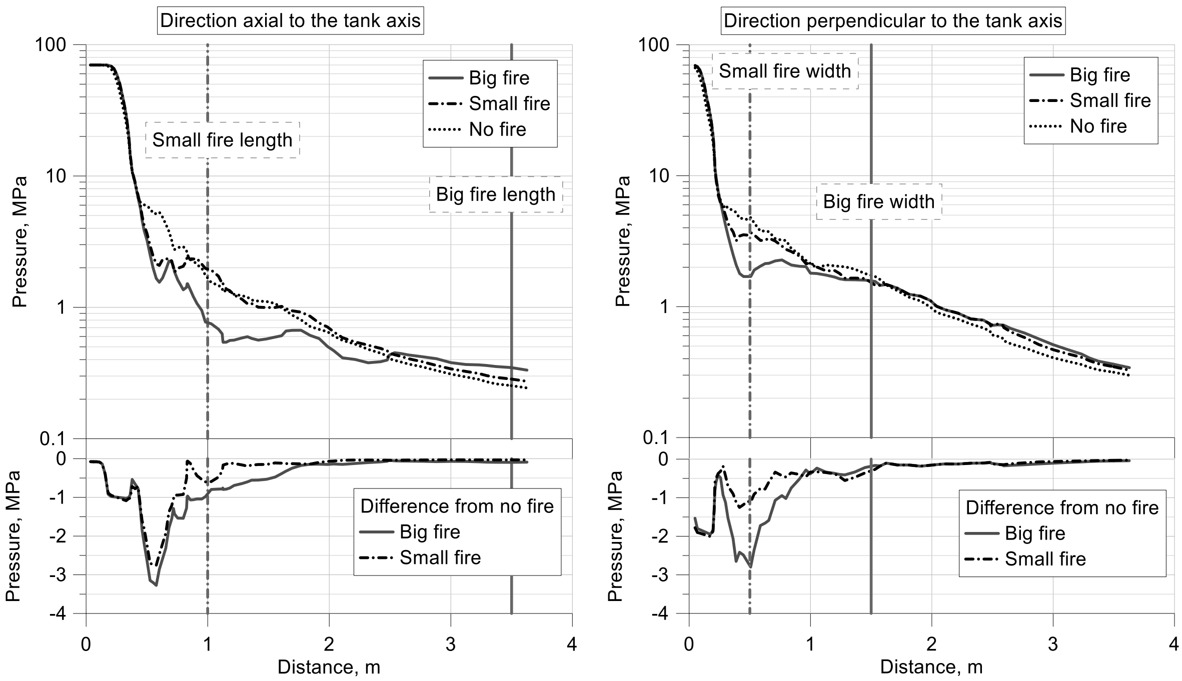

Figure 18. Peak blast wave pressure of tank rupture engulfed in fires of various areas; pressure lines measured along the centreline of the tank diameter (upper graph). Differences in peak pressure are shown in the lower graph.

6. CONCLUSIONS

For this study, a CFD model previously validated for high-pressure tank rupture is used to analyse the isolated effect of fire present of a stand-alone tank rupture in the near field. The details of propane fire surrounding tank prior to rupture contained two areas, 2 m^2 and 21 m^2, of HRR 2 MW and 21 MW respectively. Both fires encapsulating the tank prior to rupture, the intensity of the fire is seen less intense at its boarders, more intense at its core. Furthermore, pockets of oxygen in seen within the flames available to promote hydrogen combustion. During the initial stages after rupture, between 0.2 – 5 ms, the effect of fire causes profiles of higher velocity, more pronounced fireball development and enhanced hydrogen mass diffusion. During rupture in the near field, the presence of fire depending on its area causes a less pronounced blast wave pressure due to a reduced chemical reaction rate, caused by limited oxygen available. Consequently, a maximum of 3 MPa in difference is found in the starting shock pressure compared ruptures with and without rupture present, a direct result of reduced chemical energy contributing the generated pressure. Outside of the respective fire zone areas, the differences in pressure are quickly reduced. In future work, the influence of fire present of a stand-alone tank rupture generated fireball will be investigated. These gathered results will aid in creating more accurate consequence analysis and harmful criteria within hydrogen safety, taking into regard the effect of fire prior to rupture.

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APPLYING THE RESOURCE-BASED VIEW (RBV) THEORY IN SUSTAINABLE PROCUREMENT PRACTICE IN THE AEC SECTOR

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Abstract: In driving the objectives of sustainable development, construction firms have been observed to place 'sustainability policy' as a critical issue in their organisational policies. These policies are mostly implemented through their procurement processes. However, studies have shown that construction firms sustainability policies are rarely reflected in their procurement practices. Some of the reasons argued in relation to this are the complexity of the sector (where it is made up of different actors and supply chains) and a lack of clearly defined benefits to be derived in fully implementing sustainable procurement practices. Also, it can be argued that most firms adopt sustainability practices only to gain legitimacy and competitive advantage rather than complying to government laws or directives. Underpinning this research on the Resource-Based View (RBV) theoretical lens, the study through a literature review proposes a conceptual framework that illustrates how firms resources could be effectively utilised to gain a sustained competitive advantage. The firm's resources are the physical capital resources (digital tools), human capital resources (workers of the firm), and organisational capital resources (supply chains). The firms' capability in effectively utilising these resources enhances the chances of gaining a sustained competitive advantage.

Keywords: Organisation resources, resources based view (rbv), sustainability, sustainable procurement.

1. INTRODUCTION

There have been different calls and agitations for business enterprises globally to be more innovative in the way they operate by having consideration to the impact of their businesses on the environment, society, and the economy. One of the calls is the Paris agreement that was signed by 196 countries in December 2015. The member countries agreed to develop a mechanism for reducing their greenhouse gas emission (GHG) and also for reporting their efforts and contributions (United Nations Framework Convention on Climate Change, 2015, IPCC, 2018). The Architectural, Engineering and Construction (AEC) sector, is expected to contribute significantly in the reduction of the GHG emission because the sector has been noted to be the most significant global consumer of raw materials that accounts for about 25-40% of the worlds' total carbon emission (World Economic Forum, 2016). Furthermore, it has been argued that the development of strategies by organisations that improve environmental performance enhances their organisations image through gaining a competitive advantage in the market and improving relations with the society (To et al., 2015). Similarly, socially responsible firms are likely to increase their turnover, improve public image, enhance employee loyalty, and attract talented persons (Lim and Loosemore, 2017).

It is estimated that about 10 trillion dollars (€8.9 trillion) is spent annually on construction-related goods and services globally, and the sector employs about 7% of the world's working-age population (McKinsey Global Institute, 2017). The significant contribution of the sector to the global economy has called for more proactive and innovative ways of delivering their products and services. In complying with government and clients directives and also in becoming more competitive, leading construction firms have developed several strategies in driving their sustainability goals (Berry and McCarthy, 2011). One of the strategies is through their procurement mechanism (Grob and Benn, 2014, Perera et al., 2007, Bratt et al., 2013). The procurement of good and services in an organisation is commonly believed to account for about 70% of an organisation revenue, which makes a small reduction in cost to have a significant impact on profit (Chartered Institute of Procurement & Supply, 2018). On the other hand, in driving sustainability objectives, the procurement mechanism enhances sustainability performance and innovation that leads to close collaboration amongst the various team members in a project or an organisation (United Nations Environment Programme, 2017, Carvalho and Rabechini, 2017, Sanchez et al., 2014). Belfit et al. (2011) argued that an organisation disposition towards sustainability practice is demonstrated through its procurement process, which has a significant influence on the behaviour and practices of their supply chains.

However, Meehan and Bryde (2011) revealed that organisations sustainability policies are rarely reflected in their sustainable procurement practices in the AEC sector. For instance, it was observed in the Canadian AEC sector that sustainability criteria were rarely reflected in the various bidding documents (Ruparathna and Hewage, 2015). The poor performance of the AEC sector in the delivery of sustainable products has been argued to be as a result of the low level of understanding and lack of knowledge on what 'sustainability is all about' (Akotia et al., 2016, Ruparathna and Hewage, 2015). This poor level of understanding could be as a result of firms lack of willingness to invest in the delivery of sustainable projects (Russell et al., 2018, Upstill-Goddard et al., 2016). This lack of willingness to fully implementing sustainability practice is due to the lack of clear benefits to be gained in investing in such innovation (Upstill-Goddard et al., 2016, Ethical Corporation, 2018). Studies have shown that most AEC firms claiming to implement sustainability, only do so to gain legitimacy and competitive advantage rather than complying to government laws and regualtions. (Rietbergen et al., 2015, Upstill-Goddard et al., 2015). What is required from the AEC sector is to develop strategies that will educate their clients and investors between those who approach sustainability as a public relations (PR) exercise and, those who are genuinely committed to delivering sustainable products (Myers, 2005). These strategies which lead to an organisation's capability can be attained when the organisation's resources are effectively utilised (Barney, 1991). Also, as more firms develop sustainability strategies, the opportunity to develop a competitive advantage becomes more critical (Schulz and Flanigan, 2016). Therefore, how organisation strategies are utilised in the AEC sector most especially in leading contracting firms in driving and implementing an effective sustainable procurement practice is not well understood. This study is underpinned on the resource-based view theory, and it proposes a conceptual framework that provides a foundation for further studies into unveiling how construction firms could utilise their organisational resources in enhancing an effective sustainable procurement performance.

2. THE RESOURCE-BASED VIEW (RBV) THEORY

The Resource-Based View (RBV) developed by Jay Barney, studies the link between a firm's internal characteristics and performance (Barney, 1991). The theory is built on other earlier theories of competitive advantage of the firm. It argues that organisations possess, and have access to bundles of resources and capabilities that form the basis for organisational survival, growth, and overall effectiveness. The theory further assumes that competitive advantage can be sustained in a situation where the capabilities creating the advantage are supported by resources that are not easily duplicated by competitors (Hart, 1995, Barney, 1991). The capabilities of the firm as explained by Barney, is the capacity to assemble a bundle of resources to perform particular value-added tasks or activities (like design, sustainability adoption, and lean). While the resources of the firm are inputs of the production process and comprise of physical capital resources, human capital resources, and organisational capital resources (Hart, 1995, Barney, 1991). The RBV has been extended to include the integration of dynamic capabilities (Helfat and Peteraf, 2003), and natural resources (Hart, 1995).

The RBV theory further explains that the heterogeneity and immobility of an organisation's resources are what enhances its competitive advantage. For resources to have the potential of being heterogeneous and immobile such resources would have to be valuable, rare, imperfectly imitable, and non-substitutability to the organisation (Barney, 1991). RBV theory has been applied in different organisational studies, for example, Meehan et al.(2017), explore the extent to which the United Kingdom (UK) National Health Service (NHS) resources support the strategic adoption of value-based approaches in their procurement practice. In addition, Li et al. (2014), using the RBV theory explores the critical resources and capabilities of design firms in delivering green projects in Singapore. The theory has been one of the most used theoretical lenses that have been applied in understanding organisations internal processes and practices (Touboulic and Walker, 2015). However, there is a lack of research that utilises theories to explain sustainable procurement practices in an organisation (Grob and Benn, 2014), most notably in the AEC sector. Also, most of the research on the implementation of sustainable construction practice focuses more on project-related factors with little emphasis on understanding the internal organisational operations and practice (Li et al., 2014). Sustainable procurement as a process where firms strategiese to effectively engage the various actors in driving sustainability practices can be adequately understood from the RBV theoretical lens. Theoretical understanding in research is necessary because a researcher's findings on the social world are devoid of meaning until situated within a theoretical framework (May, 2001, Koskela, 2008). The adequacy of theory focuses not on its ability to understand and explain social life, but also the potential to change it (May, 2001).

3. ORGANISATIONAL RESOURCES AND CAPABILITIES

As mentioned earlier, organisational resources are grouped as physical capital resources (which comprise the firm's physical technology, plant and equipment, buildings, and access to raw materials), human capital resources (which focus on the training, experience, judgement, intelligence, relationships, and insight of individual managers and workers in a firm) and organisational capital resources (Barney, 1991). Organisational capital resources deal with a firms formal reporting structure, its formal and informal planning, controlling, and coordinating systems, as well as informal relations among groups within a firm and those in its environment. Construction firms need to develop strategies that will enable them to achieve their sustainability goals (Tan et al., 2011) which should be developed to align with various sustainable construction practices. In this context Tan et al. (2011) identified five sustainable construction practices which is: compliance with sustainability legislation, design and procurement, technology and innovation, organisation structure and process, education and training, and measurement and reporting.

The effective utilisation of an organisations' resources creates capabilities that can serve to enhances a firm's competitive advantage. Through continued use and effective utilisation of an organisation's resources these capabilities become more difficult for competitors to understand and imitate (Ruivo et al., 2015). Organisational capability refers to the ability of an organisation to perform a coordinated set of tasks utilising organisational resources, to achieve a particular result (Helfat and Peteraf, 2003). In this study, the organisational capabilities refer to the ability of construction firm or organisation to utilise their overall resources to improve their sustainable procurement performance by paying consideration to the social, economic, and environmental targets. Capabilities can either be classified as operational or dynamic (Helfat and Peteraf, 2003). Operational capabilities involve performing an activity such as manufacturing a particular product, by utilising and coordinating series of task and activities. While dynamic capabilities build, integrate or reconfigure operational capabilities. Dynamic capabilities do not directly affect the output of the firm in which they reside but indirectly contribute to the output of the firm through an impact on the operational capabilities (Helfat and Peteraf, 2003).

As a result of demands from construction clients and regulatory bodies coupled with the complexity of the construction sector, procurement practice has developed from the traditional purchasing for cost and quality to a strategic business practice aiming to deliver a sustainable competitive advantage (Hong and Kwon, 2012). This strategic business practice changes the focus of procurement from the short term cost minimisation to long term value creation and delivery (Walker et al., 2008). Walker et al. (2008), further argues that creating value through procurement is evolutionary and requires longitudinal collaboration. Furthermore, Kähkönen and Lintukangas (2012), explained that value could be generated by capabilities in three areas namely: competing and responding to industry-level challenges, exploiting relationship capabilities, and understanding and responding to customers' needs. The AEC sector in the drive to create value and gain a sustained competitive advantage have developed various corporate strategies (Berry and McCarthy, 2011). Cheah and Garvin (2004) categorised these strategies into seven different groups namely: business strategy, operational strategy, information technology (IT) strategy, marketing strategy, technology strategy, human resource strategy, and financial strategy.

Similarly, in a review of organisational strategies in delivering sustainable projects, Powmya et al. (2017) identified six strategies to be considered by construction organisations. These strategies are framed around human resources, technology, finance, knowledge, capacity development and environmental pro-activeness. However, it is not very clear how construction firms implement these various strategies in their organisations drive to deliver a high sustainable procurement performance (Li et al., 2014). As a result there is a need to explore further the level of importance and performance of the various strategies within a construciton organisation. Assessing the level of importance and performance could enable construction firms to improve their practice and also enhance their organisation's sustainable procurement performance (Martilla and James, 1977).

4. CONSTRUCTION FIRM RESOURCES

Simplifying the complex structure of an organisation Scott (2003), explained that an organisation is made up of four different elements namely social structure, goals, participants and technology. Adapting the Leavitt's diamond model as shown in Figure 1, Scott (2003) explained that the social structure deals with the norms, values and culture embedded in organisation. While the participants (social actors) are those individuals and groups that make contributions to the growth of the organisation. Goals, on the other hand, are conceptions of desired ends that participants attempt to achieve through their performance of task activities. Lastly, technology as an element in an organisation focuses on the tools and techniques for delivering an organisation's goals. However, every organisation exists in a specific physical, technological, cultural, and social environment to which it must adapt (Scott, 2003).

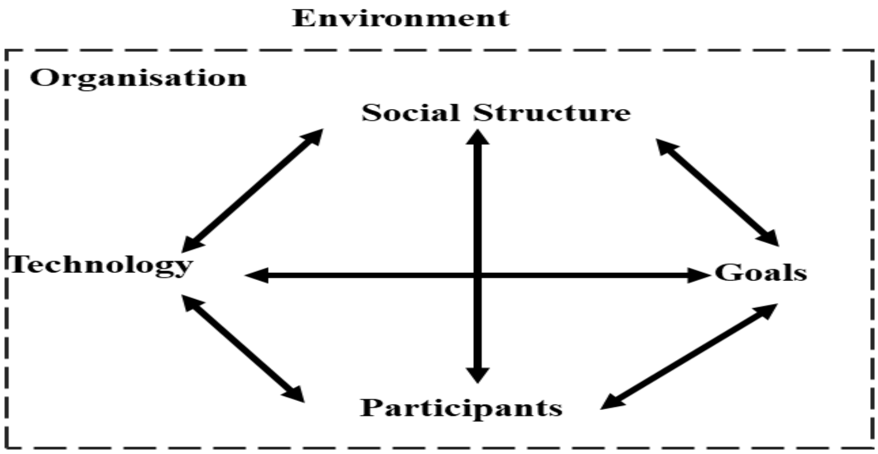

Figure 1: Leavitt's Diamond: A Model of Organisation Adapted by Scott (2003)

In understanding the structure of construction organisations, it has been observed that such organisations are highly dependent on the participation and inputs from different actors and participants (Oyegoke et al., 2010, Tennant and Fernie, 2014, London, 2008). This dependence has resulted in the shift of many contracting firms from the traditional role of active participation in construction works to a mere management role (Oyegoke et al., 2014). In this context the supply chain of a construction organisation is one of the critical resources that need to be effectively utilised in order to derive a sustained competitive advantage. However, it has been found that the adoption of supply chain management in the AEC sector is slow, patchy and inconclusive (Fernie and Tennant, 2013). With the drive to deliver more sustainable projects, the concept of sustainable development practice has been introduced into the supply chain which is referred to as Sustainable Supply Chain Management (SSCM). It is argued the SSCM enhances the performance of a firm and can also help to increase the competitiveness of a company and its supply chain (Chardine-Baumann and Botta-Genoulaz, 2014, Pagell and Wu, 2009). Despite the benefits that have been attributed to the adoption SSCM, Upstill-Goddard (2016) revealed that small and medium-sized (SME) construction firms are always very reactive in adopting sustainability. Leading construction-contracting firms can motivate their supply chains in adopting and implementing sustainability practice through the transferring of knowledge, supplier assessment, supplier development, and instigating competition amongst their supply chains (Meehan and Bryde, 2015, De Giacomo et al., 2018, Krause et al., 2000). Adopting such strategies and supports have the potential to make significant contributions to the economic and environmental performance of the industry

(Hardie,2010). However, there is limited evidence as to how these strategies are implemented in the AEC sector, therefore there is the need to unveil how construction organisations adopt and implement the various strategies in driving an effective sustainable procurement process.

Additionally, with the advancement in technology and automation in the AEC sector, firms are increasingly acquiring different technological tools and expertise to increase their efficiency. These Information Communication Technology (ICT) tools have been employed at all the stages of a construction project. McKinsey Global Institute reported that the adoption of digital technologies could be beneficial in the AEC sector through an increase in profit and performance (Agarwal et al., 2018). Also, Li et al. (2013), noted that the managerial and technological abilities of a firm are related to the firms' performance. For example, the adoption of digital technologies like the Building Information Modelling (BIM) in inter-organisational management will help in managing the inherent complexities of the industry and provide an effective way of managing the supply chain and construction processes (Papadonikolaki, 2016, Papadonikolaki et al., 2015). Both empirical and non-empirical research has shown that digital technology resources can be effectively utilised in driving sustainable procurement practices. Some of the areas that digital technology could be utilised are in whole life cycle costing (WLCC) (Al-Nassar et al., 2016, Borghi et al., 2018), collaboration amongst design team (Craggs et al., 2016), Carbon Dioxide (CO_2) reduction analysis (Rietbergen et al., 2015), and materials selection and recovery (Ahmadian F.F et al., 2017, Santos and Lane, 2017). Although, it is essential to note that the possession of such digital technology tools alone does not enhance their sustained competitive advantage but rather the managerial capabilities through an active process of organising and managing the digital tools is what enhances competitive advantage (Mata et al., 1995, Powell and Dent-Micallef, 1997). In combination these factors can help to deliver a sustained competitive advantage.

The third resource that a firm possesses is human capital and it is vital to ensure that this is effectivley utilised. This deals with the workers from the managerial level down to the base level. Schulz and Flanigan (2016) argued that it makes no sense if a firms adoption of sustainability practices at the corporate level is not entirely infused into the entire organisation and its process. Aligning organisational policies with workers values is one way that a firm can drive their sustainable procurement goals (Rickaby and Glass, 2017, Meehan and Bryde, 2011). It has been demonstrated that aligning organisational goals with workers values can have a positive impact through employee satisfaction, project opportunities and market advantage in firms that embrace corporate sustainability culture in their business practices (Eilers et al., 2016). Besides, by utilising the human capital resources and developing sustainability capabilities, Terouhid and Ries (2016) argued that workforce management and knowledge management are the critical components to people capability, which plays a vital role in the attainment of the sustainability performance of construction firms. These capabilities can be developed when organisations invest in critical resources through recruitment of experienced staff, education and training, employee empowerment and a reward system (Powmya et al., 2017).

5. CONCEPTUAL FRAMEWORK

The RBV theory focuses on an organisation's strategic internal operations and processes. In this study, this theoretical lens helps to demonstrate how the organisation's social structure can help in ensuring the full utilising of participants and technology in driving their organisation's goals. The physical resources considered in this study are the various digital technology tools possessed or owned by the firm. The human capital resources are the entire workforce working in the construction firm, while the organisational capital resources constitute the various supply chain members which constitute trade contractors and material suppliers. In an effort to drive the adoption and implementation of sustainable procurement, leading construction firms have placed sustainable procurement as a primary focus in their organisational policies (Berry and McCarthy, 2011, Zuo et al., 2012). However, the implementation of these policies by leading construction firms in their procurement practice needs to be further understood. For instance, Zuo et al. (2012), observed that sustainability policies vary amongst the different construction firms studied, and also Meehan and Bryde (2011) observed that organisation's sustainability policies were rarely reflected in an organisation's procurement practices.

The conceptual framework developed using the fishbone (Ishikawa) diagram, as shown in Figure 2, illustrates how a firms resources can be effectively utilised in driving an effective sustainable procurement practice.

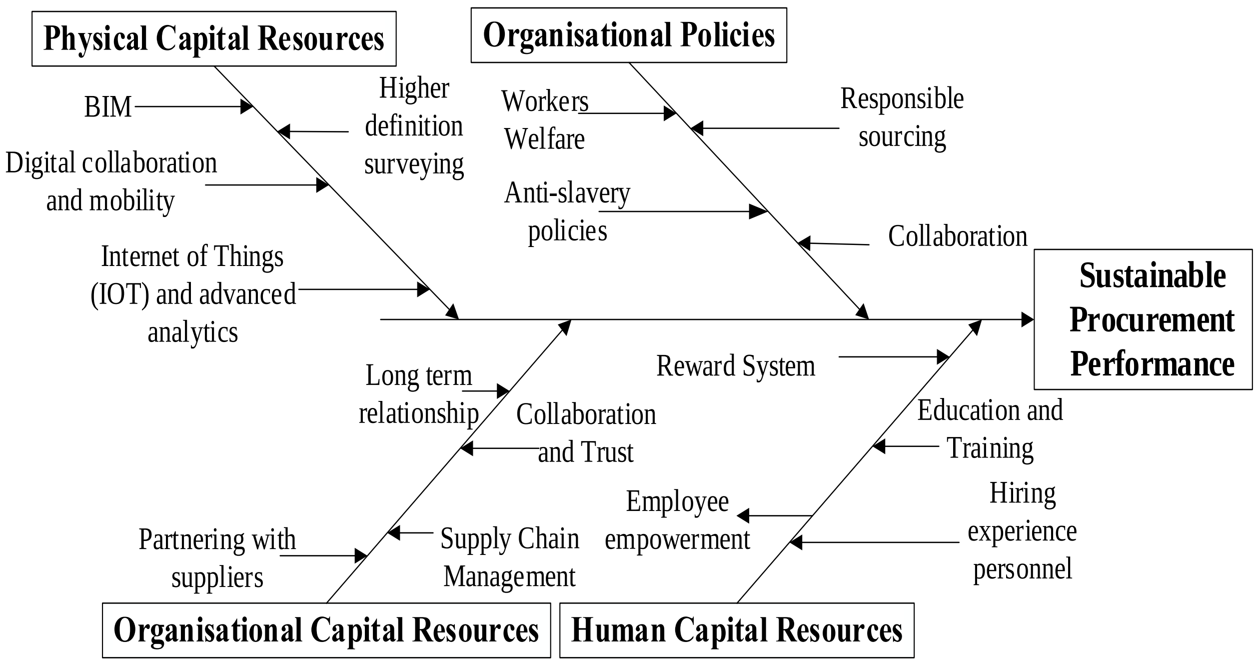

Figure 2: Conceptual Framework for Sustainable Procurement Performance

The utilisation of the organisational resources is driven by organisational policies developed at the corporate level, which leads the firm in meeting their client's demands and government regulations. The organisational policies set out the organisation's expectations and requirements in meeting their social, economic and environmental goals. As it was earlier discussed the RBV theory focuses on the internal operations of a firm. Focusing only on the internal operations of the firm limits a broader understanding of the external factors in the environment like the demand side of the market, and constraints imposed by the biophysical (natural) environment (Hart, 1995). Although the theory is quite relevant in helping managers to thoroughly understand the kind of resources that help generate sustained strategic advantages. It also helps them use this understanding to evaluate the full range of resources their firm may possess, and then exploit those resources that have the potential to generate sustained strategic advantage (Barney, 1991).

The conceptual framework has provided a springboard that will guide further study in analysing construction firm sustainable procurement practice. The framework will also help to understand how the various organisational resources could be effectively utilised to achieve a high sustainable procurement performance.

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PHYSICAL RESILIENCE FACTORS TO ENHANCE COMMUNITY RESILIENCE TO PLUVIAL FLOODS IN THE UAE: THE CASE STUDY OF ABU DHABI CITY

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Abstract: In recent years, the United Arab Emirates (UAE) has become vulnerable to several natural hazards including floods. Flood hazards have become a global concern as they considered a serios threat to lives and livelihoods. Consequently, enhancing community capacity to overcome these hazards has been recognised as important approach in disaster management. The aim of this paper is to identify the key factors within physical resilience dimension to enhance community resilience to pluvial floods in the UAE. The methodological choice of this study is qualitative exploratory design to understand comprehensively the main factors that influence community flood resilience in the UAE. The case study research strategy is used in this study which performed in Abu Dhabi city. To collect data, semi-structured interview technique has been conducted with top level management level from different local authorisations. The results presented a number of critical factors such as infrastructure capacity, building condition, building design and location of built environment. These key factors benefit communities in the UAE through appropriate preparedness to prevent and mitigate pluvial floods impacts and build more flood resilient community.

Keywords: Pluvial flood, vulnerability, resilience, community resilience, Abu Dhabi, UAE

1. INTRODUCTION

Our planet has experienced an accelerated degree of an increase the earth's temperatures and changing climatic patterns. One of the mostly magnified of these changes can be recorded in the hydrologic cycle due to higher water evaporation and increased precipitation (Ye et al., 2014). Consequently, the amount of water in our planet has been increasing as a combined result of increased precipitation and sea-level rise. All these changes, coupled with higher degree of urbanization, have led to an increase in both the frequency and intensity of natural disasters (Field, 2014; EM-DAT, 2015). According to World Bank Report WB (2010), there have been more than 82,500 deaths every year because of these natural disasters in the last four decades (1970-2010), and costed large economic losses was US$3.8 trillion from 1980 to 2012 (WB, 2014). The hydrological disasters are considering the most recurrent type of natural disasters in 2016. They have led to significant damages in properties and loss of lives in different parts of the world, which urged governments to try to find preventive measures to limit these negative impacts. The total number of people affected by hydrological disasters in 2016 was 78.1 million. There are different types of hydrological disasters such as landslide, tsunami, and flooding (Guha-sapir et al. 2016). From all these types, floods are the most common natural disasters, representing 35% of the total natural disasters globally (Le Polain de Waroux, 2011). The occurrence of floods has considerably increased all around the globe in the last three decades, (EM-DAT, 2015). In 2010, the total number of people affected by flooding was 178 million people which represented over 56% of all disasters (Renaud, 2013). There are various categories of flood such as river floods (fluvial floods), groundwater floods, artificial water systems failure, coastal floods, and pluvial floods (Jha et al., 2012; Ingirige & Amaratunga, 2013).

Pluvial floods are normally unexpected, without any warning, and sudden, which arise from continuous and heavy rainstorm (UKELA, 2014). Because of the lack of land surface permeability (low rainfall absorption level), urban areas are the most common areas expose to pluvial floods (Jha et al., 2012). Many scholars argued about the fact that climate change has a significant influence to increase the severity of pluvial floods and they are difficult to manage and predict (Houston, et al., 2011). This bring a real challenge to deal with it and provide enough warning time. Moreover, population growth and shifting people to urban areas have an impact on increasing the demand for the expansion of urban areas and that leads to change hydrological characteristics. According to Du et. al (2012), there are several environmental problems caused by rapid urbanisations and that include: changes in water resources and hydrological processes of the area, climate change, the effects urban heat island, and the species extinction.

The UAE has also exposed to a number of natural hazards especially pluvial floods as a cause of climate change that may originate from atmospheric, geological, hydrologic, or anthropogenic factors (Dhanhani, 2010; Al Khaili & Pathirage, 2014). The weather in the UAE is dry and hot where the rainfall generally is rare (less than 120 mm (4 inches) of rainfall per year). Despite of that, the recent storm hit Abu Dhabi city was in February and March 2016 which caused flooding across the city where up to 295 mm (11.6 inches) of rain have fallen which caused negative impacts on infrastructure, properties, people and economy (Perring, 2016; Miller, 2016). This was a clear indication that the natural hazards are a real threat to communities and the city. According to Almarzouqi (2017), the UAE has experienced a rapid population growth and decades of development which have led to the expansion of urban areas. However, there is a lack of literature related to floods mitigation measures in the country to protect the community from these hazards. The UAE should work effectively to enhance the procedures and long-term planning which play their role in building flood resilient community. This paper purposes to explore and identify the key factors within physical resilience dimension for developing a framework which may help local authorities in the UAE in building community flood resilience.

2. COMMUNITY RESILIENCE

It has been witnessed that communities in different parts of the world has sought for enhancing their integral life and the well-being of the overall people (Steiner, and Markantoni, 2013). Marsh and Buckle (2001) opined that the term community contain a spatial and geographic dimension which could be applied to explain everyone who is living in a particular region. Community is defined as "a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in geographical locations or settings" (MacQueen et al., 2001). Many communities around the world have faced numerous hazards and disastrous situations which has caused for thousands and millions of deaths within a community (Huppert and Sparks, 2006). With the natural disasters destroying infrastructure and taking thousands of lives etc. it has become indispensable for community to adopt particular measures against these disastrous elements so that they can create sustainability for better community welfare in future scenario (Aldrich, 2012).

The term of resilience has been used within disasters perspective in the 1980's and was associated to the notion of capability to absorb and recover from a dangerous event with minimum damage or impact (CARRI, 2013). The main objectives of resilience are to avoid, reduce, or minimize the detrimental consequences of disaster with minimum social disruptions (Tierney & Bruneau, 2007). There is growing acknowledge and effort to move towards comprehensive frameworks to support the development of resilience system. Recently, researchers Manyena (2007) and Sherrieb et al. (2012) stated that the term of disaster resilience is considered one of the most common concepts used in disaster management especially after adapted Hyogo Framework for Action (HFA) in 2005.

Consequently, community resilience is considered a basic feature of disaster management and homeland security (USDHS, 2010). It is a property or characteristic of the community, a potential outcome, and a dynamic process. It reflects the capacity of community in terms of establishing emergency plans and getting ready for any unexpected event while be retentive about the capability to be reactive and flexible to the individuality of the current condition (Wickes et al. 2010). Moreover, there is an agreement between many scholars about community disaster resilience as it refers to community ability to absorb, withstand and recover from hazards. Community resilience to disasters could be improved by emphasising the development of various measures of disaster management and by also promoting of active collaborations and connections between the emergency managers and the members of community (Longstaff et al. 2010; López-Marrero and Tschakert, 2011).

Many studies have estimated different and several dimensions to measure community resilience, however challenges are still in the development of normal metrics or regular elements that can be used to measure and assess community disaster resilience. Since resilience is a multi-dimensional notion, developing methods of resilience that are meaningful and measurable remains a challenge (Norris et al., 2008; Cutter et al., 2010; Peacock et al., 2010). For example, Cutter et al., (2010) proposed a framework that includes five resilience dimensions which are social, economic, environmental, infrastructural and finally community competence. However, other authors suggested a framework for community resilience assessment containing four main resilience dimensions: physical, institutional, social, and economic (Ainuddin & Routray, 2012; Qasim et, al. 2016). This paper will focus on physical resilience as a main dimension to enhance community resilience to pluvial flood in the UAE.

Physical resilience dimension is considered as the most essential dimension in building resilient communities to natural disaster. According to Qasim et, al. (2016) and Yoon et, al. (2016) physical resilience dimension refers to location of built environment, properties and infrastructure such as critical facilities and lifelines services. Longstaff et al. (2010) clarified that the increase in flexibility of physical system level is required to build physical resilience which able to bend instead of break. Similarly, Mayunga (2007) noted that critical facilities are essential to ensure that residents have support and resources during crisis. Many studies stated that the physical resilience could be accomplished to face the potential hazards by following good practices and measures which revolves around adequate maintenance, appropriate rainwater drainage systems, quality construction, and implementing intelligent engineering designs (UNESCAP, 2012). Therefore, the lack of critical facilities or physical infrastructure might pose direct adverse impacts on the communities' capacity to cope and adapt with these disasters.

3. THE CASE STUDY

Abu Dhabi city is the capital of the UAE and its located on the Arabian Gulf coast and it is bordered by the Kingdom of Saudi Arabia to the south, Oman to the east, and the emirate of Dubai to the northeast. The main region in emirate of Abu Dhabi is Abu Dhabi city where it has many suburban districts such as: Al Bahia, Khalifa City, Al Rahba and Al Shahama (Abu Dhabi Urban Planning Council, 2013). The hot and desert climate is a common climate in Emirate of Abu Dhabi with high humidity level and high temperature (usually more than 40ºC in summer). The city is experiencing an irregular and infrequent rainfall events where annual average is about 120mm or less. low-lying sandy deserts and extensive salts-flats in the coastal areas are the main features of the landscape of Abu Dhabi emirate. It also contains alluvial plains and gravelly plains covering wide areas of the Emirate (Shahid & Abdelfattah, 2008). Moreover, there is increasing in number of populations in Abu Dhabi city. For example, between 2010 and 2016, Abu Dhabi city experienced one of the fastest growth rates which was 5.6% as a result of increasing numbers of migrant people specially from Asian countries. The total population of Abu Dhabi city in 2016, for both residents and non-residents, was 1.807 million people (Statistics Centre Abu Dhabi (SCAD), 2018).

4. STUDY METHODOLOGY

The main purpose of this study is to determine the key physical resilience factors to improve community flood resilience in the UAE. The nature of this study is qualitative research design. According to Johnson& Christensen (2019), this kind of study attempt to understand the situation realities and feelings through investigating the 'what'. The qualitative design is presumed to help the researcher to get a comprehensive understanding of the critical factors within physical dimension to build a flood resilient community. The case study strategy is the best-suited strategy to reach the study aim as it will help in exploring a particular phenomenon and collecting a reliable data. The semi-structured interview technique is adopted in the current study so that the respondents feel the liberty to express their own perceptions and personal experiences (Yin, 2009). The interviews have been prepared by following three main steps. Firstly, through using non-probability sampling technique, the researcher has selected the appropriate participants for interviews who have enough knowledge and experience related to the study. Secondly, the researcher has applied pilot test in order to determine if there are weaknesses or limitations within interviews design. The Third step is that the researcher has allowed to make necessary revisions before applying the study. Therefore, 12 semi-structured interviews have been conducted with top level management level from different governmental bodies which are involving in emergency management in Abu Dhabi city. Each interviewee has been given the code **"R"** including to a numeric serial number (table 1).

Table 1: Profile of interviewees in Abu Dhabi

Organization	Years of Experience	Code
Abu Dhabi Police	15	R01
Abu Dhabi Police	19	R02
Abu Dhabi Police	17	R03
Abu Dhabi Municipality	16	R04
Abu Dhabi Municipality	18	R05
Abu Dhabi Municipality	25	R06
Abu Dhabi Distribution Company	17	R07
Abu Dhabi Distribution Company	20	R08
Abu Dhabi Civil Defence	16	R09
Abu Dhabi Civil Defence	19	R10
National Crisis & Emergency Management Authority (NCEMA)	23	R11
National Crisis & Emergency Management Authority (NCEMA)	18	R12

During the interview process, and in case of any needed clarifications, the participant had freedom to ask any question to get a comprehensive understanding about interview questions, where it is important that the interviewer balance free-flow and directed conversation (Lee, 1999). To ensure reliability and validity of the collected data, the interviewees were allowed to check the transcripts after the interviews were completely transcribed. The researcher analysed the key factors that contribute to effective community resilience to pluvial floods after careful reading of the notes or transcripts. Through using content analysis method, the interviews content was presented as a paragraph text which divided into segments of information. According to Krippendorff and Bock (2008), content analysis is useful technique and its utilised for identifying and determining the occurrence of particular words of themes within the content. It is used to analyse qualitative data through systematically converting text to numerical variables (Collis & Hussey, 2013). Therefore, after preparing the transcripts and identifying the key themes, the interview themes were coded into nodes using NVivo 12 software.

5. RESULTS

The participants were asked in this study to state or explain main factors that contribute to enhance community resilience to pluvial flood in the UAE in term physical resilience. It was found that the participants were concerned about the fact that effective physical resilience; such as infrastructure, building condition and design, and location of built environment; has a positive impact on community to prevent or mitigate pluvial flood risk in the UAE. These key factors are mentioned below.

5.1 Capacity of Infrastructure

The first critical factor to enhance community resilience is availability of integrated infrastructure which help to protect communities and properties from flood hazards. All participants have agreed that the existence of effective and integrated infrastructure can help to prevent and mitigate the impacts of pluvial floods. For example, Interviewee **R03** said that "*I think an effective infrastructure is the main measure to mitigate or even sometimes to prevent flood impacts*". Interviewee **R06** supported that "*An effective physical construction such as infrastructure and critical facilities help to reduce or avoid possible impacts of hazards and to achieve hazard resilience in systems or structures".* He also added that "*This includes construction of rainwater drainage system and retaining wall to protect roads and both private and public properties*". This clearly showed the participants agree that the existence of an appropriate infrastructure can help to build an effective community resilience to flood risk. From this main factor "infrastructure", there are some sub variables help to mitigate flood effects as following:

5.1.1 Rainwater Drainage System

All respondents confirmed that an effective rainwater drainage system can play an important role to mitigate flood impacts where failure of drainage systems leads to urban flooding. For example, interviewee **R02** stated that *"One of the most important structural measure for managing floods is the existence of rainwater drainage network"*. Similarly, interviewee **R05** clarified that "*I think the current infrastructure help to reduce flood risk, such as rainwater drainage systems and protect streets, houses and people from flood risk, and it needs to be continuously improved".* He also explained that the local authorities take into consideration the historical rainfall data to design the appropriate drainage system to reduce flood risk. He said that "*The design of rainwater drainage system based on the historical data available to consider suitable rainfall intensity. By considering appropriate rainfall intensity, optimum pipe size will be determined*". Moreover, interviewee **R12** stressed the significance of rainwater drainage system to mitigate flood risk *"The main measure to manage flood risk is to have an effective rainwater drainage system".* Another interviewee **R10** supported that as rainwater drainage system is the main structural measure to mitigate flood impacts, he said that "*The effective rainwater drainage system can obviously mitigate the impacts of flood risk as its one of the major structural measure to manage floods".*

However, interviewees **R01, R03, R04, R06** and **R09** argued that current rainwater drainage system needs continue improvement where some zones in the city still not covered with rainwater drainage system. For example, interviewee **R04** said that *"Currently, drainage facilities are not as effective in some areas as expected due to large amount of rainfall in one-time event, also there are some zone in the city still not covered with rainwater drainage system".* Also, interviewee **R09** confirmed that need for regular assessment and development in rain water drainage system, he said that *"There is a need for regular development in rain water drainage system through increasing their capacity and construct a new one in the new developed areas in Abu Dhabi".* This clarified that there is insufficient and ineffective rainwater drainage system in some zones in the UAE, and it was suggested by participant to develop the existed rainwater drainage system and build new one for new projects to maintain accepted level of flood mitigation.

5.1.2 Critical Infrastructure and Facilities

The second sub factor that consider one of the most efficient means of making community more resilient is to make critical infrastructure and services more robust to flood hazards and that will help to reduce damages or loss probability. However, efforts of local authorisations must be put into disaster recovery if community's critical infrastructure and facilities, such as electric power grids, communication networks and transportation system are not enough robust to these kinds of hazards. The majority of respondents (n=10) mentioned that robustness of critical infrastructure as an effective way to build community resilience to floods. Interviewee **R08** explained that *"During flood event or any natural hazard the lifeline services such as power and water services must be protected and maintain with the same level through integrated and well-prepared infrastructure".* Moreover, interviewee **R11** clarified the importance of diversity of transportation networks during emergency and for wellbeing community. He said that *"It is also necessary to consider the improvement of existing transportation system as there is no diversity in transportation system. For example, there is no train network available in Abu Dhabi city to connect different cities in the UAE where the current dependence only on the roads/ highway network especially during emergency".* In the same context, interviewee **R05** had the same point as he said that *"It is essential to protect critical infrastructure such as power stations and hospitals from any expected hazard especially floods. This includes strengthening and rehabilitation of existing structure"*. However, interviewee **R07** argued that in most cases flood losses can't be prevented as efforts must focus on quick response and recovery to accepted level of the lifeline services. He said that *"Sometimes the expected resilience is estimated to be below the desired targets because of severity of flood risk, then the efforts are focus on flood response and recovery measures to provide the essential services such as electricity and telecommunication to normal level as soon as possible".* Therefore, there is a general agreement among participants that robust critical infrastructure and services can improve community resilience by minimise losses during floods.

5.1.3 Maintenance Programmes

To keep the efficiency and effectiveness of infrastructure facilities such as rainwater drainage system it should be there an annual maintenance programme. Two interviewees confirmed that a regular maintenance of rainwater inlets, catch basins and rainwater conveyance structures will has many benefits through preventing clogging of the downstream conveyance system, removing pollutants and ensuring properly system functions to avoid flooding. For example, Interviewee **R05** stated that *"Through applying a good planning process to provide an efficient infrastructure and rainwater drainage system under annual maintenance programme, the municipality undertake maintenance tasks in order to minimise the any possible flood situation. The task generally includes cleaning storm inlets, chocked culvert, cleaning and outfalls etc before the monsoon/ rainy season start"*. Moreover, interviewee **R04** had the same point as he stated that *"It is important to rehabilitate and maintain rainwater drainage networks before raining season".* Hence, the participants affirmed that providing an appropriate maintenance programmes have a positive impact on minimising flood risk in the UAE through maintaining the effectiveness of infrastructure facilities.

5.2 Location of Built Environment

The second key factor the help to enhance community flood resilience is location of built environment. Most of respondents (n=9) emphasised that built environment location is critical measure to avoid and mitigate flood risk and this contribute to community survival and recovery. Interviewee **R12** said that *"I think flood risk might be prevented if houses and buildings are not located in flood prone areas".* He added that *"The current land use practices in the city avoid construct in flood prone areas such as Wadis to minimise flood impacts".*

Moreover, through knowing and determining flood prone areas, flood structural measures and the type of building or houses can be selected and applied such as building elevated houses to avoid or minimise flood risk. Interviewee **R06** emphasised this point as he said that "*It is important to protect people and buildings in flood prone areas through increase elevation of houses and construct flood defence system; such as: levees, storage ponds and pumping stations*". In the same view, Interviewee **R07** stressed that the critical infrastructure and facilities should always be built in a safe area away of flood risk, he said that "*Critical infrastructure and facilities such as power plants and hospitals should be far away from flood prone areas".* Therefore, the participants emphasised on importance of the location of built environment as main factor to avoid flood risk and enhance community resilience in the UAE.

5.3 Building Condition

Building condition is also another key factor that help to protect people during floods. Eight respondents have agreed the building condition has a great effect on reducing flood risk. For instance, interviewee **R02** emphasised that a good condition of houses or buildings minimise damages during floods. He said that *"I think the condition of buildings could also help to enhance community resilience by mitigating the impact of floods where the average age of buildings in Abu Dhabi city is less than 30 year which consider more adapted to natural hazards such as floods"*. Moreover, interviewee **R10** explained it more as he said that *"During flooding, it obviously that damages in new building are much lower than in old building as they built with good standards and materials that adapt natural hazard with strong structures"*. However, there is a need for regular maintenance for old houses in the country to boost their strength in facing flood risk. This is obviously illustrated by interviewee **R01** as he said that *"We have generally a good and new construction in the city but there is a need to do a required maintenance for old houses as some of them built before 1980"*. Hence, some participants saw that building and houses in the UAE mostly are quite new and in a good condition which help to reduce in some cases flood impacts and build resilient community. But others, emphasised on regular maintenance for old buildings that existing in the country to adapt flood risk.

5.4 Building Design

The design of buildings or houses can effectively minimise flood impacts if flood risk takes into consideration. The current designing standards opting for more resilient performance through better building design and that will minimise operational failures cost due to disruptive events such as floods. Six respondents clarified the importance of building or houses design to reduce flood risks. Interviewee **R06** affirmed that there is a need to consider flood risk in designing stage for new construction. He said that "*Due to the dry environment in the country, little attention has been paid to flood risk in the past. Currently we can see the gate of many houses or buildings is in the same street level and that let flood water to enter inside houses. There is a need to develop building design to adapt flood risk"*. Interviewee **R08** confirmed that *"We often see the level of houses is less than the level of roads or at the same level and this led rainwater to enter and affect houses in an easy way putting people at risk"*. Thus, participants were concerned about there are some limitations in designing of houses or buildings in the UAE to adapt with flood risk as result of dry and hot weather. They suggested that to consider flood risk in design stage of building or houses to help to build more resilient community. Figure 1 illustrates all main factors and subfactors within physical dimension in the UAE as they identified by participants.

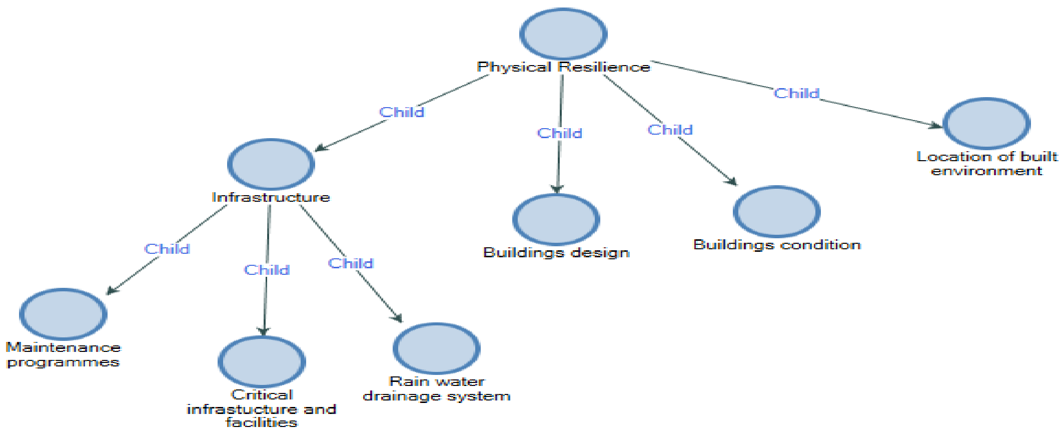

Figure 1: The key factors and subfactors within physical resilience dimension using NVivo 12.

6. DISCUSSION AND CONCLUSION

The findings of this paper showed that the physical resilience dimension is important aspect in community flood resilience framework. It was noted that the current infrastructure needs sustained improvement to mitigate flood risk happening in the future, where some areas in the UAE are still not covered with rainwater drainage networks. The results also indicated that the design of buildings and houses should be developed in order to adapt flood risk as little attention has been paid before to flood risk due to weather condition in the country. Moreover, it was found that location of built environment and building conditions are critical measures to avoid and mitigate flood risk in the UAE. These findings are in agreement with many studies (Mayunga 2007; Peacock et al., 2010; Qasim et, al. 2016; Alshehri, 2016) which indicated that communities with effective physical infrastructure, appropriate building condition and design, and with safe location, which is away from disaster risk, may help to build resilient communities through improving their ability to prepare for, respond to and recover from disasters.

To conclude, this study has attempted to identify the key factors of community resilience to pluvial flood in the UAE in term physical dimension. The results show that there are four key factors within physical dimension that may help to enhance community flood resilience in the UAE. These key factors included infrastructure, location of built environment, building condition and building design. Therefore, this paper demonstrates that further efforts and works are needed to build community flood resilience framework in the UAE. This framework requires further research work using interviews technique in term of other resilience dimensions, such as institutional, social and economic.

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A SERVITIZED BUSINESS MODEL FOR IMPROVED CIRCULAR ECONOMY PERFORMANCE IN CONSTRUCTION

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Abstract: The construction industry has continued to deploy traditional business models for project delivery instead of adopting servitized business models or service-led construction assets. This fixation has been blamed for the increasing rates of client/customer dissatisfaction. Clients are being continuously offered products that are not aligned to their business needs thereby impeding maximum functionality. Worse hit by the continued use of traditional project delivery business models in the industry is the increasing quest for improved circular economy performance by clients. Based on the foregoing, this conceptual study seeks to propose a framework for improved Circular Economy Performance using a Servitized Business Model approach within the South African construction industry. Adopting a qualitative case study research design, this study will conduct semi-structured interviews with a purposively selected sample consisting of construction clients and construction company owners. Expectedly, preliminary findings from this study provide an insight into the utility of the servitized business model in achieving the previously mentioned objectives or otherwise, albeit from the perspective of select stakeholders. This conceptual paper forms part of the PhD study which is still in its nascent stages.

Keywords: Business model, circular economy, construction industry, servitization.

1. INTRODUCTION

The construction industry has been consistently labelled as an industry that undermines the sustainability of the natural environment due to the nature of its activities. Available evidence indicates that it has continued to destruct the environment whilst consuming a considerable amount of resources and generating an equal amount of waste (Ametepey, Aigbavboa, and Ansah, 2015; Djokoto, Dadzie, and Ohemeng-Ababio, 2014). Over time, scholars propose the adoption and implementation of various sustainable construction processes as a panacea for resolving this challenge (Ametepey et al., 2015; Djokoto et al., 2014; Kibert, Sendzimir, and Guy, 2000).

Likewise, an increase in the advocacy by construction clients for the delivery of sustainable built environments has been observed: built environment that meet the needs of humans today without compromising the future generation's ability to meet their own needs. (Feigie, Wallbaum, and Krank, 2011; Akanbi, Oyedele, Akinade, Ajayi, Delgado, Bilal, and Belloe, 2018). Thisobserved rise in advocacy levels has been traced to the need for the development and sustenance of a pro-sustainability institutional reputation by construction clients as well as the enablement of operational effectiveness of institutional buildings and processes. One such area where this quest for functionality has been buttressed is in delivery of value across the whole-of-life cycle of the project/asset (Feige et al., 2011). Sustainable construction seeks to achieve set principles which includes minimizing resources consumption, increased utilization of renewable and recyclable resources, protecting the natural environment, and pursuing quality (Djokoto et al., 2014).

As part of society's sustainable development (SD) mandate, a new paradigm known as circular economy (CE), is now gaining momentum. The CE is defined as an "economy which is regenerative by design" (EMF, 2013); "an economic system where products and services are traded in a way to overcome the current production and consumption model based on continuous growth and increasing resources throughput" (EMF, 2013:20; Ghisellini, Cialani, and Ulgiati, 2016). A report by Potting, Hekkert, Worrell, and Hanemaaijer (2017) highlights several circularity strategies (9Rs) that exist to reduce the consumption of natural resources and materials, and minimise the production of waste ranging from "smart product use and manufacture (Refuse, Rethink, and Reduce)", to "extended lifespan of product and its parts (Re-use, Refurbish, Remanufacture, and Repurpose)" and "useful application of materials (Recycle, and Recover)".

The nature of client and supplier relationships have since changed due to some developments in the global economy. Hence, businesses are increasingly becoming client driven, since innovation has developed to permit the provision of information and customer solutions at lower cost. These advancements require businesses to re-evaluate their value propositions for customers (Teece, 2010). Also, Teece (2010) maintains that business model innovations have been necessitated by technological advancements which create both the need to bring new discoveries to market and the opportunity to satisfy unrequited customer needs. Similarly, new business models, in themselves, represent a form of innovation. There is in existence, a plethora of business model possibilities: some will be much better adapted to customer needs and business environments than others.

As indicated in the literature, one of the key empowering agents for CE is in reality, the new utilization culture, where the responsibility and ownership of products is not the fundamental centre of focus; rather, it's optimum functionality (Ghisellini et al., 2016; van Loon, Delagarde, and Van Wassenhove, 2018; Junnila, Ottelin, and Leinikka, 2018). Accordingly, researchers have recommended that renting, as opposed to owning, is the fundamental mandate of a CE business model as it allows manufacturers to create sustainable products without cannibalizing their own sales.

The seeming inability of traditional business models to enable improved CE implementation in the construction industry has been noticed Servitization has been suggested as a panacea to resolving this challenge, especially as it concerns CE performance (Falk and Peng, 2013; Kryvinska, Kaczor, Strauss, and Greguš, 2014). But to date, little is known about the operationalization of servitized business models (SBM) and its utility in engendering improved CE performance within the construction industry. This is the gap which this study shall seek to contribute towards bridging.

2. LITERATURE REVIEW

2.1 Circular Economy (CE) Performance in the Built Environment (BE)

The construction industry has a reputation for producing a significant amount of waste. Kibert (2008) highlights that half of the waste generated by the construction industry globally results from end-of-life activities. This is because buildings are often disposed at the end of their useful life in a way that makes the component materials difficult to reuse. Even though the recycling of buildings is becoming popular, a progressively gainful utilization of recovered building material is direct reuse. This is on the grounds that materials reuse requires minimal energy usage when contrasted with the energy needed for material recycling (Akanbi, et al., 2018). Hence, building deconstruction is progressively favoured over demolition in view of its financial and environmental advantages (Coelho and de Brito, 2011; Akanbi et al., 2018).

Building deconstruction is a practice that supports the concept of circular economy (CE) model which has been adopted by developed and emerging economies. Its adoption has led to the creation of markets for recovered materials from Construction and Demolition Waste (CDW) (Akanbi et al., 2018). Thus, CE is viewed as a sustainable development strategy that aims at improving the efficiency of materials and energy usage (Douglas, Ekehorn, and Lockwood, 2016). This is a paradigm shift from the existing linear economy model of take-make-consume and dispose to a more sustainable model of take-make-consume-reuse and recycle (Douglas et al., 2016; Akanbi et al., 2018).

Besides, the desire for circular economy and optimal material reuse calls for the need to improve techniques for whole-lifecycle performance assessment of buildings. In that capacity, it is critical to create performance profile for buildings to know the best time for obtaining its optimal salvage value. To accomplish a viable entire life performance evaluation of buildings, performance characteristics of individual building components must be taken into consideration (Akanbi et al., 2018). Henceforth, companies and collectives are eager to move towards more circular and/or sustainable economic business models as a way of commercial differentiation, competitive advantage and potential growth with economic spinoffs. These are the reasons why industrial actors, non-expert in circular economy, require support and guidance with the transitions from linear to circular economy (Saidani, Yannou, Leroy, and Cluzel, 2017).

In view of these definitions, CE can be regarded as a way of accomplishing SD. Lieder and Rashid (2016) outline the implementation of circular economy principles in business models and supply chains as a prerequisite for sustainable manufacturing for greater economic and environmental performance of countries. Therefore, the introduction of servitized business models (BMs), where the utilization or the capacity of a product to function is sold instead of the product itself, has been acknowledged as an enabling factor of CE transitions in companies (Bressanelli, Adrodegari, Perona, and Saccani, 2018). However, it remains to be seen how the construction industry can leverage the concept of servitization for improved circular economy performance.

2.2 The Concept of Servitization

Vandermerwe and Rada (1988) considers servitization as a concept adopted by companies that are consciously seeking to develop service offerings to support their products to gain competitive advantage. By adding services to products supplied, firms distinguish their offering from competitors, increasing customer loyalty and competitive advantage. This research study examines servitization as the transition by manufacturing companies towards offering goods accompanied services rather than goods alone (Neely, 2008). Servitization is considered an overarching concept that includes but goes beyond service infusion and is defined as the process of transiting from a product-orientated business model and logic to a service-centric approach (Ahamed, Inohara, and Kamoshida, 2013).

A developing enthusiasm for this theme by the scholarly community, business and government has been buttressed (Baines and Lightfoot, 2011). But a lot of this enthusiasm depends on the conviction that a move towards servitization will create extra value-adding capacities for conventional manufacturers. The main distinguishing factor in the whole integration of products and services offering is the provision of services which has now gained much interest in consideration as an explicit strategy. Now, services are included as fundamental value-added activity for value proposition and thus, reduces the product to be just a part of the offering (Oliva and Kallenberg, 2003; Vandermerwe and Rada,1988). Figure 1 below depicts the added value from the P-S (Product -Service) providers' perspective.

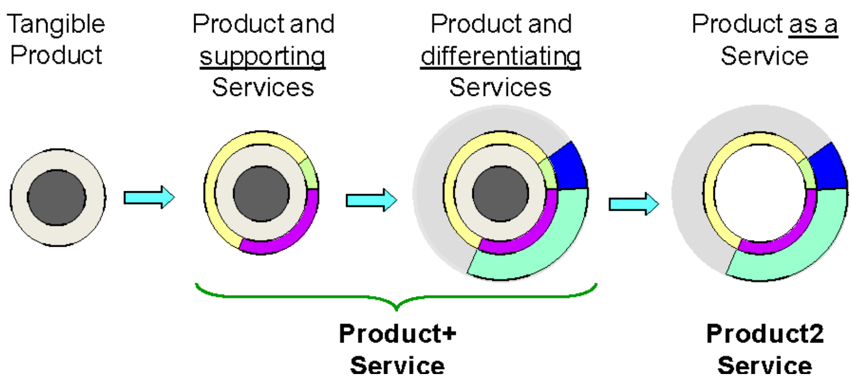

Figure 1: Stages of service provision. Source: (Ducq, Chen, and Alix, 2012)

2.3 Key Indicators for Measuring CE Performance

Table 1 shows three categories for measuring CE performance adopted from a study Moraga et al. (2019) and expected key indicators for measuring CE performance adopted from Potting, et al. (2017).

Table 1: Categories and expected indicators for measuring CE performance in the construction industry

1. **Categories**	2. **Indicator**	3. **Circularity**	4. **Applicability in construction**
5. **Function**	6. Co-creation of value and clients' satisfaction	7. Refuse, Rethink, and Reduce	8. Functions should be aligned to client's business model. Functionality is key
9. **Product**	10. Servitized products/ products with extended lifespan.	11. Reuse, repair, Refurbish, remanufacture, and repurpose	12. Sustainable products that are easy to repair and maintain, or use discarded parts for same or different function
13. **Material**	14. Renewable material	15. Recycle, and Recover	16. Usage of materials that are aligned to green/ sustainable construction goals

2.4 Servitization as a Strategy to Enable the Attainment CE Indicators in the Built Environment

In the synthesis of the "servitization" literature, it is clear that traditional manufacturers had to overcome major organizational, financial, customer, supply chain, and market related hurdles through transition form product offering to product-service offering in order to become successful providers of integrated product-service offerings (Falk and Peng, 2013). Although the concept of servitization deals with services exclusively, its origin and motivation arise from the manufacturing industry, since these services are augmented elements of the tangible product offering.

The main goal of shifting from product-centric to product-service delivery offerings was to co-create value with customers in order to gain benefits by enriching its product offers with services (Kryvinska, Kaczor, Strauss, and Greguš, 2014). A servitization strategy might be utilized to build and maintain a competitive advantage, even in the long run. Adding service components to tangible goods also offers an ample opportunity to influence decisions of clients when purchasing, which brings about new marketing benefits and, in future, repeat sales and maintain good customer relationships. This can only be achieved by offering coveted complete solutions rather than typical after sales services (Rymaszewska, Helo, and Gunasekaran, 2017).

Moving from traditional business models or traditional ways of delivering products to clients to more servitized business models, means that organizations/companies have to align their business strategies to respond to clients' needs through delivering products that are fit for purpose. It is through adoption of "servitization" that construction industry clients can be offered products thereby bringing value in the consumption process. Therefore, consideration should be given to design for functionality and sustainability throughout the lifecycle of the product offered (Noar, Druehl, and Bernardes, 2018). Thus, this study concerns itself around design for servitized business models that will be developed through employing the Business Model Canvas (BMC) approach and its nine building blocks and the theory of change.

2.5 Proposed Framework for Servitization Transitions to Enable Improved CE Performance

Figure 2 shows a proposed servitization framework for enabling improved circular economy performance in the construction industry. Based on the framework, each building block of a servitized business model will be evaluated as to how it can give high level of success to each indicator compared to a conventional business model.

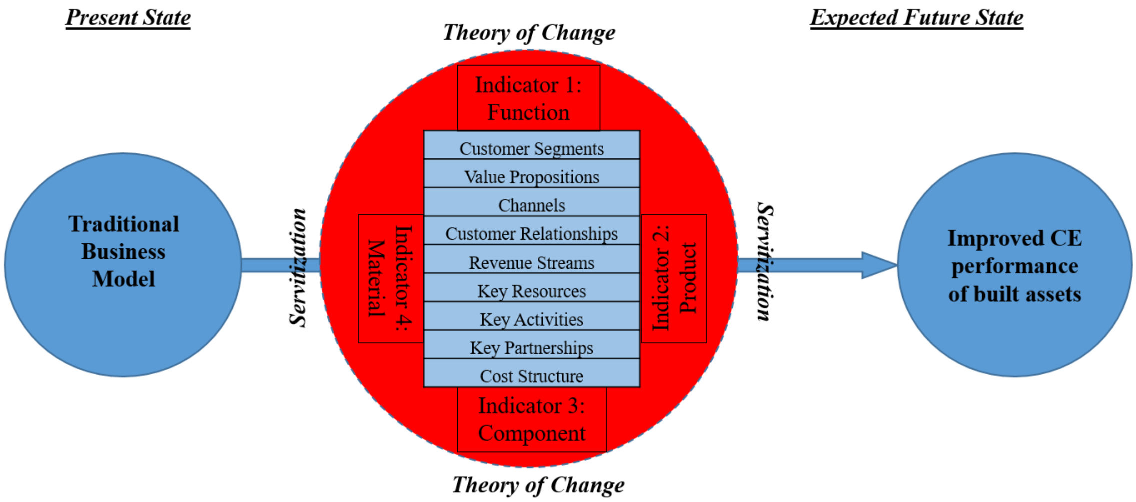

Figure 2: Proposed servitization transition Framework.

The proposed servitization framework above depicts how a conventional business model can be converted to a servitized business model (SBM) to enable improved CE performance for built assets through servitization and theory of change. For example; indicator 1: Function, and Indicator 2: Product, in a conventional business model, functionality is not optimal since clients are offered products that are not aligned to their business model and thus, value is not offered to clients since their main concern is ownership of the product.

In a SBM, functionality and value of the product are the fundamental concerns, while on the other hand ownership and responsibility remains with the offeror. This can be achieved through realigning the building blocks of a BMC to the aims of servitization and CE concepts. For example; ***key partners*** will have to realign from just *investors* and *supply chain members* to broader partners that will include *insurances* and *visionaries*. Likewise, ***value proposition***, it will have to realign from just providing *low cost products* to *product-service offerings*, *functionality*, *efficiency*, and *client satisfaction* just to mention a few.

3. RESEARCH METHOD

3.1 Research Approach

This study employed a qualitative research approach. The reason for this method stems from the study's desire to elicit answers to how' or 'why' questions about 'a phenomenon rather than 'how many' or 'how much'. Consequently, the study's research approach focuses on proposing a framework premised on the servitized business model for improving CE performance in the construction industry.

3.2 Sample Selection

This study purposively selected interviewee sample consisting of construction clients and construction company owners. Initially, 20 interviewees were identified and comprised of 10 construction clients and 10 construction company representatives. However, only 8 clients and 6 construction company representatives expressed interest. These shortcomings were mainly due to tight schedules from the owner's side and projects that are in the pipeline.

3.3 Data Collection

Data was collected through semi-structured interviews and all the interviewees were notified that the interviews were highly confidential, and no information will be disclosed without their consent. The semi-structured interview guide consisted of five broad questions which have been designed based on insights drawn from existing literature on the relationship between servitization and circular economy in the built environment. The interview questions were designed to enable the interviewees to use their personal experiences on construction business models as well as products offered to construction clients. Each question was also aligned to the aim that the study seeks to achieve. Interview sessions lasted for an average of 20 minutes. Interviewees were also given an opportunity express their views in terms for functionality and value of the products offered.

3.4 Data Analysis

Data collected from the interviews was analysed using thematic analysis technique in which pre-set themes were adapted sub-categories, namely:

- Level of knowledge pertaining to servitization and circular economy
- Recognition of potential contribution of the CE performance, and
- Issue of responsibility and ownership.

To make sense of the data, the transcripts originating from the transcription exercises were read more than once by the researchers independent of each other. Data from the transcripts was coded and pre-set themes evolved from the coded data. Since this conceptual paper forms part of the PhD study which is still in its nascent stages, the researcher will continue with collection and analysis of data. Thus, only preliminary findings are discussed in subsequent sections.

4. PRELIMINARY FINDINGS AND DISCUSSIONS

The preliminary findings are presented below in a descriptive manner according to the pre-set themes.

4.1 Level of Knowledge Pertaining to Servitization and Circular Economy

To establish the level of knowledge, interviewees were asked to share their understanding pertaining to the concept of servitization and circular economy. From the responses received, they turn to associate these two concepts with the extended product life and financial increment. The responses received from the participants concur with a statement made by Falk and Peng (2013) that the servitization can be used to build and maintain competitive advantage in the markets and increase profit margins.

As for construction clients, they have a sound of knowledge with regards to sustainable construction products and circularity, however, those who are meant to deliver seem not to be interested. Construction company owners also mentioned that they are aware of terms like "sustainable and green construction" and the need to transit towards offering sustainable construction products that will bring more value to their clients.

One interviewee in particular highlighted that "many industries are transforming daily and adopting new innovative methods in their respective industries, however, the construction sector seems too comfortable in their old business models". The interviewer continues and mentions that one of the reasons behind this is fear of failure in the markets and accountability in the event of failing meet the required standards.

4.2 Recognition of Potential Contribution of the CE Performance

According to Ametepey et al., (2015) and Djokoto et al., (2014), sustainable construction aims at achieving certain principles which includes: reduction in the consumption of resources, using resources that are renewable and recyclable, and also protecting the natural environment. At the same time, interviewees are in agreement with the ideas brought to the table by scholars.

The two samples of interviewees recognize the potential contribution of the CE mandate that the construction industry find ways and transit to smart product use and extended product lifespan. Accordingly, interviewees mentioned that at the end of the product life, some materials can be recovered and reused and to some extent, recycle if not need. Thus, sustainability will be practiced and the needs of today will be met without compromising the needs of the future generation. The responses from the interviewees are in line with views of scholars in the academic literature (Feigie et al., 2011; Akanbi et al., 2018).

4.3 Responsibility and Ownership

Interviewees acknowledges the concept of servitization and circular economy as well as the ideas behind utilization of servitized business models to improve circular economy performance. However, the sample representing the construction clients are more concerned with the issue of capacity and ownership. These two concepts concur when it comes to the ownership of products. These concepts are clear that product ownership is not the main focus; in its place, functionality and satisfaction is key (Ghisellini et al., 2016; van Loon, Delagarde, and Van Wassenhove, 2018).

Clients mentioned that their key principle is ownership and thus, implementation of these concepts should be looked into again. Henceforth, scholars suggest that for businesses leasing instead of owning is a key mandate of the CE business model as it allows manufacturers to manufacture durable products without cannibalizing their own sales (Junnila et al., 2018).

5. CONCLUSIONS

This study has used the servitization and CE literature to comprehensively explore the applicability of these concepts in the construction industry in assuring client value through delivering that are complemented by services. Moreover, the study also used the phenomena of Product-Service Systems (PSS) as a strategy towards attaining the concept of servitization since it is used as a marketable set of products and services that are capable of jointly fulfilling customers' needs in an economical and sustainable manner.

This study also highlighted the need for a better understanding of how servitized business models can leverage upon functionality and satisfaction through offering coordinated blend products and services that deliver value in use and for improved circular economy performance.

It proposes that construction business models find ways of adding value by adding services to the product to satisfy client's needs and also create awareness on concerns and opportunities associated with servitization while at the same time it aims at developing a framework for servitization which will enables companies to transit from traditional business models to servitized business models. Since this study is on-going, it is expected that upon completion of data collecting and analysis, findings would assist in operationalizing servitized business models (SBM) and its effectiveness in engendering improved CE performance within the construction industry.

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DISMANTLING BARRIERS TO EFFECTIVE DISASTER MANAGEMENT IN NIGERIA

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Abstract: Barriers to managing the disaster cycle remains challenging in the built environments' effort to delivering a wholesome contribution to planned and emergency responses. Planning for and responding to the effects of displacement and damage to lives and the built environment resulting from these disaster events require effective forecast, adequate planning and swift responses to recover and reconstruct. The resulting consequences of these disasters have been the foci for disaster planning and management. Current disaster management protocols in Nigeria are bureaucratically centred around policy formulation without adequate inclusion of expertise from the built environment. This paper is focused on examination and assessment of prevailing disaster management efforts. Teasing out project management principles and how applicable these principles could be to improving trust, comprehensive planning and rapid response from stakeholders in the disaster management cycle. Bringing required expertise and knowledge into the built environment curriculum at various levels could be another key step towards improved engagement with core disaster management practices. An effective, inclusive and statute engagement framework initiative that harnesses the vast knowledge and expertise inherent in the construction industry will be invaluable to disaster management processes and efforts in Nigeria in coming years.

Keywords: Policy, resilience, disaster management, construction industry, inclusion.

1. INTRODUCTION

Disaster and the management of it has always been with humans, particularly in our built environment. Disasters occur in various ways and on varying scale, across the world. *(WHO, IPCC, UNO, UNISDR, ICRC)*. The planning and timely response to rescuing lives and properties are the most critical priorities leading to reconstruction, relocation and rehabilitation following impact in a disaster zone. These steps have always been the prerogatives of disaster management efforts.

Presently, the involvement of the construction industry is left to the last stage of the disaster cycle in the area of re-construction. Existing barriers to the inclusion of the construction industry in all stages of disaster management have been identified as lack of capacity, socio-political factors, geo-political factors and policies amongst numerous other factors. The scale at which hazards climax into disaster has become unprecedented, but so are the ways experts and stakeholders are tackling these issues. (*Etinay et al, 2018, King et al, 2018, Ingirige, 2016, Coetzee, 2012).* Disaster managers are becoming experts in predicting, planning for and managing hazards ever than in the past. It is therefore imperative that identified barriers to disaster management efforts, efficacy and efficiency must be addressed (*Coppola,2015*).

Hazard recognition, detection and assessments that inform current disaster management approach will be teased out. The aim is to proffer different alternative to current approaches to disaster planning and management. The alternative could contribute to the current body of knowledge in this field.

Planning for, and managing disasters are integral aspects of the contributions the built environment, alongside other stakeholders, provide towards ensuring the stability of habitational environment within communities before, during and affect hazard impacts. Presently, these efforts, as they relate to the inclusion of the construction industry, are not well represented in the disaster management cycle, wholesomely. This paper is aimed at exploring present disaster management efforts and the inclusion of the construction industry in the disaster management cycle. The paper is also focused on teasing out existing project and disaster management cycle theories to further identify efforts that will benefit from improved process and involvement of the construction industry. This will be achieved by exploring current best practices within present efforts and practices with a determination to arrive at a conceptual framework analysis. The conclusion will explore this analysis in ways that will impact the participation and inclusion of the construction industry in effective planning of disaster management policies and practice in Nigeria. In conclusion, the paper will discuss pedagogical framework that should address embedding critical course modules in disaster management training into the built environment professional education.

1.1 Conceptual Background

Changes in climate patterns around the world are argued to be general contributors to natural hazards and some believe these hazards are exacerbated, in turn, by anthropogenic activities (O'Brien *et al, (2006), Cowen & Seifter (2014, Clarke & Dercon (2016.*). Extreme weather events are becoming more prevalent occurrence around the world especially in the last decade. There are scientific and expert concerns to the extent these events impact on our world (*Sendai Framework for Disaster Risk Reduction 2015 – 2030,*). Environmental influences affecting the way we live and build up capacity to confront these extreme weather and human activities are major concerns for disaster management experts and stakeholders around the world. The United Nation office for disaster reduction (*UNISDR*) suggests that current world weather trends would be common in coming years with devastating consequences for humanity *(Sendai framework 2015-2030).* The connection between environment hazards, disasters and human displacement remain conceptual foci for disaster mitigation and management (*Smith,2003*). Conflict is another recognisable risk factor in the displacement of people and destruction of habitat around the world. Again, these displacements and loss of habitat and supporting structures account for major percentages of disasters affecting people and structure (*IDMC,2019*). Anthropogenic factors are present and the issue of conflict between people is a hazard factor that usually generate huge catastrophe. These events could be extremely difficult to predict or managed.

In Nigeria, like most countries globally, there are many challenges presented when organising and managing disaster efforts. The focus of this paper is to analyse how some of these challenges could be mitigated or managed.

Project management challenges in disaster management in Nigeria

Project management challenges in Nigeria remain critically top issue in effective planning, management and control of disasters. Construction project management theories such as Just-in-time (JIT), Process management principles, can complement and improve the quality and speed of disaster efforts (*Rose,2013*). There are, however, some barriers to applying these project management principles to disaster management efforts in Nigeria. Issues such as listed below are some identified restrictive reasons project management initiatives in disaster management are not easily aligned.

Resistant to change. The nature of the construction industry has hitherto been adversarial. The construction industry response to change is sluggish at best. These might be due to the nature of mindset in the built environment where natural laws applying to structural alignment of buildings hardly changes. The industry is, however, overcoming some it's traditional reluctance to change through application of technology and introduction of modern methods of construction. But reaction to change can be managed in four ways that renders resistance ineffective (*Foster,2012*) namely: (a) change the situation, proactively. (b) Accept the change and flowing with it is another way of embracing change. (c) There is opportunity to change one's perspective to issues or withdraw from the process of change. (d) The author is of the view that reaction to change provides perception of choice and consequently empowerment.

Manpower resources. Training, recruiting and maintaining adequate skills and expertise in the industry remains a barrier that interferes with participation of built environment professionals in the construction industry. The development and stable distribution of electricity in Nigeria remains a massive challenge. (*ESI,2017*) Expertise and knowledge in disaster management is a skill set not present in the experience of most construction experts in Nigeria. Developing "*participatory skills*" towards overcoming challenges present in disaster management is essential to upgrading manpower resources in the construction industry (*Bingunath,2016*)

Process management. Managing process of activities is key to delivering quality projects at competitive cost and on time. Managing disaster entails huge process management. From planning to the actual logistics of delivering aid, reconstruction materials and crucial manpower to disaster impact zones entails vast amount of processes. Managing and streamlining these process challenges is critical to successful contribution to and participation in disaster efforts. Process management will involve knowledge of the processes involved. Managing processes ensure priorities are set. Time allocation is critical in the control of processes from initial response to reconstruction.

Administrative procedures. Bureaucratic endeavours have become usual ways of applying sets of principles and practices in the construction industry. The reluctance to adapt to change has earned the construction industry a perception of a fastidious sector. The National emergency management agency (NEMA) responsible for coordinating and managing disaster responses in Nigeria could be described as an arm of the Nigerian government focused on administrative and political affiliation to government rather than to active engagement with disaster management planning and operations (*Mashi et al,2019*)

Project constraints - Operations management. Disaster response and relief efforts could pose huge challenges in terms of human and material logistics. Moving relief materials and people in critical periods and phases of disaster could provide certain obstacles. (*Tatham & Christopher,2018*).

Personality clashes. between the "old" and "new" approaches to management. The old being practitioners who rose through the ranks and the new, university trained professionals. These clashes are embedded in the work culture and attitude of these two groups resulting in unnecessary delays in actioning disaster efforts.

Disaster management efforts must focus on extrinsic as well as intrinsic factors necessitating global displacement of people. The United Nations also recognises that there are many global issues hampering or minimising disaster management efforts. Some of these issues are resource constraints, population explosion issues, migration of people across the global as well as poverty affecting people especially in low income areas of Africa and Asia particularly. Whenever these chains of events occur, regardless in which order, the disaster cycle is replicated.

Khan et al (2008) believe that disaster is *"adverse extreme event"* which eruptive attributes could utterly dislodge human activities as well as dislocate habitations. The authors are convinced that disaster will most certainly occur when "vulnerability" combines with *"hazard and insufficient capacity"* to mitigate the resulting *"chances of risk"*. A position illustrated with the diagram produced below. (Figure 1)

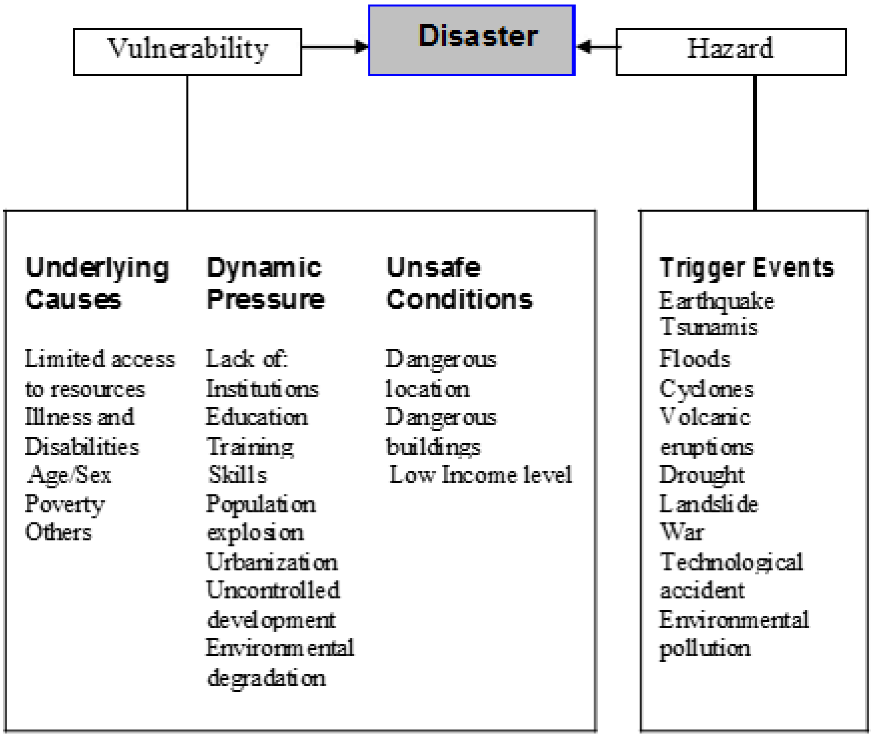
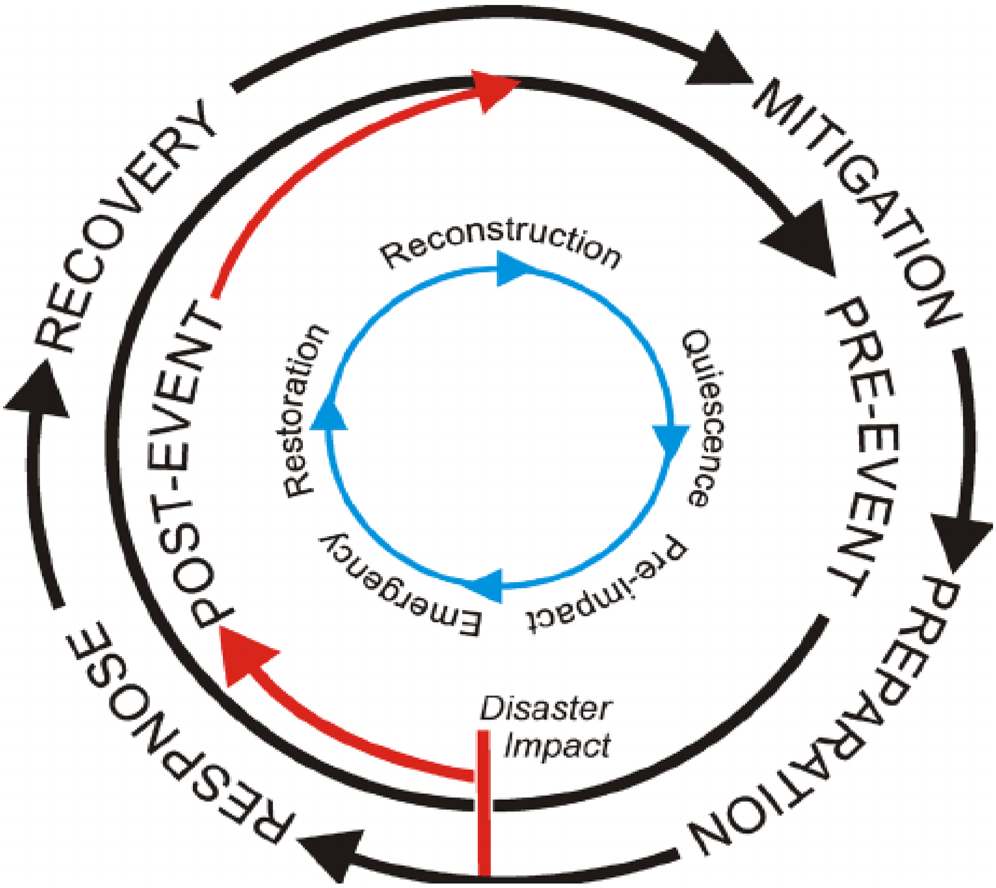


Figure 1: Disaster Vulnerability undertones (Khan et al,2008)

2. DISASTER CYCLE

The disaster management cycle profiles the totality of activities from pre to post disaster periods with a profound aim of either reducing or eliminating effects of hazards on human habitations and livelihood. Pre-disaster activities involve information gathering and dissemination as a risk reduction strategy (*Khan et al, 2008).* Pre-disaster engagement looks at preparing and proffering solutions to mitigating any potential risks attendant on these events. When hazards lead to disaster, emergency response provide services around ensuring relief get to where they are most needed, the impact zone. The next stage of a typical disaster cycle is the reconstruction stage where efforts are geared towards rebuilding lives and structures. At this stage, disaster management efforts are expected to concentrate on ensuring relief activities are thoroughly coordinated and evacuations well managed. However, the 1994 conflict in Rwanda, where people and habitations were destroyed, exemplifies challenges and limitations of the disaster cycle. Lessons from the Rwandan genocide experience presented complexities that were daunting to surmount in typical disaster management efforts. Though situations and tensions leading to the genocide were well observed and documented *(Taylor & Terror,2002)*, the ferocity of the conflict defied predictability in terms of failed diplomacy that led to a huge human tragedy of this generation (Adelman et al,1996). The set of challenges presented in managing anthropogenic disasters such as the Rwandan example would have included human conflict management on an unprecedented scale.



Herold & Sawada (2012).

Figure 2: Disaster cycle

2.1 Barriers to Disaster Management

Research has indicated (*Adelman et al 1996, Aitsi-Selmi,2015, Seneviratne et al 2010, Balcik et al 2010, Etinay et al 2018, Amir, (2018)*) that managing disaster resilience, planning and response is hindered by some factors, a few of which are discussed below. Most of these factors are endemic in the Nigeria disaster management arrangements.

Capacity.
Existing capacities, to cope with the ever-expanding scale of natural and anthropogenic disasters, are becoming continually overstretched. The involvement of traditional stakeholders and Non-governmental organisations (NGOs) are falling below the level of capacity needed to robustly plan for and respond to disaster incidents and reconstruction. Due to nature of disasters, there could be several factors that might hinder help getting to the right place at the speed required. (*Mashi et al, 2019*)

The issue of capacity or the lack of it present reoccurring challenges to disaster management efforts in Nigeria. There is the challenge of inadequacy of skills needed in carrying out crucial response or rescue efforts in most disaster zones, especially in the developing world. Where there is enough skilled professionals or experts, there are sometimes the issue of mobilisation of personnel needed to accomplish disaster efforts. There is also the issue of community capacity to cope with disaster and the contribution they make toward bolstering resilience pre -, during and post – disaster events. Data on how communities respond to and cope with disasters, could help disaster managers and stakeholders determine contextual intervention strategies (*Gil-Rivas & Kilmer, 2016*). Capacity of each community will certainly depend on the level of resilience that is present within each community. A cogent capacity indicator that is usually oversighted in disaster management calculations. Technological advancement that aid the prediction and processing of data on hazard behaviours is a stream of capacity growth in disaster management (Khan, et al.2008). The introduction of technological tools in disaster management efforts remain inadequate to the global challenges faced. Improvement in the built environment supply chain structures will enable the construction industry to utilise improved Modern Methods of Construction (MMC) in disaster zones and areas around the world but enough progress that would translate into widespread use of these skills and expertise still hinge on capacity mechanism expansion. Hence the challenges encountered when bridging the alignment of human and material resources, limits the reach of disaster planning and efforts. (*UNISDR 2007, Balcik et al, 2010*)

Bribery and corruption.
Bribery and corruption is a major challenge to disaster management efforts (*Sampson,2015*) around the world. Corruption in disaster management is multi-faceted. Abuse of power remains on top of the list of corrupt practices. A form of this type of corruption is Nepotism where relatives and friends are appointed without experience or merited qualities required for the position, a practise prevalent in developing nations but quite predominant in Nigeria.
Financial corruption in form of embezzlement and misappropriation of funds into other use different from intended use is another example. This problem plights disaster funding as donors are sceptical and hence reluctant to release financial, material and labour force funding that are critical to fast and effective disaster efforts. Non - governmental organisations (NGO's) and other stakeholders that form the first line of response are most affected when dealing with disaster responses in the developing world due to high levels of political cum financial instability and absence of accountability in this part of the world. Nigeria is scored 3.0 on the world bank transparency index where the score is 1 – 6. 1 is lowest and 6 is the highest. *(The World Bank Group,2019*)

2.2 Disaster Management Initiatives

There are some disaster management initiatives efforts been explored, in countries around the world, towards improving present global disaster planning and response efforts. These initiatives are geared towards encouraging the inclusion of the construction industry in disaster management efforts. There has been an attempt in Bangladesh to remove some barriers that hinder the inclusion of the construction industry in disaster management efforts in that part of the world. The Bangladeshi initiative exemplifies a comprehensive approach to disaster management that involves the construction industry in a not-for-profit participatory capacity and could therefore provide a base for best practice, in the move towards inclusion. *Izumi & Shaw (2014)* argued that involving the private sector in disaster management in Bangladesh strengthened and even improved some Disaster Risk Reduction (DRR) initiatives, tremendously. The authors focused on strengthening risk reduction capabilities as a capacity mechanism towards building comprehensive disaster resilience and management. To the strength of this argument, the authors believe improvements could be approached through six avenues namely Involvement, Improvement in building regulation standards, Disaster demand activities, Transiting from the present not-for-profit into disaster response continuity alignment, knowledge transfer schemes and utilising disaster management experiences from around the world. This argument has a global resonance.

The African Risk Capacity (ARC) initiative was brought together by 32 African nations of the African Union (AU) to tackle disaster management capacity challenges in that part of the world. (*Insurance journal,2017*)

The Hyogo framework for action (2005-2015) emphasises the need for partnership with the private sector in disaster management through enhanced organisation and execution of disaster management planning and responses. The framework pointedly relates *to "specific gaps and challenges"* in present global efforts. Three of these main gaps have relevance to this research. These three areas of disaster management are; Governance, knowledge management and preparedness for effective response and recovery. Allusion to these three responses is made in *Izumi & Shaw (2014)* argument for private sector involvement in the disaster management cycle. Furthermore, the Sendai framework for disaster reduction, which succeeds the Hyogo framework, sets out four major priorities for action (p14). *"Investing in disaster risk reduction for resilience"* poignantly bears reference to an element of investment in private sector participation initiative. The argument for private sector full involvement in disaster planning and management is integral to continued success of global disaster planning and management efforts. This is where the construction industry role becomes pivotal to disaster resilience and the totality of disaster management experience. It has been suggested *(Witt, et al,2014)* that the construction industry's role in the disaster management circle could be further enhanced by promoting resilience in the project cycle itself. Though the bane of disaster management efforts globally has been inadequate alignment of available manpower, technical and digital resources (*Ingirige 2016, Warner 2010, Witt et al ,2014 Seneviratne,2010)*. There are some thinking in the built environment that support incorporating elements of curricular inclusion of disaster management teaching into core-built environment disciplines in institutions of learning. Such step could synergise and energise global disaster preparedness, planning, responses, reconstruction and rehabilitation *(Ingirige,2016. Witt et al,2014)*

2.3 Disaster Management and Project Management

Disaster education, as a critical component of disaster management, is essential to promoting public safety awareness (*Olowoporoku,2017*). Through such education, the community is enlightened on basic early warning indicators, preparedness for disaster, effective communication that could lead to good disaster response arrangements. (*Dufty,2018*).

Coetzee and Niekerk (2012) examined the interconnectedness of elements of disaster management cycle theory that came to limelight in the 1920's. The authors argued that the relationship and interdependence between emergency, relief, recovery and rehabilitation in the disaster management processes could be harnessed and made to work through exploring theoretical concepts embedded in the general system approach.

Malilay et al (2014) raised vital key issues in ways which disaster management encapsulate efficiency in the health sector. Although the authors analysed disaster management in the health setting, the relevance to disaster management in the built environment is unique. Between disaster impact and recovery, the authors' model alludes to the criticality of "rapid needs assessment" in disaster response. The concerted drive to effective and efficient planning and responses in disaster management had always been the harmonisation of the disaster cycle elements. *Foster (2001)* postulates that a project management approach to disaster management could be beneficial to disaster management in the areas of risk assessment and process elimination. This postulation could be applied into the built environment disaster management core approach to the disaster cycle. The principles of "*rapid needs assessment*" as a key element to solving rapid response dilemma in the disaster cycle is relatable to instant field assessment. The issue with Foster's (2001) postulation, though, is that disaster management is a more complex, multidimensional endeavour than suggested. Whilst *Malilay et al (2014)* argument might be applicable to a fast-paced rapid assessment cum response situations, there are some instances when planned intervention and logistic arrangements are almost impossible to achieve. Cases of the recent disaster in Mozambique and the Rwandan genocide serve cogent examples of these constraints.

A recent annual flood disaster review effort by The National Emergency Management Agency *(NEMA*) in Abuja, Nigeria provides a critical narrative to supporting the "inclusion failure" argument. The review indicated proportions of shared disaster management responsibilities are managed between federal (national) and state (regional) governments and state departments with noticeable absence of private sector organisations (PSOs).

Introducing some project management principles such as the Just-in-time (JIT) principle, in some instances, to relief efforts, could contribute to efficiency in the management of an effective disaster cycle. Teasing out some project management ideas to align with the disaster cycle, as shown in Table 1 below, might enhance the effectiveness of current practice.
Applying Project risk management to disaster mitigation efforts, for instance, should ensure that known risks are assessed using established risk management techniques, analysis notably qualitative risk and SWOT analysis. Project management approaches can be applied to the disaster cycle with the purpose of improving the speed of turnover of each element of the cycle. Project time management principles will help improve the speed at which planning is made and overall response pre and post disaster.

Table 1: Project management aligned to the disaster cycle.

Project Management Principles	**Disaster Cycle**
Project time management	Pre and Post disaster response
Project risk management	Mitigation
Project stakeholder management	Preparation
Project human resource management	Response
Project quality management	Recovery

Eliminating existing barriers in policy bureaucratic approach to disaster project management is contingent on producing very tangible improvement to ways disaster management is planned for and organised coupled with the speed of response that would improve disaster planning and overall response and relief arrangements (*Bingunath,2016*). A comprehensive policy inclusion approach that is beneficial to the construction industry is well fitted into and emphasised in the eighth corridor of the Nigeria Emergency management Agency (NEMA) "Zero document". Clearly, there exist theoretical inclusion proposition for the construction industry in the Nigeria zero document, but the practical inclusion option is not adequately provided for (*NEMA*).

3. CONCLUSIONS

To the extent that application of project management principles and theories would appear to be viable alternatives to prevailing approaches to disaster management, project management steps could become integral imperatives in moving disaster responses and reconstruction to the next critically required level of excellence. Mandatory inclusion of the construction industry in disaster management policy formulation and participation is therefore critical to an ever-growing need for rapid global disaster planning, response and reconstruction. With average world temperature soaring by a massive 2.7% in the last decade alone *(Rahmstoff &Coumon,2011)*, the need for an effective global synergy of evidence-based practice and response framework could never be overemphasised. The construction industry has vast untapped repository of expertise and knowledge that could be integral to an efficient global disaster management. Identified barriers and obstacles to structured policy inclusion of construction industry (CI) by policy makers in a complete disaster cycle must be appropriately tackled *(Ingirige,2016 p592)*. These barriers could be overcome through robust participatory inclusion of the construction industry in robust disaster efforts. Efficient rapid response to challenges posed by climate change and anthropogenic disasters must embody the combination of planning, readiness, institutional capacity building, adequate planning and effective management strategies that harnesses and utilise the strength of the construction industry in these areas *(O'Brien, et al 2006).* Addressing improved approach to disaster management should force rethink in finding ways to building up a versatile risk assessment and recovery response apparatus in the disaster cycle. The rehabilitation and reconstruction stages should consider building more resilience into planning policies by way of improving design resilience. New building codes and a sustainably resilient supply chain, that recognises the ever-changing nature of disasters, should be factored into the disaster cycle whilst strategizing issues such as temporary relocation where rehabilitation is immediately unachievable. Towards effectively improving the level of inclusion of the construction industry crucial role in disaster management activities, percentile increment in statute (Policy) involvement could produce tangible outcomes throughout the disaster management cycle. An efficient framework approach that will entrench effective disaster planning, management and resilience building must consider these factors. Priority 3 of the Hygogo initiatives emphasised the "*strengthening*" of resources and expertise towards encouraging and providing information empowerment steps that are important to "risk reduction plans". The document was keen on the development of frameworks that will specifically "*promote*" pedagogical disaster management knowledge integration and transfer. This paper is a reflection of early stage thoughts on how construction management principles could contribute to existing body of knowledge in the field of disaster management.

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CRITICAL SUCCESS FACTORS THAT ENABLE THE UTILISATION OF AGRICULTURAL WASTE AS BUILDING MATERIAL

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Abstract: A substantial amount of literature suggests that innovation is a process of adding value to a product for sustainable competitive advantage in any organisation. However, the development of agricultural innovation management has resulted in an extensive and disjointed body of literature. In Nigeria, rare literature exists that addresses agricultural waste management, whether in form of a framework or guideline. There is indeed abundant evidence on the utilisation of agricultural waste material for construction purposes to address housing deficits and promote sustainable development. This paper sets out to identify the critical success factors that enable the utilisation of agricultural waste as building materials. However, before attempting to identifying the CSFs, this paper firstly explores the literature that affect the innovation management of agricultural waste as building materials via innovation system, agricultural and construction innovation. This study explores cases from participating stakeholders in selected organisations in Nigeria through semi-structured interviews, which aim to investigate the validity of the critical success factors as identified from literature and to identify new ones. The study finds some critical success factors that enable the use of agricultural waste as building materials in Nigeria. These are: good governance; people/actors; cooperation and coordination; research and development; knowledge transfer and funds and finance. This paper discusses the five most important success factors to present a holistic view of innovation management. From this it is concluded that a few dominant relationships exist among the factors within the innovation system, agricultural innovation and construction innovation.

Keywords: Actors, agricultural waste, innovation, management, strategy.

1.0 INTRODUCTION

It has been reported that the current housing shortage of about 17 million units, especially in urban areas, affects over 140 million Nigerians (Yakub, Salawu, & Gimba, 2012). Furthermore, a survey carried out by the United Nations also calculated Nigeria's housing deficit at approximately 17 million units (Ibem, Anosike, & Azuh, 2011). This apparent lack of adequate housing has often been attributed to the high cost of building materials, as the cost of such materials in the construction industry worldwide comprises up to 40-50% of the total construction cost (Adenuga, 2013). Furthermore, according to Adogbo and Kolo (2009, cited by Oladiran, 2015), there is an increasing demand for import-based innovative products in Nigeria, which has also led to a decline in the quality of its indigenous products. However, a substantial proportion of the raw material used in manufacturing these products are sourced from abroad, as the high inflation rate in Nigeria means the cost of building materials have dramatically increased. Thus, there is an urgent need to produce low cost, sustainable building materials that are affordable to both urban and rural dwellers using locally made raw material (Oladipo & Oni, 2012; Taiwo & Adeboye, 2013). However, the nature of this new development in the field of agricultural innovation management has resulted in an extensive and disjointed body of literature on critical success factors that enhance the usage of agricultural waste.

However, evidence suggests that the utilisation of agricultural waste as material for construction purposes can address the housing deficit and promote sustainable development. This paper focuses on the body of literature concerned with the critical success factors relevant to the factors that enables the utilisation of agricultural waste as building materials. It also explores cases from participating stakeholders within the field of agricultural, construction, manufacturing and management in Nigeria through semi-structured interviews. This aims to validate or add to/challenge the critical success factors identified within the literature review.

2.0 LITERATURE REVIEW

2.1 Innovation in General

According to Govindarajan & Trimble (2012), innovation becomes successful when factors that determine the level of innovation progress are in place in an organisation. However, many organisations do not understand that breeding and nurturing innovation requires an appropriate environment (Maxamadumarovich, Obrenovic, Amonboyev, 2012). Maxamadumarovich et al. also state that the innovation ecosystem factor that entails a complex range of economic, legal and societal inputs that allows innovation to flourish. Moreover, Jackson (2011) argues that an innovation ecosystem frames the economic dynamics of the complex collaborations that are formed between the actors, and enable development and innovation. Moreover, the actors which is a factor in this collaboration include the material resources (funds, facilities, equipment, etc.) and human actors (students, researchers, industry, staff and industry representatives, etc.) that comprise the institutional entities participating in the system. Jackson further explains that the fundamental expectation behind ecosystems thinking is to expand the capabilities of one actor beyond their own boundaries and to transfer knowledge into innovation in collaboration with others.

However, it is an important factor to understand how the existing innovation policy approaches of developed countries can be adapted for developing countries. Aubert (2004) explains that the first step is to look at the innovation policy mix (ecosystem) where developed economies have a notable preference evidenced by its adoption over the last decades), and to identify the factors that enhance the successful implementation of the policy mix, including the factors that drive innovation adoption. The next section considers the success factors that drive innovation in the construction industry.

2.2 Construction Innovation

Zwikael (2009) argues that, due to the nature of the construction industry, every project is unique and requires the use of particular (as opposed to conventional, standardised) project management tools and techniques. Furthermore, Zwikael notes that, if a project is completed on time, within the agreed budget and quality, the project is deemed successful. However, evidence suggests that this is far from the truth. Hence, the construction industry needs to pay particular attention to its critical success factors if it is to survive the challenges posed globally, including the assumption that the construction industry does not innovate (Toor & Ogunlana, 2005). Moreover, Yang, Wang, & Cheng (2009) explain that the unique nature of each completed project does not allow the critical success factors identified in one project/industry to directly transfer to another project/industry. Instead, a project's unique nature can be considered an innovation. However, the successful implementation of innovation requires major contextual factors that are critical if success is expected in any construction project. These factors are culture, business strategies, capacity and capability, from the participants involved, which tends to be complicated. On the other hand, for innovation - whether technical or non-technical, linear or non-linear, dynamic or rigid - critical management skills are prerequisites to effectively manage the collaborative working relationship (Cheng, Li, & Love, 2000). However, to ensure successful construction innovation, long-term, stable collaborative interactions with committed partners should be a factor by developing a productive context and by using appropriate management skills (Cheng et al., 2000). However, to wholly explore more factors that enable the use of agricultural waste as building material, the next section considers the success factor that drive agricultural innovation.

2.3 Agricultural Innovation

To successfully innovate in the agricultural sector, the critical success factors that enables innovation needs to be considered. Many researchers believe that valuable innovations will sell themselves, that the obvious benefits of a new idea will be widely realised by potential adopters, and that the innovation will, therefore, diffuse rapidly. However, this is seldom the case; instead, most innovations diffuse at a disappointingly slow rate (Rogers, 1995).

Spielman, (2005) describes innovation in agriculture as an idea, practice, or object that is perceived as new by an individual or another unit of adoption. However, in industrial and agricultural innovation literature, a division is made between products, processes, and social/organisational innovations, where agricultural innovations, as conventionally premeditated, are mainly categorised as products, but with elements of processes; moreover, technology is also used synonymously with innovation (Spielman, 2005).

Individual innovations (individual adopter) and collective and collaborative innovations (group of persons and organisations are also outlined as factors that enables innovations in agriculture (Sonnino, Dhlamini, Santucci & Warren, 2009). Nevertheless, for an innovation to be effective and represent an improvement many success factors must be considered alongside innovation objectives; Sabiiti (2011) identifies these factors as leadership and policymaking. In addition, Madurwar, Ralegaonkar & Mandavgane, (2013) add planning, public awareness, government policy and laws, and the sufficient utilisation of resources. Nonetheless, Klerkx, Hall & Leeuwis (2009) state that mutual information sharing between private and public sector partnerships and R&D are amongst the most important factors to enhance innovation. Moreover, Ogunwusi (2013) added that rural economic development and the availability of grants, market diversification, leadership and policy are factors that enhance innovation in the agricultural sector of the economy.

3.0 ADOPTED CRITICAL SUCCESS FACTORS THAT ENABLES UTILISATION OF AGRICULTURAL WASTE AS BUILDING MATERIALS IN NIGERIA

To illustrate the CSFs that could enable the improved utilisation of agricultural waste as building materials from the reviewed literature, selected key words and points are documented from innovation, construction innovation and agricultural innovation literature. The researcher identified a set of characteristics that a paper should present in order to maximise the quality of the methodical review. These inclusion criteria included industries and sectors involved in the utilisation of agricultural waste as building materials; this aimed to develop a broad picture of the factors that enables the utilisation of agricultural waste that are not limited to innovation alone. This inclusion was extended to the area of innovation management. However, to gain broader knowledge about the topic, a wider range of countries were considered to ensure a cross-cultural view about innovation and innovation management in the agricultural, manufacturing industry and construction sectors, including the public sector. As a result, more than 78 different factors were extracted, and five common, relevant factors were identified and adopted as critical success factors, which are discussed below.

3.1 Good Governance

According to Bevir (2012), governance means all processes of authority, whether undertaken by a government, market, network, formal or informal organisation, or territory, and whether through laws, norms, power or language. However, ESCAP (2006) explains that there is a handful of attributes associated with good governance, which are: participation, rule of law, transparency, responsiveness and harmony-orientation. Participation is required from all actors in governance, either directly, through a structured institution, or indirectly by the collaboration of institutions or organisations. The rule of law generally entails good governance through open-minded, permissible frameworks that are objectively prescribed. However, in the context of this research, the rule of law means that stakeholders collaborate to assist in the utilisation of agricultural waste as building materials by impartially following the procedures, policies and guidelines that govern the implementation of the framework. Furthermore, transparency is also required, whilst responsiveness means that all participating institutions involved in good governance ensure the rapid or reasonably timed sharing of information to all actors and key players. Finally, harmony-orientation means that all actors participate in the utilisation of agricultural waste, as building construction materials consistently need to reach a far-reaching consensus in the best interests of the end user.

3.2 Cooperation and Coordination

Ahuja (2000), describes organisational cooperation as the joint pursuit of agreed goals in a manner equivalent to a shared understanding about contributions and remunerations. In the context of this research, cooperation denotes the interactive outcomes of inter-organisational relations, which foster an innovative process in order to achieve the organisation's desired goals and aspirations. However, to effectively achieve cooperative success, all involved actors rely solely on partner agreements that stipulate the provision and appropriation of resources for the collaborative effort (Okhuysen & Bechky, 2009). Therefore, organisations negotiate what they are willing to contribute in terms of time, resources, market access, and so on, to get what they want from the alliance; this can include a new IP, greater efficiency, enhanced legitimacy, and so on (Oliver, 1990). The agreement forged on these inputs and outputs describes the extent of the cooperation or the intended scope of the relationship. Furthermore, Oliver describes coordination as an outcome that can be characterised by efficiency, the relative cost of designing and operating coordination mechanisms, and by effectiveness, namely the degree to which coordination efforts produce the desired alignment or adjustment of action. In comparison, Okhuysen & Bechky, (2009) briefly explain how coordination can be achieved; this typically involves the specification and operation of information-sharing, decision-making, and feedback mechanisms in the relationship to unify and organise partners' efforts, and to combine partners' resources in productive ways.

3.3 Research and Development

Research and development are described as organised actions that link both basic and applied research and aim to discover solutions to problems or create new goods and knowledge (OECD, 2002). However, R&D may result in the identification of rights of intellectual property, such as patents and copyright laws. In addition, research is normally described as the initiator of new knowledge, including those piloted at universities, and is fundamental for sustainable development (OECD, 2002). Becker & Dietz, (2004) explain that the importance of cooperation within R&D in the development of new products cannot be over stressed, where the increased dynamic of technical progress, the growing complications of technology, and the expanding stress of competition and costs underline the need to effectively collaborate in R&D. However, the continuous expansion and improvement of in-house R&D and outside collaboration shows positive outputs when properly managed and can increase new product developments. Therefore, to effectively implement agricultural waste for building construction purposes, R&D is one of the major critical success factors to affect the actualisation of new products from agricultural waste.

3.4 Knowledge Transfer

Argote, Ingram, Levine & Moreland, (2000) state that knowledge transfer is becoming increasingly important amongst organisations and society. Furthermore, they maintain that organisations that can transfer knowledge effectively from one unit to another are more productive and more likely to survive an economic crisis than those who are less skilful at knowledge transfer. Cummings & Teng, (2003) explain that, even though organisations can realise remarkable increases in performance through knowledge transfer, a successful knowledge transfer in any form needs to follow a unit-by-unit information dissemination process. Knowledge transfer is becoming increasingly important in successfully driving home the aims and objectives of an organisation. Nevertheless, today’s firms are more frequently organised on a global basis to take advantage of differences in expertise that are readily available, including labour costs, and access to global markets (Messick & Mackie, 1989). In the context of this study, effective knowledge transfer from the agricultural sector to the research institute, and from the research institute to manufacturers is an important success factor that can enhance the innovation management of agricultural waste for building construction purposes.

3.5 Fund and Finance

One of the success factors for improved innovation management is access to funds. In most developed and developing countries, governments have made the most of the funding available to research organisations and universities. Furthermore, many developing countries do not share the privileges received by developed countries due to the prevailing politics, policy and corruption. Banks are cautious about giving loans and credit due to corruption and the risk that an organisation may be unable to service the loan. Thus, Samila & Sorenson, (2010) suggest a venture capital system to help develop a pool of entrepreneurial talent in an area, develop ideas, and to train and encourage a community of entrepreneurs capable of bringing ideas to market. Furthermore, since high technology businesses often require both inventors and entrepreneurs, venture capital allows regions to exploit a larger share of the ideas that emerge from the region and consequently to grow more rapidly. Nevertheless, some agencies may sponsor technologies that better fit with established firms than with start-ups.

4.0 METHODOLOGY

4.1 Research Method

To properly conclude a research study, the researcher needs to adopt a research method to address the research aims and objectives. Although there are various research approaches to consider, two basic approaches are possible, which are qualitative or quantitative research (Saunders & Lewis, 2012). Quantitative methods look to count data and generalise results from a sample of the population of interest (Saunders & Lewis, 2012). Qualitative is concerned with the quality of the information, and the attempts to gain an understanding of the underlying reasons and motivations for actions in order to establish how people interpret their experiences and the world around them (Saunders & Lewis, 2012). This paper adopts qualitative method so as to address the contextual conditions of the findings and to understand people's views.

4.2 Case Study

A case study research method has been widely used in qualitative research approaches to examine contemporary real-life situations and provide the basis for the application of ideas and an extension of other methods. (Yin, 2009) defines the case study research approach "as an empirical inquiry that investigates a contemporary phenomenon within its real-life context and in which multiple sources of evidence are used. In this paper a multiple case study method is adopted based on the nature of this research to validate the adopted CSFs from the literature and be able to develop further CSFs. Also. to account for the views of stakeholders in organisations that facilitate the use of agricultural waste as building material. This is justify based on Yin, (2003) submission that multiple-case design allows for numerous sources of evidence through replication rather than sampling logic as a basis for generalisation, and the role of the researcher is to provide the reader with the information needed to judge the validity of the research finding from literature.

4.3 Data Collection and Analysis

This study utilized semi-structured interviews as the primary data collection method, due to their usefulness in enabling exhaustive empirical investigations (Van Teijlingen, 2014). Interviews are often the primary source of data for a case study technique, (Yin, 2003) and based on the context of this research where a real, live issue needs to be addressed. Thus, a series of open questions were designed in order to meet the purposes of the research (Yin, 2003). Two professionals were interviewed from each of the five case study organisations, and, to ensure accuracy, the interview transcripts were tape-recorded and manually transcribed. The participating organisations were coded as O1, O2, O3, O4, O5 as specified in Table .

Table 1: Case study organisations and employees and their assigned identity codes for the semi-structured interviews (source: Field Data, 2016)

Role	Assigned ID	Organisation	Job Functions	Time
CS1	AJBMI	Construction material manufacturing company (03)	Project officer	1h 21m
CS2	STNL	Construction firms (01)	Housing officer	1h 12m
CS3	AFOOS	Agricultural firms (02)	Field officer	1h 42m
CS4	AFSAOS	Agricultural farms (02)	Field officer	1h 8m
CS5	OSKPI	Cement Industry (04)	Operation manager	59m
CS6	FOMAONR	Ministry of Agriculture (05)	Director	1h 6m
CS7	PMTSCL	Construction firms (01)	Project manager	1h 11m
CS8	FMLFNL	Construction Company (03)	Operation manager	1h 18m
CS9	LCAPCB	Cement Industry (04)	Project manager	58m
CS10	FMANR	Ministry of Housing (05)	Director (Housing)	1h 17m

The qualitative data was analysed using thematic coding and cognitive mapping was conducted on the recorded data. By thematically coding the transcribed data the researcher could identify themes and label them under distinct names (Bernard, 2000). Cognitive mapping was employed to organise and analyse perceptions and to establish causal relationships between factors (Kulantunga et al., 2011). The analysis of the qualitative data was supported by NVivo 23, which is computer aided software; thus, to perform the analysis, the interview transcripts were uploaded to NVivo and carefully examined with the aim of identifying factors that enable the utilisation of agricultural waste as building material. To enable further analysis, the main factors related to the research questions were imported to Decision Explorer software to generate cognitive maps for each factor identified.

5.0 RESULTS AND DISCUSSION

To address the research problem, this study raised the following research question: *What are the factors responsible for the non-utilization of agricultural waste as raw materials for construction purposes in Nigeria?* This research question is explored from the stakeholder organisations perspectives.

5.1 Factors Responsible for the Non-Utilisation of Agricultural Waste as Raw Materials for Construction Purposes

Growing population levels, thriving economies, and the rapid development and rise in living standards have greatly enhanced the generation of agricultural waste in developing countries (Minghua *et al.*, 2009). To ensure the safety of their inhabitants, cities are usually responsible for the effective and efficient management of waste. However, they often face difficulties that lie beyond the ability of the municipal authority to resolve (Sujauddin, Huda, & Hoque, 2008). This is mainly due to the lack of organisation, limited financial resources, complexity, and system multidimensionality (Burnley, 2007). In the last few years, many studies have been undertaken to determine the influential factors affecting the agricultural waste management systems in the cities of developing countries. However, this section of the research aims to determine the key factors responsible for the non-utilisation of agricultural waste for building construction purposes and the factors that influence the performance of the system in Nigeria. As such, a number of factors were identified and documented in the literature. However, to validate and discover further factors, ten respondents in various organisations that are envisaged to manage agricultural waste as raw materials for construction purposes, were consulted using semi-structured interviews.

When asked to comment on the factors affecting the non-usage of agricultural waste as raw materials for construction in his region, AFOOS identified several factors responsible:

> "*Successive governments have paid lip service to technological developments in general. The Transformation Agenda of the previous government is a classic example of this. In a nutshell, I will say that the Nigerian government has continued to lack the will needed to advance innovations in that area".*

AFOOS also noted that:

> "*Agricultural wastes are often viewed as 'waste' by an overwhelming majority of Nigerians, and this stems not only from cultural beliefs but also from the religious beliefs of most Nigerians".*

In view of AFOOS comment, the utilisation of agricultural waste in Nigeria has been relegated as a concern, which contrasts with other developing and developed countries that have focused significantly on the area of agricultural waste regeneration programmes. AFOOS further noted that cultural and religious beliefs have impacted on this, although economic factors also affect the non-utilisation of agricultural waste for construction purposes:

> "*It is very hard to invest in innovative processes that enhance [the] usage of agricultural waste for construction due to the economic situation in Nigeria".*

AFOOS referred to the economic crises that have recently impacted Nigeria, and have seen a fall in foreign exchange earnings:

> "*Foreign exchange factor is also a major factor affecting the non-usage and innovation of agricultural waste into building material, where [the] importation of building material is used as means of foreign exchange fraud by businessmen and politicians".*

Similarly, FOMANR affirms AFOO's view that the Government pays lip service to such innovation advancement and innovation management structures:

> "*Because of the political conditions in Nigeria coupled with the failure of the government in power supporting waste to wealth program, and [to] develop a tangible innovation management framework in [the] form of an organisational framework, most agricultural wastes are laying waste as that result".*

This suggests that successive governments in Nigeria have not paid adequate attention to the issue of agricultural waste management and the utilisation of agricultural waste as raw materials for building construction purposes. Thus, an appropriate innovation management framework has not been developed to enhance the use of agricultural waste as building materials. Similarly, LCAPCB states that:

> "*Politicians are not ready to fund any research and development program due to greed and self-centeredness and lack of vision for the country".*

Furthermore, STNL mentioned factors that need to be addressed in order to utilise agricultural waste as a building material:

> "*Inadequate knowledge sharing between private and public sectors that are needed to come together to develop a model that can be used for [the] utilisation of agricultural waste as a building material, [a] lack of incentives for those involved in the use of agricultural waste as building materials, and inadequate funding for research and development"*

Also, FOMANR describes the cultural factor in the context of agricultural waste:

> "*As a local product for local people. Therefore, private and public organisations find it hard to invest in the research and innovation drives that can help to transform agricultural waste for building purposes as seen in some developed and developing countries. People will opt for modern imported products that are still products from recycling process*"

Therefore, some of the factors revealed by the literature were validated during the data collection. However, some factors are new and important to the objective of this study. These factors include traditions and cultures, Government support system, political instability, and corruption alongside the inability of the government as factors that affect the utilisation of agricultural waste as a building material. For clarity's sake, the key factors affecting the use of agricultural waste as raw materials for construction in Nigeria, as collated by research data collected from semi-structured interviews, are highlighted in Table 2

Table 24: The key factors affecting the use of agricultural waste as raw materials for construction.

Factors	**Respondents %**	**Number of responses**
Innovation system, collaboration, research and policies by government and private organisations	100	10
Innovation management framework and structure	100	10
Economic	90	9
Political stability	80	8
Socio- cultural (beliefs and traditions inclusive)	70	7
Effective knowledge sharing	80	8
Ignorance, awareness and lack of technical know-how	50	5

The success factors that enable the use of agricultural waste as building materials, as identified in the literature and from empirical data are discussed in the following sub-sections.

5.2 Government Support System

According to Dubai (2011), the government support system facilitates, enables, supports and develops programs focused on particular sectors: policy development and advocacy (remove barriers), training and capability development (sector productivity and competitiveness), incubation, access to finance, and market access. When all these areas are missing, there is neither an enabling environment nor a framework for development. Based on the data collected, 100% of respondents either strongly agreed or agreed that the lack of a government support system is a key reason for the neglect of the potential for agricultural waste as raw materials/materials for construction. This means the government does not support any formal or informal network comprising institutions, services, personnel, and organisations that support the innovation management of agricultural waste and its utilisation for building construction purposes. It is suggested that the main reason why the Nigerian government does not support this is due to its earnings from crude oil, which will be discussed in the next subsection.

5.3 Traditional Beliefs and Culture

There is a traditional belief system and culture concerning waste. Traditional beliefs form a system amongst rural and some urban dwellers and comprise part of a cultural ideology concerning agricultural waste. These beliefs have, in part, prevented people from developing their knowledge on how agricultural waste can best be managed to produce building materials. Interestingly, some of the responses from the key stakeholders still demonstrate this cultural belief system. Indeed, 93.1% of respondents either strongly agreed or agreed that 'traditional beliefs and culture are the key reason for the neglect of the potential of agricultural waste as raw materials for building purposes. This suggests that cultural beliefs have a significant impact on the non-adoption of agricultural waste for building materials in Nigeria. Another factor that affects the utilisation of agricultural waste as building materials is research and knowledge transfer, which is discussed in the next subsection**.**

5.4 Effective Research and Knowledge Transfer Structures

Another major factor affecting the utilisation of agricultural waste is the lack of effective research and knowledge transfer. Nevertheless, the term research and development (R&D) is widely linked to innovation, both in the corporate and governmental world, and the private and public sectors. In every sector, R&D allows organisations and sectors to maintain a top level amongst market competition (Von Zedtwitz & Gassmann, 2002). Furthermore, in the absence of R&D programs, an organisation may not survive on its own, and may have to rely on other ways to innovate, including acquisitions or partnerships. In contrast, R&D partnering helps organisations to design new and improve existing products. R&D is different from most operation activities performed by a corporation. Indeed, research and/or development is typically not performed, unless with the expectation of immediate profit. Instead, its focus is on the long-term profitability of a company, which may lead to patents, copyrights, and trademarks. Nevertheless, developing internal and external knowledge transfer capacities help to achieve organisational goals and enhances an organisation's profitability. Therefore, the government and individual organisations should engage in R&D programmes and policies, and link with international organisations and universities with track records for innovation management techniques and methods to share knowledge and information about how agricultural waste can be utilised as building materials. To achieve the best R&D and the best knowledge transfer, the Nigerian government should develop holistic policies that support the innovation management of waste material (including agricultural waste). This is discussed in the next subsection.

6.0 CONCLUSION

Findings from the qualitative survey offer a clearer view of the CSFs that enables the utilisation of agricultural waste by identifying the factor that hiders the utilisation of agricultural waste as building material, as demonstrated by the strong agreement (100%) amongst participants that innovation systems, collaboration between key parties, and policies enhances the utilisation of agricultural waste for construction products. Moreover, 70% believed that socio-cultural beliefs and traditions are major influences, whilst 80% noted that political factors, such as good governance and policies from politicians and other vices, have a substantial effect. Thus, where politicians do not believe in the development of an internal capacity for the development of sustainable approaches, no innovation can be achieved. However, 90% believed that the economic situation was a major factor affecting the utilisation of agricultural waste as raw materials for construction purposes; if there is an economic recession, it will become difficult to acquire adequate machinery and funding for innovation purposes and challenging to access manufacturing equipment by private individuals. Furthermore, 50% of the respondents agreed that awareness and technical know-how can enhance the utilisation of agricultural waste as building materials, whilst 70% of the respondents agreed that political stability is a major factor that enhances the use of agricultural waste as building materials.

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HOW TRAINING CAN SUPPORT LOW CARBON PRIORITISATION IN FLOOD AND COAST RISK MANAGEMENT CONSTRUCTION

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Abstract: This paper presents research work and major findings from both a survey and action research, where a leading government agency and its supply chain was selected as the population for the survey and action research activities. The survey covers participants from the whole value chain within the project lifecycle, since many authoritative sources call for integration, and for change to be implemented in partner organisations; two main actions: implementation of a whole life carbon planning tool (WLCPT) and promotion of low carbon within the public domain by the author have been taken forward. The survey and action research activity results show that training improves low carbon prioritisation, but the type and approach to training also has an influence. This suggests that there is still further work to be undertaken in sharing knowledge and best practice examples across industry, and how the provision of such valuable data and information needs to become integral to project deliverables, to facilitate the change required to fully embed low carbon into flood and coast risk management (FCRM) construction and wider industry. This research supports industry knowledge specifically for evidencing that training supports low carbon prioritisation and that low carbon solutions lead to reduced cost and improved efficiency, specifically in FCRM construction. Evidencing this supports a need for wider changes to organisational culture to fully embed low carbon solutions in public sector construction. This will in turn have an impact on the amount of carbon being used, which can positively affect climate change as a whole. Through the literature review it is evidenced that carbon has an impact on climate change; organisational culture and training can facilitate the successful implementation of new initiatives such as low carbon solutions to support the climate change challenge. However, attempts to embed low carbon into infrastructure construction practice have had limited success to date; the research study demonstrates that training can have a positive influence in embedding low carbon solutions.

Keywords: Training, low carbon, organisational culture, flood and coast risk management (FCRM).

1. INTRODUCTION

'A mass extinction event, only the sixth in roughly 540 million years, is underway' (Barnosky, et al. 2011); this stark and direct message was published seven years before Greta Thunberg took to protesting outside Swedish parliament in August 2018. The United Nations Secretary-General Antonio Guterres provided a warning that 'Climate change is the defining issue of our time – and we are at a defining moment … we face a direct existential threat' (UN, 2018). The IPCC published a special report, warning that swift action is needed to 'keep global warning under 1.5°C', in order to avoid catastrophic impacts to life on Earth (IPCC, 2018). Also a Climate Change Emergency was declared by the UK Parliament on 1st May 2019, followed by Scottish and Welsh governments, and many towns and cities across the UK. Despite this stark and direct message, it has taken eight years to revise *Climate Change Act (2008*); UK government has called for a move to Net Zero for carbon emissions exceeding the target of an 80% reduction of 1990 levels for the built environment.

Acceptance and implementation change across society and organisations takes time. This is not to diminish the efforts and drive of those currently raising awareness and demanding governments and organisations take action, it is simply the recognition that in order to make and sustain change and influence organisational culture, key areas need to be addressed. In the context of UK Public Sector Flood Risk Management (FCRM) construction, the research aim is to investigate whether the prioritisation of low carbon solutions influences organisational culture. The collaborative and common objective approach to low carbon is aligned to Publicly Available Standard (PAS) 2080 (Construction Leadership Council, 2016).

This paper presents research work and major findings from both a survey and action research approach, whereby a leading government agency and its supply chain was selected as the population for the survey and action research activities. The survey comprised 24 questions, and the action research activities consist of two main actions: implementation of a whole life carbon planning tool (WLCPT) and promotion of low carbon within the public domain by the lead author. The paper makes a comprehensive review of the previous research on the level of low carbon training and its link to low carbon prioritisation, and the effect of organisational culture; it then discusses the data collection method; presents raw data that is applicable to both the survey and action research approach and, finally, analyses the results by mapping organisational culture and determining whether training influences low carbon prioritisation.

2. LITERATURE REVIEW

2.1 Organisational Culture

Organisational culture is defined as: goals and measures; customs and norms; training; ceremonies and events; management behaviours; rewards and recognition; communications; physical environment and organisational structure (Galpin, 1996). It is the 'shared assumptions, values, and beliefs, which determine how we behave' (Mayhew, 2016). Mayhew (2016) also states that 'Culture is all about relationships. As a leader you will only find effectiveness if you can relate to those you are leading and help move forward'. Culture is also viewed as the foundation that establishes the trust that impacts on the degree at which employees buy-in to change and highlights the commitment to drive and sustain change. In addition to this, it focuses on employee willingness to share information and collaborate, which ultimately determines organisation ability to survive disruptions, and its ability to advance (Alavi & Kayworth, 2005; Barney, 1986; Janz, 2003; Taylor, 2013). According to Gaplin (ibid) there is no single component to describe organisational culture as each element is individual to the organisation and relies on how each element interacts on a day-to-day basis. Understanding and diagnosing organisational culture can assist in implementing the type of change needed and establishing organisational readiness for change (Burnes, 1996 and Sundar, 2013).

What happens in organisations and reasons for this point to the 'true culture'. The behaviour of employees may illustrate what the current culture is, and can change what an organisations' culture can be; each individual in an organisation is part of a culture, and therefore can affect it. The repetitive nature is what makes 'something cultural', the only way to change this and manage change is to 'create a different pattern which stands opposed to a culture's rhythm'. Breaking current practice, creating different ways of working and 'then exploiting the habit-trigger to direct attention is a new way', by promoting different initiatives and rewarding those who adopt these initiatives (Mayhew, ibid). This view is also supported by Gaplin (ibid) who states that '… the primary motive for managing culture during change is to implement and sustain those changes. Too often, executives and managers struggle when implementing changes because they don't understand how to make them important to employees …'. Bascal (2009) emphasises that the success of organisational change requires an understanding of how individuals change, associating this understanding with specific phases such as preparation, acceptance and commitment whereby individuals gain an understanding of the changes and therefore automatically have a positive acceptance. In contrast Kubler-Ross and Fisher (2009) focus on the psychological changes associated with an individual's positive and negative feelings and reactions. Their reactions are different, and this can lead to negative attitudes towards their work, and then in turn make them risk averse and afraid to innovate (Scott, et al. 1989).

2.2 Organisational Change

Change needs to come from both company and individual level. A 'cultural change' needs to occur within an organisation when major change is implemented (Scott, et al. ibid) and in order for a major change to be successful a sense of urgency needs to be established and a clear understanding of the internal and external drivers required (Kotter, 1979). As an example, in the case of the UK Environment Agency and its supply chains, the sense of urgency comes from the need to save the Environment alongside Government drivers for low carbon construction, BIM and efficiency; these internal and external drivers have been relayed to supply chains via the Water and Environment Management (WEM) framework Deed of Agreement (Agency, 2013). In principle the targets in which all supply chain organisations represented have agreed to, are set at client organisation level, framework level and contract level. However, the order in which these initiatives are prioritised above others, often comes down to individuals representing each project and their interpretation of the targets required and their resistance to implementing changes required. The success of organisational change 'requires understanding on how individuals change' (Bascal, 2009). Where as they should all be equally important, it is often the case that cost reduction and efficiency are prioritised higher than carbon reduction; as long as there is a reduction in the carbon recorded between appraisal, detailed design and construction phases there is less effort applied to strive for greater improvement.

Since this cultural change has not occurred to its full potential in the last decade (Hall, 2010) how are we to ensure that the next decade is any different? According to Burners (1996) 'managers need to have extensive and deep understanding of strategy, structure, systems, people, style and culture'. This view is supported by Kotter and Schlesinger (Kotter, 1979) who believe establishing a sense of urgency and understanding of internal and external triggers for change, are imperative to the success of any organisational change. When a major change occurs in an organisation, what actually happens is the 'corporate culture' changes (Scott, et al., ibid). Galpin (ibid) states that 'effective implementation of organisational changes requires that changes in operations, systems, procedures and the like be clearly connected to an organisation's culture'. Making this connection embeds change in to the day-to-day life of organisations, sustaining desired effects. (Latham, 1994, Egan, 1998, Wolstenholme, 2009). Having a positive acceptance of a change is dependant on how individuals change and understand these needs (Bascal, ibid). This view is also supported by Scott, et al. (ibid), who state that a lack of understanding and awareness of individual change may lead to a negative attitude towards their jobs, making individuals risk averse and afraid to innovate.

2.3 Training

Motivating future generations through education and training; or engaging and incentivising employees, in order to deliver the changes required, supports the need to attract the right caliber of talent into the industry, effectively utilising avenues currently available through professional bodies and learning institutions to promote a more ‘holistic learning across disciplines’ (Wolstenholme, ibid; Henderson, 2009; Hall, 2010). This learning however needs to incorporate both the ‘hard’ and ‘soft’ skills. By definition, hard skills tend to be processes and systems, and soft skills more from the behavioural. In order for this to be achievable, education systems and organisational change initiatives need to take into account the ability of individuals to engage collaboratively with value chains in which they work and interact. In the context of low carbon, PAS 2080, Volvo (2017) provides a structure for four key roles within supply chains: asset owners/managers; designers; constructors; product/material suppliers. Although each have a shared role and responsibility, greatest efforts in carbon reduction comes from collaboration. The carbon reduction hierarchy is focused around stages with the greatest chance to reduce carbon and cost being in the early stages. Greenhouse gas emissions are at the control of the organisation, capital and operational carbon are emissions that asset owners have the ability to control through design and operating philosophy. PAS 2080 recognised that a process is needed to achieve carbon reduction: continual improvement; target setting; baselines; monitoring; reporting and quantification of greenhouse gases give the greatest chance for carbon reductions. Supported by robust governance and leadership which allows the space to challenge. Winter (2003) states the 'hard' system perspective has a clear objective or goal and a management process. The 'soft' system perspective is an ever changing flux of messy situations and the process of managing.

It is therefore on this basis that when promoting low carbon, the greatest change can be achieved collectively across the construction industry. Ainger (2012) emphasises the need for collaboration and improved knowledge sharing to rapidly drive forward the commercial applicability of innovative solutions within the industry to the broad dissemination stage. It is considered that this approach allows for a diversity of approaches to the challenges, allowing a number of different attempts to take solutions forward, with a quicker route to adoption as standard across industry. This, he contends, is required if the decarbonisation challenge is to be answered with any effectiveness and will need to be incentivised by DEFRA and OFWAT (Chisholm, 2013).

According to the ICE (2011) low carbon infrastructure is defined as a ‘similar level of service from existing networks but with greatly reduced carbon emissions over traditional approaches’. Waller (2013) states that ‘collaborative working relationships can increase efficiency with less defensive and more constructive mindsets’, meaning parties need to pool knowledge and effort, and focus on successful outcomes for all participants. Anglian Water challenged their standard approach whereby ‘design engineers followed a four-stage process to reduce embodied carbon impacts: challenging the need to build any new structures, identifying which structures/assets could be reused, identifying alternative lower embodied carbon materials and finally using recycled material and reducing the quantity of raw materials’ (ICE, ibid).

All supply chain partners from clients, cost consultants, design consultants, site investigation contractors, main contractors and sub contractors, to end users, all need to have a wide understanding of low carbon project objectives. McCreery (2003), notes that the training and development of Project Managers is difficult due to the large knowledge base needed, since project management is both theory and practice based. Winter (2003) supports this view and states that, 'all practical action is theory laden, whereby theory leads to practice and practice generates theory, neither are prime as the process regenerates itself'. However, according to Carbone and Gholstone (quoted in Pant, 2008), 'while certain aspects of the profession might learn in the class room setting through simulation and with case studies, there are other aspects of the job that requires a different type of experience … particularly hard to train in a classroom are the soft-skill aspects of the job'. This view is supported by El-Saaba (Pant, ibid) who adds that the 'human skills of project managers have the greatest influence on project management practice and technical skills the least'. It is the human element that also has the greatest influence on organisational culture affecting the shape and succes of organisations and in turn the successful implementation of low carbon initiatives.

2.4 Low Carbon Tools

Whereas an organisation's success and project level outcomes maybe achievable, the additional aims of low carbon has over the last decade been reliant on client lead approaches. This needs to change 'for the supply side to demonstrate how it can create additional economic, social and environmental value through innovation, collaboration and intergrated working' (Wolstenholme, ibid).

'Monitoring and reporting of carbon emissions is of great importance because it facilitates understanding within companies of their emissions profiles and where opportunities for reductions lie' (Chisholm, ibid). There are several carbon calculators available to the public and construction industry free of charge. The analysis of materials, resources and methodologies can be assessed using on-line resources. However, not all carbon calculators are suitable or appropriate for construction especially within FCRM construction. This is due to the content not covering all aspects of FCRM works or due to aspects highlighted by McKinskey (2018), who state that social tools play a critical role in how technology overall can encourage organisational change. In its survey, three key areas were highlighted from respondents as having both a role in adoption of tools and how respondents within organisations work. These were: real-time interactions; ability to collaborate with specific groups of individuals; and accessibility across multiple organisations.

Following carbon calculators are available for free use by the infrastructure industry (Circular Ecology, 2017):

- AggRegain Carbon Dioxide (CO2) Emissions Estimator Tool – For Aggregates;
- Asphalt Pavement Embodied Carbon Tool;
- Carbon Build Neutral;
- PAS 2050 Carbon Calculator for Stoneworks;
- The Highways Agency Carbon Calculator for Construction;
- Transport Scotland Carbon Management Scheme – Carbon Calculator for Road and Rail Schemes;
- Environment Agency Carbon tool.

Carbon reporting within UK Public Sector FCRM has been in place since 2005, and carbon monitoring within the wider water industry has been in place since the 1990s, using the commonly used Carbon Accounting Workbook (CAW) (UKWIR, 2009). The collation of carbon data at a project level comprises complex communication processes between numerous project participants involving large amounts of information; this often causes errors and omissions during design and construction (Eastman et al., 2008, Sebastian, 2010). This calls into question the reliability of data, the consistency in which data is gathered and reported, the level of manual intervention required and the level of training undertaken in order to ensure that low carbon solutions are implemented and data recorded competently. Each of the publicly available carbon tools are stand-alone and are specific for their choosen audience. However, despite all of these available tools, they are all individual, either online systems or Excel based. Through wider utilisation it is expected that improvements could be made to the quality of carbon data reported and ensure that carbon reporting is more consistent across the infrastructure industry. In order to achieve this, greater leadership in promoting and prioritising carbon reduction is required, along with a fundamental cultural change and investment within the infrastructure industry to ensure that carbon calculation is undertaken utilising the same carbon calculation processes, with carbon data begin provided at source. A clear step forward is required for the next generation of carbon tools which is to use the carbon data at source and Building Information Modelling as the basis of an integrated system approach. According to Sebastian (2010) 'BIM comprises collaboration frameworks and technologies for integrating process and object-orientated information throughout the life cycle of buildings in a multi-dimensional model. BIM information sharing among project participants from different disciplines can be centralized and coordinated effectively'.

3. METHODOLOGY

Through the research method of a questionnaire and action research approach, the implementation and development of a whole life carbon planning tool (WLCPT) has provided a suitable context for a shift in practice to be tested. The research tested eight objectives and hypothesis and measured ten variables, of which the following research objectives will be utilised for this paper.

- OB1: To investigate whether training influences low carbon prioritisation
- H1: The level of training influences low carbon prioritisation
    - VAR 1 training
    - VAR 2 low carbon prioritisation

A questionnaire was undertaken within a leading government organisation and its supply chain; the questions were provided in order to establish satisfaction levels in regards to training and level of low carbon implementation. The outputs of the action research, have been implemented and developed based on the survey findings:

- Action 1: Implementation of a WLCPT and supportive training

The main survey was constructed to test current thinking; to test the hypothesis and to support action research actions. It comprised the following topic areas: demographic; organisational culture and organisational leadership, and; low carbon and change. In addition to these main topic areas, questions on carbon leads, training and cost were included.

The survey was completed by project management teams from a leading government organisation undertaking FCRM construction projects; a specific delivery unit within the department was selected. Teams delivering construction projects were at various stages in the project life cycle, ranging from pipeline projects, appraisal, design, construction and post construction. The survey looked at establishing whether low carbon is successfully understood and embedded into UK public sector FCRM construction; also, whether there has been sufficient prioritisation and promotion of low carbon and to establish whether the importance of low carbon has been fully realised.

Having identified gaps in the existing body of knowledge, through the initial review, the next step was to carry out a more detailed and specific review on the following concepts as covered within the survey: low carbon prioritisation, implementation and promotion. The review remains as an on-going process which requires refinement and modification as the study progresses; new findings emerge all the time and it is important to reflect. The survey has resulted in adjustments and a new direction for the main body of the research (Easterby-Smith et al., 2008).

Training is associated with the implementation of a WLCPT and the ongoing awareness raising and promotion of low carbon. The WLCPT comprises of two main components: the Carbon Modelling Tool (CMT) and the Carbon Calculator (CC). The CMT allows for a top down method to undertake whole life carbon assessments. It utilises benchmarked data from completed and approved carbon calculators. Essentially it allows for early carbon target setting but it also ensures that design processes review carbon at early stages ensuring that they do not become an afterthought. The WLCPT enables low carbon solutions to be promoted through capital optioneering and delivery processes. The CC assessment involves reviewing carbon associated with materials, transport of people/plant/materials/waste, the construction process i.e. the energy required to build elements as well as the running of site cabins, the operation of the elements ensuring that any carbon associated with use/maintenance/repair/energy is captured, the demolition of the elements and the replacement of the elements. The outputs from the WLCPT are utilised to measure whether there has been a reduction in the volume of carbon at project level.

It is through ongoing communications and review that the availability of training has been promoted. Training has developed significantly since the availability WLCPT. Initially it was provided by the research practitioner, supplier bought-in service and via a wider network of carbon champions. This has been via webinars which provided an overview of the organisation's drivers, WLCPT and when it should be used. Also, through specific face-to-face sessions, utilising a project example and working through the process. In undertaking these activities and seeking feedback from participants, the benefit of being taken through in detail how to complete WLCPT and being provided an overview as to why it needed to be done was promoted. In addition to this the findings from the Assurance report (Environment Agency, 2018) the need for more comprehensive training was required. Works were progressed to put together a package of training modules around low carbon and WLCPT thus:

- Low carbon awareness e-learning module;
- WLCPT e-learning module.

The WLCPT e-learning module became a key produce of the research practitioners work to ensure that the quality and usability of the tool was readily transcribed into an on-line learning activity. The outputs of the WLCPT and the level of training undertaken have been analysed to test the OB1: To investigate whether training influences low carbon prioritisation. The module is available via an internal Learning Zone portal. An external link is also available for framework suppliers and external users of WLCPT.

Additional training undertaken for project teams was in the form of low carbon solutions workshops; these took the alternative view of providing examples of low carbon case studies and factsheets and utilising an external trainer to provide an overview as to why low carbon solutions are the right approach, using breakout sessions to encourage participants to think about their projects and where low carbon solutions can be implemented.

4. RESULTS AND ANALYSIS

Project managers from the leading government organisation North unit were requested as part of their progress meetings to complete the survey; respondents had a direct input to project delivery and comprised of team members from the client, design/engineering consultant, construction, cost consultant organisations, in addition to other contributing parties. The maximum expected survey returns of 325 (65*5 = 325), 112 returns were received, 20 were incomplete and were removed from the analysis since it was judged they could not contribute towards study findings and conclusions; the remaining 92 returns represented a 28% return rate. In testing the following hypothesis:

- H1: The level of training influences low carbon prioritisation

Testing H1: The level of training influences low carbon prioritisation, the correlation assessment scored low. The VAR 1 results from the survey and action research methods, provided the following results: 55% of the survey participants were satisfied with the level of training received, this aligns to the organisational culture levels of low carbon prioritisation, promotion and implementation. However, when compared to the VAR 2, levels of low carbon prioritisation, the success in implementing industry approaches at project level these did not follow the recommended approach of embedding low carbon into decision making (HM Treasury, 2013). Table 1 VAR 1 Training survey analysis provided an overview of respondent results. Table 2 VAR 2 provides the percentage responses to low carbon prioritisation, of these items

- My organisation utilises low carbon data to prioritise/inform project options

It analyses at 33% however the responses of Q12 and Q13 the stages at which low carbon planning and calculation are included within particular project stages, the results for project appraisal showed 47% for carbon planning and 31% for carbon calculation. This indicates that the link between level of satisfaction levels for training utilisation of carbon data to prioritise/inform project options and the level of carbon planning and calculation undertaken at options appraisal requires further focus and clarity on what is required and how carbon data should be used, supported by improved training.

Table 1 VAR 1 Training survey analysis

Variable 1 training satisfaction levels	
Extremely satisfied	2
Moderately satisfied	29
Slightly satisfied	24
Slightly dissatisfied	20
Moderately dissatisfied	15
Extremely dissatisfied	2
Percentage	**55%**
SD	1.19

Table 2 VAR 2 low carbon prioritisation

VAR 2 Survey question 11	**%**
My organisation has low carbon targets which are applied across the organisation	57
My organisation has low carbon targets applied to particular customers	16
My organisation uses low carbon solutions and technologies that are shared and used by our suppliers and/or clients	39
In my organisation I find it easy to use low carbon data and information without intervention	3
My organisation receives low carbon data and information from its supply chain and/or client which allows you to bring it together with other data to promote low carbon on our projects	23
My organisation's project leaders encourage low carbon solution and technology sharing	39
My organisation utilises low carbon data to prioritise/inform project options	33

The results of the questionnaire provided a correlation between each variable Table 3 provides a summary of the analysis. Indicating that training does not influence low carbon prioritisation.

Table 3 Correlation of variables

Correlation		**Cohen and Holliday** (Cohen, 1996)
VAR 1 (survey) and VAR 2	0.28	A low correlation

Following the implementation of the new WLCPT and the review of training compared to low carbon prioritisation and achievement, the previous correlation from the survey analysis of VAR 1 and VAR 2, has been reconfirmed. Table 4 provides the outputs from 33 projects where project managers or project executives undertook the WLCPT e-learning module and achieved a reduction in capital carbon. Overall, 45% had completed the training, of these projects only 30% also achieved a capital carbon reduction. 55% had completed no training but 25% still achieved a capital carbon reduction. However, this indicates that the level of training has a limited influence on low carbon prioritisation. Utilising the data collated a chi-square calculation in Excel was undertaken using a frequency count in a 2 x 2 contingency table; n = 33, formula result = 0.48; the finding is that the null hypothesis cannot be rejected.

Table 4 Action research VAR 1 training and achievement of VAR 2 low carbon prioritisation

Projects where training and capital carbon reduction has been achieved	
Training & carbon reduction	8
No training & carbon reduction	10
Training & carbon increase	5
No training & carbon increase	10

It is at this point that the two types of training become conflicting, the training for completing a WLCPT with the carbon data does not necessarily indicate that the right low carbon decisions were made at project level, merely that that the data was reported. In analysing this data further, the projects reported were analysed to determine whether low carbon best practice approaches were implemented. The practice types are as identified within the assurance review and within the case studies and factsheets provided as part of the low carbon solutions workshops. These were as follows (Environment Agency, 2018):

- Alternative materials – This has largely focussed on the use of recycled plastics and trial of AACM (CemFree);
- Asset Repair – Multiple repair techniques and products identified with significant savings where applied;
- Optimised design to inform alternative construction methods – Multiple examples of embankment and reservoir design optimisation to reduce volumes of material imported or transported on site;
- Materials and waste management – Multiple examples of avoiding disturbing contaminated land, reusing contaminated arisings, reducing transport distances, and minimising waste produced;
- Efficient construction – Main areas found are use of pre-cast catalogue products such as Brico Bloc and Redi-roc blocks;
- Innovative Technologies – Generally one off or limited applications e.g. inflatable weir and hydroslide technologies.

The review indicated that 60% of the projects implemented best practice approaches; of these, those who did not undertaken the e-Learning training but still reduced carbon 5 of the 8 projects implemented best practice approaches. These results indicate that the training utilising examples of where low carbon, resulted in reduced cost and improved efficiency had a greater impact on project team and supporting them in making the right low carbon decisions. This is also supported by the survey response whereby 86% of participants viewed low carbon solutions to have a similar or less cost than conventional solutions (Q23 of the survey), this is in-line with industry findings and the Infrastructure Carbon Review (HM Treasury, 2013). However, when assessing the stages in which carbon calculation and planning were actively discussed at project stages; low carbon planning was only actively discussed in appraisal (47%) and construction stages (41%) followed by design (35%), with 45% in the remaining stages. This indicates that the wider opportunity to reduce carbon in-line with the carbon reduction hierarchy (Environment Agency, 2018), is not being fully realised. Carbon calculation was also focused on construction (57%), design (47%) and appraisal (35%), with 55% in the remaining stages. This indicated that although carbon planning maybe accounted for the true quantification of carbon usage is primarily being for reporting purposes rather than as part of the decision-making process.

The VAR 1 results also scored low; 63% for the sharing and utilisation of low carbon best practice and lessons learnt. This indicates that although low carbon solutions were being implemented, the wider benefit of knowledge share was not being capitalised. This was also evident in the availability of the case studies required for the low carbon solutions workshops and the need to collate and create these from historic projects rather than having them readily available for use.

5. CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations are made regarding the level of training and its influence on low carbon prioritisation. The alternative hypothesis identified in this paper, is accepted but also influenced by the type of training received. In the case of providing low carbon data for reporting the correlation H1: overall, the level of training does influence low carbon prioritisation, however as the e-learning training was mainly focused upon completion of the WLCPT, the data required, when it should be use and why, it is deemed to have a limited affect and does not provided examples of best practice approaches. Best practice approaches were covered within the low carbon solutions workshops, when analysing project returns to ascertain whether best practice approaches were implemented, 60% provided clear evidence in their method, approach and materials selected. Of these the projects that did not undertake the e-learning module still demonstrated a clear training benefit by evidencing that best practice approaches were implemented. This indicated that training does influence low carbon prioritisation and that the type and approach of training can provide an influence. Through the activities identified within the action research approach: Actions - implementation of a WLCPT and supportive training to support further knowledge sharing opportunities are required; the approach to producing case studies and factsheet on low carbon, reduced cost and improved efficiency examples needs to be explored further as there is a clear demonstration that they aid learning and support low carbon prioritisation on projects - gathering such information is not systematic nor is it currently part of project deliverables. This needs to be reviewed as part of project scopes, to ensure that shared learning is more widely maximised, for the benefit of client organisations, supply chains and the industry.

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A FRAMEWORK TOWARDS THE REDUCTION OF THE ECOLOGICAL AND CARBON FOOTPRINT OF CONSTRUCTION ACTIVITY IN GHANA

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Abstract: The lack of an empirical framework for the reduction of construction activity carbon and ecological footprint hinders the realisation of sustainability in the built environment in Ghana. In essence, the study sought responses from experts to know how construction companies focus on sustainability to reduce the carbon and ecological footprint of their activities in Ghana. A review of relevant literature was carried out in order to develop a model to reduce carbon emissions levels and ecological footprint of construction activities. A pilot study has been conducted with the goals of testing and adjusting the Delphi questionnaire for the main study. The experts rank the level of integration of sustainability measures in Ghanaian construction industry low and recommended that a sustainable construction framework would help Ghana to achieve sustainability. Therefore, the model to be developed will aid the drive towards a low level of carbon emissions in construction and help in identifying any inefficiency in the use of construction designs and programmes and weaknesses in adhering to specifications. It would also reduce the ecological footprint for an improved built environment in Ghana to influence the realisation of three sustainable development goals (SDG 9, SDG 12 and SDG 13).

Keywords: Built environment, carbon and ecological footprint, construction activity, empirical framework, sustainability.

1. INTRODUCTION

There is a growing awareness of the need for adopting sustainable practices in the construction industry. The reduction of construction activity carbon and ecological footprints is essential for the attainment of three Sustainable Development Goals (SDG 9, SDG 12 and SDG 13). However, limited studies have focused on reducing the carbon and ecological footprint of construction site activities (Carmichael *et al.,* 2014: 534). According to Yao (2013: 20) "…. as we head into an uncertain future with resource depletion and energy security issues, striving to achieve sustainable urban environments becomes a prerequisite if mankind is to thrive on Earth". Hong *et al.* (2015: 249-259) says that greenhouse gas (GHG) emissions generated in the manufacturing of materials and the fuel used in construction equipment accounted for 88% to 96% of the total carbon emissions. About 40% of the world's resources and energy use are linked to the construction and maintenance of buildings (Edeoja & Edeoja, 2015; Rahim *et al*., 2014), and these are responsible for 40% to 50% of the GHG generated and contribute a quarter of the global total carbon emissions (Huang *et al*., 2017; Kim & Rigdon, 2016).

The rapid growth of the Ghanaian population is increasing urbanization, which has caused an increase in energy per capita, consumption of limited resources and extensive use of petroleum resources leading to an increase in GHG emission and global warming, and a decrease in biodiversity (Mustafa & Bakis, 2015). The construction activities in Ghana also causes land degradation, loss of habitats, air and water pollution and high energy usage (Ofori, 2012; Djokoto, *et al.,* 2014). The deforestation rate was 0.81% of the total land surface in 2010, and the cost of environmental degradation ranks as one of the highest in the world at roughly 10% of the GDP (UNEP, 2015). These effects seem to be increasing as a result of efforts to reduce the over two thousand housing deficit in the country.

Research on carbon emissions from human activities during the building construction phase is scarce (Huang *et al.,* 2017; Kim & Rigdon, 2016). From this perspective, achieving sustainable development requires construction companies to be proactive with a new approach to business. This can comprise new processes, new materials, products, technologies, and new business models to ensure that things must be done differently if new trends are to be adopted in the long term (Campos *et al.,* 2012; Emuze & Smallwood, 2013).

The construction sector, when given good policy initiatives and regulatory guidance for sustainability practices, can provide the necessary impetus for socio-economic development in Ghana (Osei, 2013), by using natural resources more efficiently to protect energy, water and materials and control waste from construction (Kim & Rigdon, 1998; Mustafa & Bakis, 2015). This will strengthen the field of building sustainability by contributing to the global movement against the effects of climate change. The conclusion from these studies shows a significant benefit of preventing further damage to the environment and provides the possibility of continuous improvement and the attainment of an ecosystem equilibrium for sustainable development. The objective of this study is to evaluate the modalities and sustainability practices employed by construction companies in Ghana to reduce the carbon and ecological footprint on the environment emanating from their activities in the industry.

2. LITERATURE REVIEW

The sustainability concept can be defined as "…meeting the needs and expectations of the present without compromising future generations to meet their own needs and expectations" in the Brutland Report which is published by United Nations' World Commission on Environment and Development (WCED, 1987). The three main dimensions of sustainability involve issues of balancing economic and social development with environmental or ecological considerations (Hacking & Guthrie, 2008, cited in Persson, 2015:43). Du Plessis (2009) indicated that environmental or ecological sustainability is the basis of the sustainability dimensions. Kibwami & Tutesigensi (2016) explain that environmental sustainability serves as the entry point to initiate the promoting of sustainable construction. Sustainable construction is the creation and responsible management of a healthy built environment based on resource-efficient and ecological principles (Kibert, 1994; 3-12; Saleh & Alalouch, 2015: 179). Kibwami & Tutesigensi (2016) stressed that sustainable construction was interpreted mainly in terms of environmental sustainability and measures that promote environmental sustainability could be adopted for sustainable construction. They indicated that embodied carbon emission should be considered in sustainability assessment of building projects particularly in developing countries where increased construction activities resulting from rapid growth and urbanization have impacts on the environment in terms of carbon emission. De Boeck (2013) confirmed that this is putting the African continent at risk with regards to meeting the increasing demands for housing construction. Gan *et al*. (2015) indicated that the adoption of sustainable construction is impeded by five categories of economic, resources, consciousness, process, and policies and regulations. Therefore, the construction industry is to take systematic steps to improve construction activities to reduce carbon and ecological footprints to meet sustainability requirements for the achievement of sustainable development goals.

However, the implementation of sustainable construction in Ghana is faced with many challenges. Ametepey and Ansah (2015), identify most severe sustainable construction challenges in Ghana to be resistance to change, lack of government commitment, fear of higher investment cost, lack of professional knowledge, and lack of legislation. Du Plessis (2007) and Mensah *et al*., (2015) found out that Contractual, legal and business enablers, as well as knowledge and framework gaps, exist with regards to the practising of sustainable construction in developing countries such as Ghana. Ametepey and Ansah (2015), recommend that active measures should be put in place to overcome identified challenges in Ghana. Kwaku *et al*., (2014) also stress the need to determine whether the construction industry is adopting the necessary tools and processes and undertaking the actions needed to become sustainable as well as determining what actions could be taken to ensure the sustainability of the construction industry.

The construction sector has been found to employ approximately half the resources man consumes from nature (Bakens, 2003), estimated to generate approximately 40% of all human-made waste (Hassin *et al*., 2013) and consumes around 40% of all energy produced (Saleh, 2015). The global carbon emissions generated from buildings increased at an average of 2.7% per year (Metz *et al*., 2007, cited in Hong *et al*., 2014: 249-259). By reviewing previous research, Yan *et al.* (2010) summarized four primary emission sources on construction sites, namely building materials production and transportation, energy use of construction machines, energy use for processing resources, and disposal of construction waste (Hong *et al.,* 2015: 249-259). Hong *et al*. (2014) emphasized that on-site electricity use and building materials production were the two most significant contributors to direct and indirect emissions.

The effects of carbon emissions as a result of construction include global warming, scarcity of water, pollution of air, and soil, melting ice caps and increasing oceans level, degradation of the ozone layer, extreme weather events and changes of the seasons, reducing biodiversity and desertification according to Radu *et al*. (2013). Gottfried (1996) confirmed that these effects are limiting the earth's carrying capacity and affecting the environment. However, Huang *et al*. (2017) contend that there is limited research on how to reduce the effects of construction activity on the environment. Therefore, research on the carbon and ecological footprint is of particular significance in dealing with climate change for environmental sustainability to restore the ecological balance, which requires urgent action to reduce GHG emissions. The seeming consensus is that there is a need for more comprehensive work on methodologies or frameworks to be scientifically developed and empirically verified for sustainability practices of construction companies in Ghana. This will provide decisive support for low-carbon building design and construction, and exploring the way towards the reduction of the carbon and ecological footprint of construction activities.

2.1 Conceptual Framework for the Study

The conceptual framework that will guide the study is established based on the literature reviewed. The research project focuses on the sustainable construction practices of construction firms during the construction phase of a project life-cycle excluding the conceptualization, planning, development and design phases of the construction process. The research, therefore, focusses on the carbon and ecological footprint issues regarding environmental sustainability to establish a sustainable construction model that works for the construction companies. Environmental sustainability serves as the entry point to initiate promoting of sustainable construction since sustainable construction was found to be largely interpreted in the terms of conserving the environment (Kibwami & Tutesigensi, 2016). This implies that measures that highly promote environmental sustainability could be adopted to achieve sustainable construction as shown in the conceptual framework in figure 1.

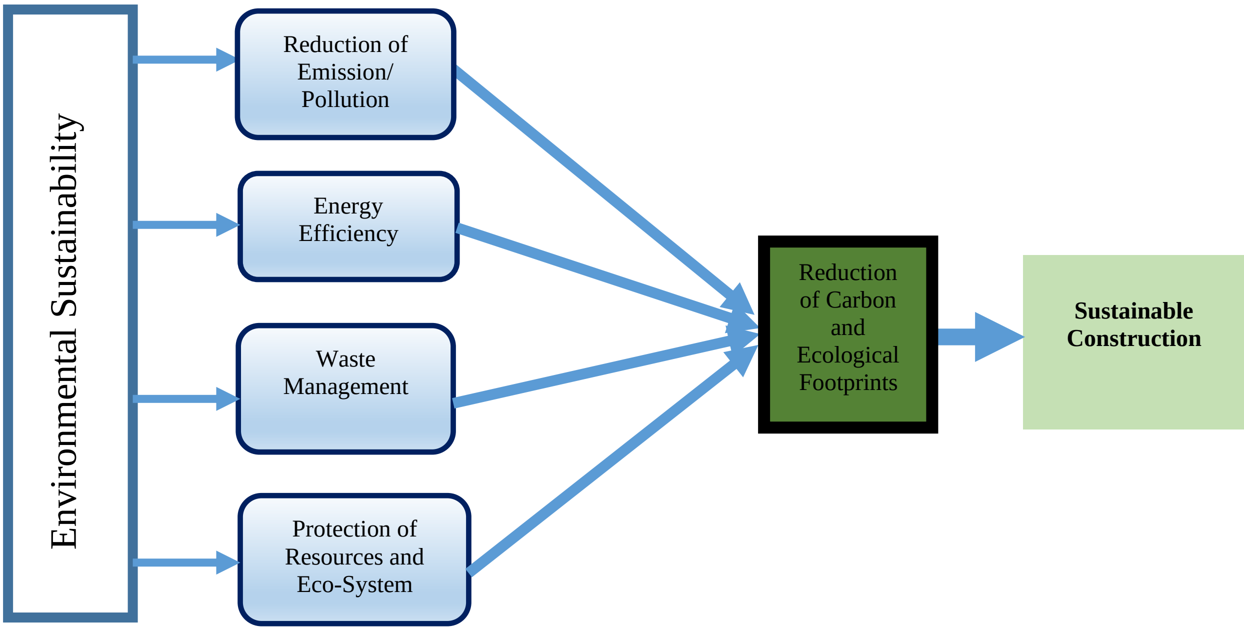

Figure 1: Conceptual framework
(Source: Researcher's construction)

The main research question that would need to be answered for the development of the framework is: How do construction companies focus on sustainability to reduce the carbon and ecological footprint of their activities in Ghana? This principal question leads to the postulation of the research problem statement, namely '*The lack of an empirical framework for the reduction of construction activity carbon and ecological footprint hinders continuous improvement within public sector construction in Ghana'*.

The principal question has been broken down into the following sub-questions to resolve the problem above:

1. Why is sustainability a focus area that cannot be ignored by construction companies in Ghana?
2. How are architectural and engineering firms responding through design to sustainability requirements in Ghana?
3. How do contractors incorporate low impact building materials in the construction process in Ghana?
4. How is energy-efficient equipment utilisation influencing the construction process in Ghana?

5. What modalities do contractors employ to reduce construction site solid waste production and discharge in Ghana?
6. What sustainable construction model works for companies in Ghana?

Moreover, sustainable construction efforts are influenced by environmental sustainability that relies on management of the natural resources, emission and pollution to achieve sustainability which is influenced by the reduction of carbon and ecological footprint (Chen *et al*. 2000, Tam *et al*. 2006). The table 1 below shows how the variables in the conceptual framework relates to sustainable construction.

Table 1: Research construct and variables

Element/construct	Variables	Criteria	Description	References
Sustainable construction for Environmental Sustainability	Reduction of Emission/ Pollution	Air	Air quality and management (provision and density of air pollutant monitoring and devices)	Donatiello (2001)
		Noise	Noise control (monitoring devices & noise barrier).	Donatiello (2001)
		Water	Water quality and water contamination	Donatiello (2001)
	Energy Efficiency	Energy	Rate of energy (fuel, gas, electricity) consumption.	Donatiello (2001)
	Waste Management	Waste	Waste generation and management (minimization, generation, source evaluation, collection, storage, separation, treatment, transportation, and disposal).	Donatiello (2001)
	Protection of Resources and Eco-System	Resources recovery	Policy and rate of recoverable natural resources	Phillips (2006)
		Water	Water consumption and waste water treatment.	Donatiello (2001)
		Green Areas	Availability and density of public green area	Donatiello (2001)
		Land	Land degradation due to construction activities.	Donatiello (2001), Dixon et al. (2007)

(Source: Adopted and modified from Manowong, 2012)

3. RESEARCH METHOD

The research adopts a modified Delphi method in a Participatory Action Research (PAR) project to develop a model for environmental sustainability practices of construction companies in Ghana. The Delphi survey involves a group of experts who reach consensus through iterative rounds through the use of questionnaires. The Delphi survey have the ability to provide anonymity to respondents, a controlled feedback process, and the suitability of a variety of statistical analysis techniques to interpret the data (Shariff, 2015; Dalkey, 1972; Ludlow, 1975; Douglas, 1983). According to Hsu and Sandford (2007), these characteristics are designed to offset the shortcomings of conventional means of pooling opinions obtained from a group interaction (i.e. influences of dominant individuals, noise, and group pressure for conformity). The Delphi method starts with a pilot study from the literature through content analysis to identify the problem, conceptualize and design the study, develop the sample, refine the research instrument, and develop and test data analysis techniques. The overview of the Delphi research process is shown in Figure 2.

Because the study involves different organizations and professionals in the same construction industry, it requires the anonymous approach offered by the Delphi method. The Delphi in PAR is a form of action research in which the researcher operate as full collaborator with members of organizations in studying and transforming those organizations. It is used for an ongoing organizational learning process, a research approach that emphasizes co-learning, participation and organizational transformation (Greenwood *et al*., 1993). It is concluded that the Delphi technique is an appropriate and acceptable mechanism to achieve consensus when developing sets of indicators for a project (Habibi *et al.*, 2014:12).

However, the reported data in this paper is drawn from a pilot study. The pilot study is conducted with the goals of testing and adjusting the Delphi questionnaire to improve comprehension, and to solve any procedural problems. The questionnaires were designed to understand the experts' knowledge of the topic and the various advancements being made towards sustainability in the country, if any. According to Jacobson *et al.* (2005), the participants are regarded as experts owing to their lived experiences related to the research topic and ensuring that relevant issues are being studied. The experts are selected based on their ability to answer the research questions and their current involvement in the efforts towards making a Ghanaian construction industry sustainable, or are likely to influence innovation or change in the paradigm of the construction industry (Ahmed, 2014). The experts are selected from Architectural and Engineering Services Limited (AESL), Ghana Real Estate Development Association (GREDA), Environmental Protection Agency (EPA), and Academia.

A five-point Likert scale was used to gather the experts' opinion on the topic and a snowball sampling technique was used to identify and select the sample. Many of the questions asked the respondents to rate from 1 (strongly disagree) through to 5 (strongly agree). The questionnaires are distributed to the experts, who have direct influence on the Ghanaian construction industry, including architects, local building contractors, consultants, policy makers and academia who completed and returned them to the researcher. These stakeholders/experts can play an important role in the influencing of sustainability in the Ghanaian construction industry. Twenty-one valid responses were received out of a total number of 30 professionals, which equates to a 70% response rate.

The results of the pilot study will guide the questions for Delphi round one questionnaire. The results of round one will then be analysed and the responses will be the basis on which to develop the questions in the round two questionnaire. The purpose of round one is to generate a list, then to pare down the list in round two. The output of the first round is ranked and rated. The round two questionnaire will then be released to the research participants and when completed, returned for analysis. The continuous verification throughout the Delphi process is critical to improve the reliability of the data. However, the participants are first given the opportunity to verify that the round one responses did indeed reflect their opinions and may change or expand their round one responses now that the other research participants' answers are shared with them. Again, a similar process of analysis will be used in round two and three. The final data collected will be calibrated, a "Truth Table" built and contradictions will be solved to arrive at minimal formulae for the development of the framework for environmental sustainability in the construction industry. The data collected will be analyzed and the results interpreted to formulate theories that are grounded in the cases. The required framework is then proposed and validated. The experts determine whether the framework is adequate and whether it sufficiently answers the questions within the context of Ghanaian construction industry. This will be achieved by focusing on whether:

1. The framework leads to the minimization of the carbon and ecological footprint in the industry;
2. There is energy and resource-efficient use within the industry.
3. There is improved workflow and continuous improvement in the industry;
4. There is an improvement in stakeholders' working relationships and social benefits to the community; and
5. The quality of project performance and industry competitiveness is enhanced.

When the above statements have been confirmed by the role players, then the framework will be concluded to be adequate and sufficient for the industry.

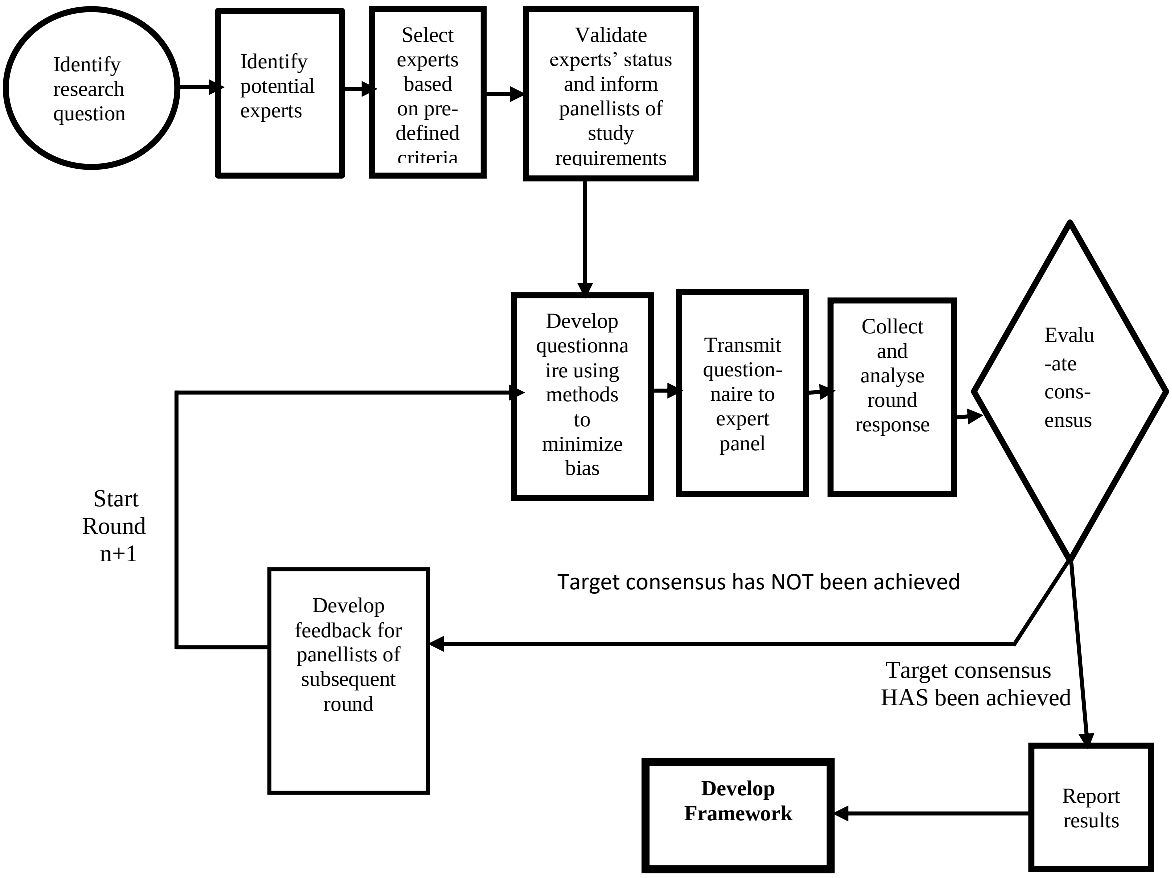

Figure. 2: An overview of proposed Delphi research process
(Source: Adopted and modified from Hallowell & Gambatese, 2009)

4. FINDINGS AND DISCUSSION

Table 2 summarises the demographic information of the selected pilot study participants who are expert and who have direct influence in the implementation of sustainable construction in Ghana. The participants were from various sections of the construction sector. A semi-structured questionnaire was prepared to solicit responses from the participants. From the response received, 14.3% are Quantity Surveyors, Environmental Officers and Project / Construction Managers respectively participated in the study. 23.8% of Architects participated in the study and constitute the highest number of professionals who responded. The Architects were followed by 19.5% of the Engineers. 9.5% of Academics and 4.8% Quality Control Officer also participated in the study. It is notable that 80.9% of the respondents have over 15 years of experience in the construction industry. The experts have either worked on some construction projects where sustainable practices where adopted or have the ability to influence the implementation of sustainable construction in the country.

Table 2: Demographic and general information

Profession / occupation	Number	Percentage (%)	Years of experience	Number	Percentage (%)
Quantity surveyor	3	14.3	0-5	0	0
Project / Construction manager	3	14.3	5-10	1	4.8
Architect	5	23.8	10-15	3	14.3
Engineer	4	19.0	15-20	6	28.5
Environmental officer	3	14.3	20-25	7	33.3
Quality control officer	1	4.8	25-30	3	14.3
Academic	2	9.5	Above 30	1	4.8
TOTAL	**21**	**100**		**21**	**100**

A Likert-type scale of 5 was used to rate the participants opinion on the level of integration of sustainable construction in the Ghanaian construction industry and related concepts as shown in figure 3a and 3b. A score of 5 implies strong agreement with the examined drivers, whereas a score of 1 constitute strong disagreement. The survey indicated that 100% of the respondents agree that the creation of public awareness, professional knowledge in sustainable construction and willingness to incorporate sustainable practices respectively can drive the achievement of sustainable construction. In addition, 67%, 86% and 95% of the respondents strongly agree that guidance related to sustainable design, construction standards, sustainable construction codes and regulations, and availability of a sustainable construction framework respectively will drive the sustainable construction in Ghana. This confirmed the literature that lack of awareness, lack of professional knowledge (Ametepey and Ansah, 2015) as well as framework gaps exist with regards to the practising of sustainable construction in developing countries (Du Plessis, 2007 and Mensah et. al., 2015). If these barriers are removed, and the identified drivers are achieved, sustainable construction would be achieved in Ghana.

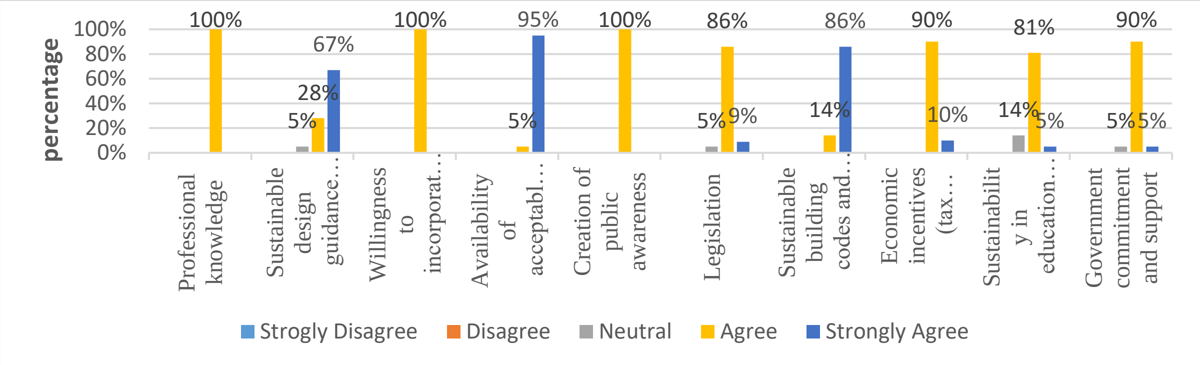

Figure 3a: Assessment of drivers of sustainable construction

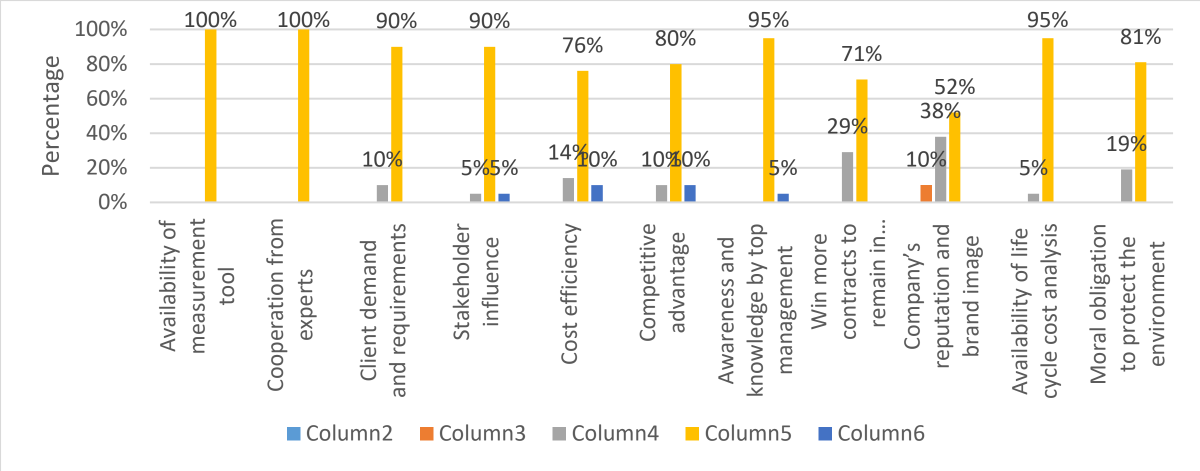

Figure 3b: Assessment of drivers of sustainable construction

Figure 4 below shows that 100% of the respondents indicated that the integration of various sustainable measures in Ghana ranged mostly from low to moderate.71%, 67%, 62% of the respondents indicated that production innovation and certification measures, land use strategies, ecosystem preservation strategies respectively are low in the Ghanaian construction sector. No respondent stated that the integration of a sustainability measure is either very good or excellent. The result implies that it is essential to make more effort to introduce sustainability measures that are aligned to construction practices to reduce carbon and ecological footprint in Ghana.

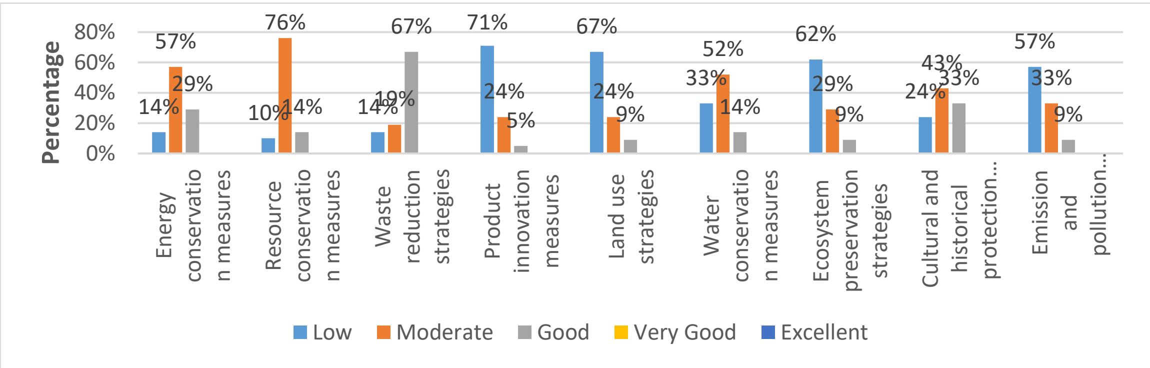

Figure 4: Level of integration of sustainability measures in construction projects

In other to gain insight into the level of integration of emission and pollution reduction measures in construction practices in Ghana with regards to reduction of carbon and ecological footprint for sustainable construction, the respondents were asked to rate the level of integration of the subject matter based on their perception, experience and level of understanding of the subject. A total of 90% of the respondents indicated that the level of integration of emission and pollution measures in construction practices in Ghana ranges from low to moderate. 10% rated emission and pollution integration measures to be good. The advantages of sustainable construction should be publicised to the stakeholders of the construction industry and to guide them towards changing lifestyle towards lowering high carbon emissions (Chan *et al.*, 2009).

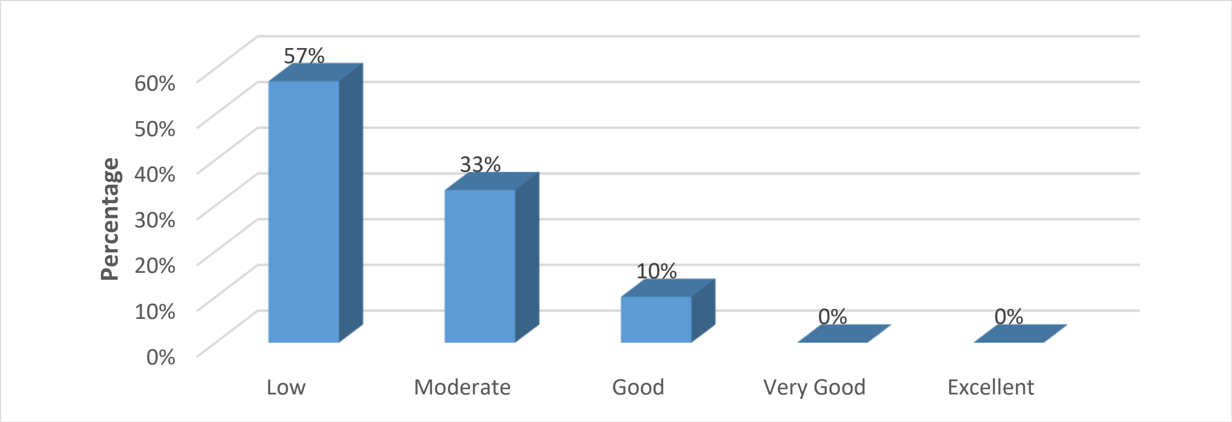

Figure 5: Level of integration of emission and pollution reduction measures in construction

Additionally, the result of the level of integration of resources conservation measures in the construction projects in Ghana in figure 6 illustrate that 90% of the respondents perceived that the resources conservation measures ranges from moderate to good. 10% of the respondents rated the resources conservation low. According to Du Plessis, (2007) self-motivation and commitment is key to bring about changes in behaviour. Stakeholders in construction must continually be inspired to accept the concept of sustainable construction. The increase in the level of awareness and the benefits of the sustainable construction can be achieved by increasing the level of conferences, seminars, training and workshops. Private sector, public sector and academia will be required to collaborate and coordinate to promote sustainable construction.

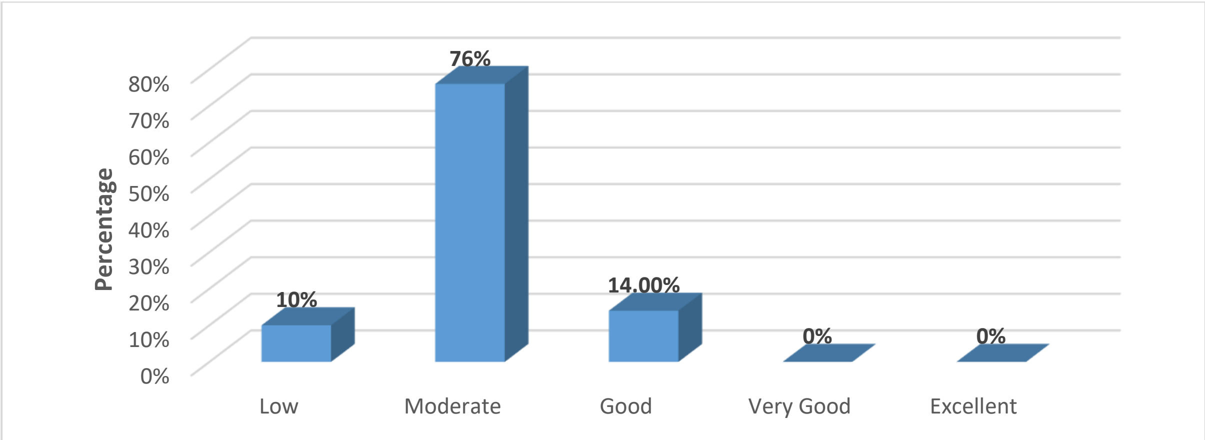

Figure 6: Level of integration of resources conservation measures in construction projects

5. CONCLUSIONS

This study has presented data collected using a questionnaire for the pilot study of ongoing doctoral studies. The objectives of the pilot study are to test and adjust the questionnaire to improve comprehension and to solve any procedural problems that may arise. The instrument also assesses how contractors are focusing on sustainability to reduce the carbon and ecological footprint of their activities in Ghana. The preliminary results reveal that the level of integration of sustainability measures are low in Ghanaian construction, although the respondents strongly agreed that the availability of a contextualised sustainable construction framework would help Ghana to make progress regarding SDGs relevant to the construction industry.

It is therefore anticipated that the application of the framework to emerge from the study will help the construction professionals to know what to do to achieve sustainability in terms of:

1. Identifying any inefficiency in the use of construction designs and programmes, and weaknesses in adhering to specifications in order to recommend the necessary change to reduce the carbon and ecological footprints in construction; and
2. Observing site activities, delivery patterns, usage and fixing of construction materials, components, and plant to prescribe the best methods to reduce carbon and ecological effects.

The result of the research work is also expected to achieve a high level of conformance of construction industry practitioners desiring to reduce carbon and ecological effects in planning, monitoring and controlling construction activities to achieve environmental sustainability in developing countries such as Ghana.

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CONCEPTUAL PERSPECTIVE ON THE SUSTAINABILITY OF COMMUNITY-LED TOTAL SANITATION PROGRAMME IN GHANA

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Abstract: The sustainability of sanitation interventions is a significant challenge. Community-led total sanitation (CLTS) is a sanitation intervention that uses a participatory approach to address open defecation by triggering the emotions of the community members to generate a collective demand for a behavioural change in sanitation. This study seeks to evaluate the performance and sustainability of the CLTS programme by critically examining the activities of institutions and organisations implementing it. A sequential mixed-methods approach is planned for the main study, but the initial findings from desktop research constitute the source of the data shared in this paper. Results from this study will reveal activities that are yielding sustainable outcomes as well as organisations and institutions contributing to the SDG section six; 'provision of sustainable sanitation for all'. A sustainable activity framework designed at the end of the study will serve as a harmonised framework, which can aid in monitoring and evaluation of sanitation interventions by policymakers as well as practitioners and managers implementing CLTS.

Keywords: Community, health, programme, sanitation, sustainability, Ghana

1. BACKGROUND

Globally, 900 million people still practice open defecation (OD) (WHO and UNICEF, 2017). Two hundred fifteen million people of this population live in Sub-Saharan Africa (Galan *et al.*, 2013; UNICEF/WHO, 2015). The story is not different from Ghana as six (6) of the ten (10) regions practice open defaecation. That notwithstanding, threatening/alarming revelations on OD from studies show high levels of viral, bacterial, helminths and parasite pathogens transmission through contact with human faeces (Bartram *et al.*, 2010; Prüss *et al.*, 2014) and increased risk of child stunting resulting from high rates of open defecation practices (Amy *et al.*, 2015; Spears *et al.*, 2013:8). Unfortunately, the world could not meet the set target to halve the population without access to basic sanitation by 2015. Given these enumerated facts, the world has committed itself once again to provide available and sustainable water and sanitation management (Goal 6 [6]; Sustainable Development Goals [SDGs] for all by 2030. Encapsulated in this goal is a provision to end open defecation by the year 2030.

The quest to end open defecation has led to the development of many sanitation approaches or interventions. One of such interventions that has gained international recognition is Community-led total sanitation (CLTS) developed by Kar Kamal of the Institute of Development Studies (IDS) in 2000. The reason for this recognition is that its aim coincides with the section 6.2 of SDG 6. Thus, the intervention aims to achieve an open defecation-free (ODF) community by igniting a change in sanitation behaviour through social awakening, which is stimulated by facilitators of the programme. Simply put, the aim of the programme in a fullest or total sense is to stop all forms of OD and also to ensure that everyone has access to a hygienic toilet and washes his or her hands with ash or soap and water whenever he or she comes into contact with faeces. The programme, after its inception in Bangladesh, has spread rapidly across over 60 countries.

Though highly recognised as one that can aid in ending OD, the intervention is faced with the challenge of sustainability of its outcomes. Popular among them are reversibility challenge where community members reverse to OD after the end of the programme and collapse of latrines. In view of this, several researchers have attempted to find a lasting solution to the problems (Crocker et al., 2017; Venkataramanan et al., 2018) through in-depth studies. Reports by Cavil *et al.* (2015), Magala and Roberts (2009), and Sah and Negussie (2009) revealed that the sustainability challenges, cut across all sectors; institutional, political, physical, social, economic and so on. Cavil *et al*. (2015) in their report titled "Sustainability and CLTS: Taking Stock", grouped the sustainability challenges into three dimensions, which include enabling conditions, physical and technical, and social and behavioural sustainability. Empirical studies have been conducted on social and behavourial change, and physical and technical dimensions. However, with regards to enabling conditions dimension (which comprises of institutions/organisation and processes), studies are limited. Meanwhile, CLTS is implemented globally by both international and local non-governmental organisations (NGOs) (Crocker *et al.*, 2017; Venkataramanan *et al.*, 2018). According to Venkataramanan *et al.* (2018), over seventeen organisations are seemingly implementing the programme. The case is not different from Ghana as the piloting phase of the programme was done by four organisations but now, there are about ten local and international NGOs implementing the programme (Magala and Roberts, 2009). With all these implementers, the intervention has not yielded many results as elsewhere and so OD is still a challenge in most rural communities in Ghana.

Therefore, the main purpose of this study is to evaluate the performance and sustainability of the CLTS programme by critically examining the implementation by all the organisations involved in the CLTS intervention. An evaluative study will enable the researcher to identify the activities that are enhancing performance as well as sustainability and to further enumerate the challenges faced by these organisations. The reviewed literature presented in the next section of the paper identifies the organisations implementing the programme, performance and sustainability factors that will inform the constructs to be examined in the future primary data collection exercise. Following the literature review is a succinct version of the research method. A discussion of the conceptual framework links the implementation factors, performance and sustainability factors together to form coherent ideas on how to take the study forward as highlighted in the concluding remarks.

2. LITERATURE REVIEW

2.1 The CLTS and its Successes

CLTS is a sanitation intervention, which emerged in 2000 in Bangladesh and has since remained the most widely implemented policy intervention for ending open defecation in rural communities all over the world. The reason for this worldwide recognition is its focus on the SDG 6 of ending open defecation by 2030. Another reason is its participatory implementation activities leading to behavourial change towards sanitation and this has made CLTS intervention, an appealing choice to governments and donors. The implementation of the programme comes in three phases: pre-triggering (selection of community, entry into the community and establishing a rapport), triggering (embarking on walk of shame, selection of natural leaders, mapping out areas of OD, choosing a sanitation technology, construction of pit latrines) and post-triggering (verification and declaration of ODF communities and certification). All the above phases are backed with regular follow-ups and monitoring. These activities are not cast in stone. They allow innovations at any phase but the focus of behavourial sanitation change should not be compromised (Kar and Chambers, 2008).

The programme has been very successful in many countries as reports have indicated remarkable decline in OD and change in behaviour towards sanitation in Bangladesh, Indonesia and India **(**Cavil *et al.*, 2015**;** Cameron and Shah, 2019; Kar and Chambers, 2008). According to Cameron and Shah (2019) and Mukcherjee *et al*. (2012), in Indonesia, three years after the implementation of the programme, 95% of the communities that were declared OD had sustained their ODF state. African countries such as Ghana, Mozambique, Zambia, Kenya, Malawi and Ethiopia have also had some success though not as significant as in India and Bangladesh. That notwithstanding, several impact studies conducted on CLTS has yielded positive results. For instance, an impact study by Crocker *et al.* (2016) in Ghana showed 19.9% decrease in OD and increase in latrine construction. Another study by Crocker, Saywell and Bartram (2017) conducted in Ghana and Ethiopia showed an 8 percent sustained increase in latrine construction and usage. In Zambia, Yeboah-Antwi *et al.* (2019) showed a 15.9 percentage increase in access to improved sanitation, 4.8-percentage decrease in household lacking access to any toilet and a modest increase in handwashing behaviour, after the implementation of CLTS programme. Other successes include a study by Tessema (2017) and Tulu *et al.* (2017) in Eastern Ethiopia, showed a 78 percent increase latrine construction and ownership increase in latrine usage among members of communities implementing CLTS than those communities not implementing the intervention respectively. Their study also indicated a significant decreased OD. However, in Ghana, report by WHO (2017) and study by Monney *et al.,* (2015) indicate a 4 percent increase in national sanitation. However, the figure is surprisingly low after over a decade of implementation, a specific project carried out by Crocker *et al.* (2016) revealed a decrease in open defecation by 19.9%. However, the reasons for this surprisingly low success in the nation has not yet been analysed and hence the need for this study.

2.2 Factors Enhancing the Success and Effectiveness of CLTS

The success of the CLTS intervention is as a result of social cohesion and participation, sense of latrine ownership, the quality of training giving to traditional leaders (and facilitators) (Cameron and Shah, 2017; Crocker *et al.*, 2016; Garn *et al*., 2017; Harter et al., 2019; Kar and chambers, 2008; Mosler et al., 2018). The literature on CLTS intervention has consistently associated the increase in latrine coverage to factors such as social cohesion and participation, involvement of motivated skilled facilitators, criteria for community selection (lack of previous subsidy programme and current environmental and sociocultural conditions) and long term follow ups (Freeman *et al.,* 2017; Garn *et al*., 2017; Venkataramann *et al.,* 2018). Another review of CLTS published by USAID in 2018, opined that the effectiveness and success of CLTS is likely to be a function of the implementation modality as well as physical environmental and contextual factors. The review further indicated that though researchers often cite these factors, they are often not well defined. In order to define such factors, Harter, Lilje and Mosler (2019) carried a study to ascertain the factors in the implementation process that contributes greatly to the effectiveness and success of the CLTS programme. Their study revealed that latrine coverage was significantly influenced by the participation of community members, and the expectations of participants receiving incentive. Other researchers have attributed the success to the mode of measurement or assessment used by CLTS implementers. Thus, the CLTS programme uses latrine coverage and the number of households having access to latrine in its verification and certification processes to declare a community as ODF (Kar and Chambers, 2008). In Ghana, a community is declared as ODF if 80% of the people in the community have access to latrine. Another significant factor, according to Kar and Chambers (2008:8), is the type of organisation implementing CLTS programme. However, little research has been conducted in this area. However, the programme is strongly challenged with the sustainability of its outcomes. This study therefore, seeks to evaluate the sustainability of the CLTS programme by critically examining the activities of the organisations implementing it, to ascertain the factors that are contributing to success as well those contributing to the surprisingly low success in Ghana.

2.3 The Factors affecting Sustainability of the CLTS Intervention

According to UNICEF (2015), "sustainability of an intervention is the ability of a programme's outputs, outcomes and impacts to persist after the withdrawal of all forms of assistance". In relation to CLTS, sustainability is defined as the ability of a community to achieve and maintain its ODF status (Bongartz *et al.*, (2016); Cavill *et al.*, (2015). The main aim of CLTS is to produce an open defecation-free community by changing behaviour and enhancing the construction of pit latrines (Kar, 2005; Kar and Chambers, 2008). Thus, the focus of CLTS is often on latrine construction and coverage rather than sustainability (Boongartz *et al*., 2016). For this reason, sustainability is regarded as its major challenge. According to Bongartz *et al.* (2016) and Cavill *et al.* (2015), sustainability of the CLTS interventions has been the major debate in conferences and workshops in all the countries implementing CLTS. While some researchers have attributed the sustainability challenge to the fact that the household latrines are hastily built and as a result do not last (Bongartz *et al*, 2016; Cavill *et al.*, 2015; Tyndale *et al.*, 2013), others view it as a flaw in the programme's development (Carnicross *et al*., 2015; Crocker *et al*., 2016).

In addressing the sustainability issues, several studies have been carried out to ascertain information on factors contributing to sustainability. A study conducted by Cavill *et al*. (2015) grouped sustainability factors under three dimensions, namely (1) enabling conditions, (2) physical and technical factors and (3) social and behavioural factors. The enabling conditions refer to institutions and the processes of implementation, physical, technical factors refer to a sustainable market and sanitation services, and the last dimension refers to sustainable change in social and behavioural norms, motivation, equity and inclusion, and meeting the needs of all people.

However, in an attempt to ameliorate the situation, many studies have been conducted on these sustainability factors and the one that has seen little or no research is that of the institutional or organisational factors. This study seeks to critically evaluate the activities of these organisations in order to determine whether they are enhancing the performance and sustainability of the CLTS programme.

3. RESEARCH METHOD

The selection of the research choice was based on the central question as "to what extent are the organisations implementing the CLTS programme and tackling performance and sustainability of issues"? Through literature review (i.e *Saunders et al*., 2009), the research method choice selected is the mixed methods (MM) approach. Johnson and Onwuegbuzie, (2004); Morgan, (2007); Leech and Onwuegbuzie, (2007); Tashakkori and Creswell, 2007 define MM as a third paradigm that employs both quantitative and qualitative data collection and analyses techniques in a single study, and the data, when properly integrated provide comprehensive findings (Doyle *et al*. 2009) to research problems. MM provides a rigorous data collection as well as analysis by integrating both quantitative and qualitative techniques in a single study (Creswell, 2003; Creswell and Plano, 2007). According to McKim (2017: 202), MM is "a rigorous, newer (in history) approach that provides deeper meaning of the phenomenon being studied". CLTS is an intervention that aims at ending all forms of OD (human phenomenon) and bringing about change of behaviour of people towards sanitation. Evaluating the intervention of such a phenomenon requires a methodology that will give a deeper meaning of the issues confronting it. Both quantitative and qualitative data will be collected from stakeholders. The researcher must be able to integrate the data collected from several sources to create the required breadth and depth of knowledge of the phenomenon. After reviewing the topology of MM, the mixed sequential mixed methods was selected. The research will be carried out in three phases based on the following sub-questions:

1. Which organisations are responsible for the implementation of the CLTS programme in Ghana?
2. What is contributing to the low performance and sustainability of the CLTS programme?
3. How do these organisations carry out their implementation activities?
4. How do these activities contribute to the performance and sustainability of the CLTS programme?
5. What can be done to raise the level of performance and sustainability?
6. How can an innovative framework be developed for the CLTS programme?

The first phase starts with review of literature to identify the organisations implementing the programme. This phase employs qualitative techniques in data collection in that managers, stakeholders and practitioners of identified organisations and institutions will be interviewed to ascertain relevant information regarding their activities where they have successfully implemented the CLTS programme. With this information, the communities will be visited to obtain baseline (necessary because impact evaluative studies by Crocker *et al*. (2016) did not include baseline data and so listed it as a limitation to their study) data from the facilitators as well as community members using focus group discussions as well as interviews and direct observations. In the second phase, data collected from the first phase will be compared with the CLTS outlined activities. Findings from the comparisons will be used to develop a set of questionnaires (using a five-point Likert scale) which will be based on identified performance indicators and sustainability indicators. The questionnaires will then be administered to the practitioners, managers and stakeholders as well as expert in the field. Through focus group discussions and interviews, the questionnaires will be administered within the communities visited during the first phase. The information gathered in this phase will be both quantitative and qualitative data. Finally, the information gathered from the implementers of the programme and the beneficiaries (communities) will then be analysed using STATA and factor analyses to compile a performance and sustainability activity framework. Please see the research process illustrated in Figure 1.

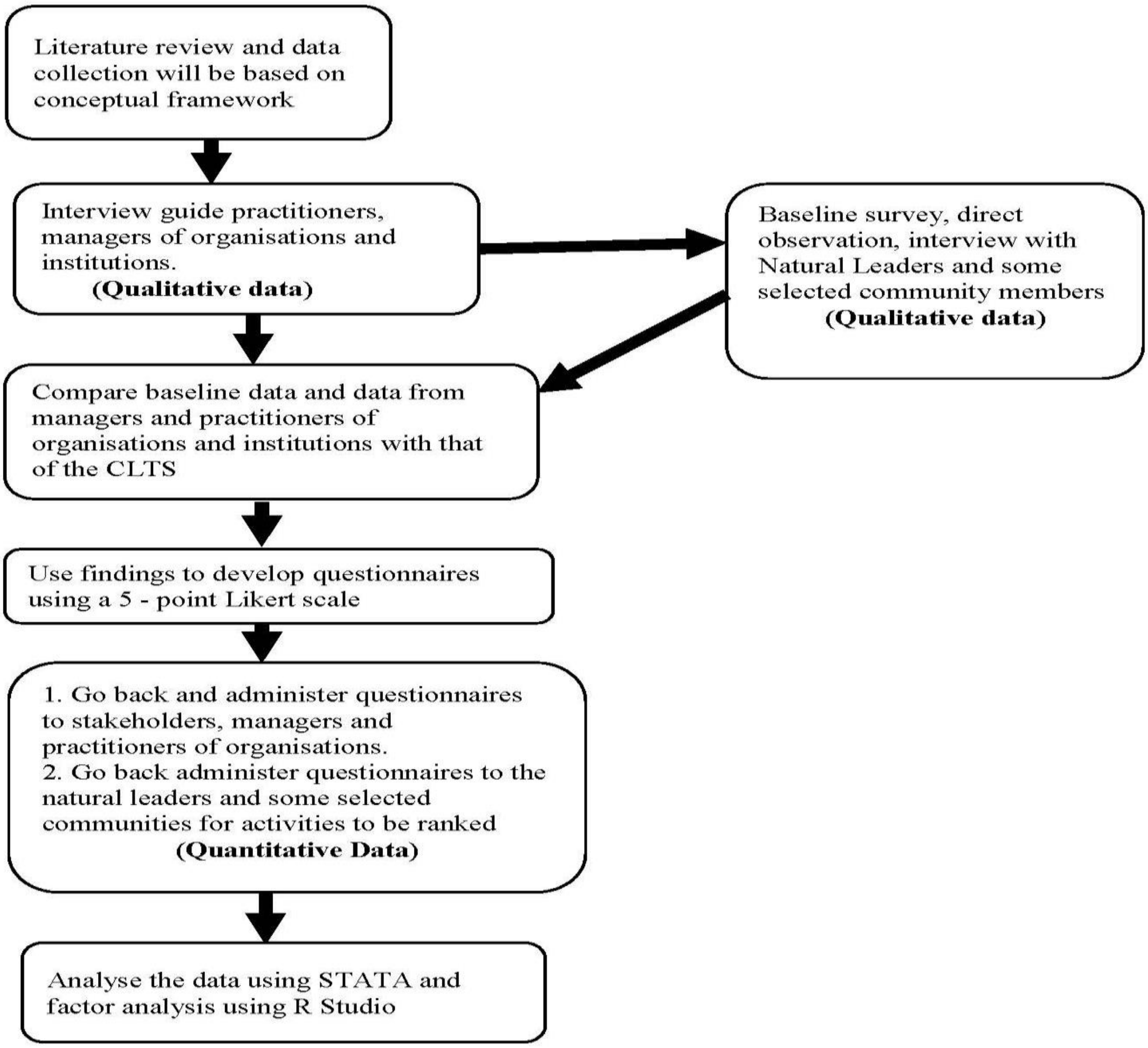

Figure 1: Overview of the data collection process

4. DISCUSSION ON CONCEPTUAL FRAMEWORK

The findings in this section are all from literature. They are based on the conceptual framework.

In Ghana, the CLTS programme ends after triggering and this is a severe challenge. In addition, another major sustainability challenge is the reversibility of community members to OD after attaining ODF status. Reasons as to why this is the case has only been given from the perspective of facilitators and implementers of the programme. Though evaluative study by Magala and Roberts (2009) sought the opinion of native leaders, community members were not involved. Interviews with community members will reveal the actual reasons for the reversibility of the programme. Through focus group discussions, community members might be able to propose probable solutions to the problems. An impact evaluative study done by

Crocker *et al*. (2016) did not include a baseline study. They, however, assumed the baseline information. Baseline data taking during this study will help reveal the real happenings on the ground and present an accurate picture of sustainability issue to policymakers.

CLTS is implemented on a large scale by NGOs. All these organisations embark on the same activities enshrined in the CLTS Handbook. The impact of their activities on the people, their mode of delivery and effectiveness of their activities are not known. Findings from this study through interviews and focus group discussions with community members will reveal the organisations whose activities are yielding sustainable results. This will help policymakers to make partnership decisions with the organisations. Findings from the literature indicate that NGOs do facilitation of the CLTS and so the programme ends once the facilitators leave the community. Crocker *et al.* (2016) recommended that for the sustainability of the programme, implementers should consider training NLs for facilitation. Interview with the community members during this study will reveal which of the facilitators (external or internal (NLs)) they prefer to work with and which of them do they think will help to sustain the programme upon completion.

Follow up is a critical component of the CLTS programme. However, many studies have indicated a lack of follow up and have because of that proposed rigorous follow-up. How rigorous the follow up should behave not been addressed. Findings from the study will help in addressing that. In addition, the effectiveness of the follow-ups in terms of timing, contact time (with community members during follow-ups) and planning will be revealed as community members will indicate the appropriate times for follow-ups. So far, there has not been any sustainable and innovative activity framework designed to enhance performance and sustainability. Findings from this study will be used to design a framework that could be used by implementers of CLTS as well as all bodies working around the clock to end open defecation.

5. CONCLUSIONS

The conceptual paper posits that the sustainability of the CLTS programme is a major challenge. The challenges involve financial (economical), technical, institutional, social and physical spheres. It also requires capacity building, selection of facilitators and traditional leaders, mode of delivery, regular follow-ups and an enabling environment for sanitation marketing (meeting material and technical demand) and artisan training. Sustainability of the CLTS outcomes also requires post-open defaecation free follow up, and motivation in the form of reward. All these factors need to be tackled in the programme to generate long-lasting solutions. Unfortunately, that is often not the case. Therefore, a study that involves all stakeholders participating in the CLTS programme as illustrated in Figure 2 is imperative.

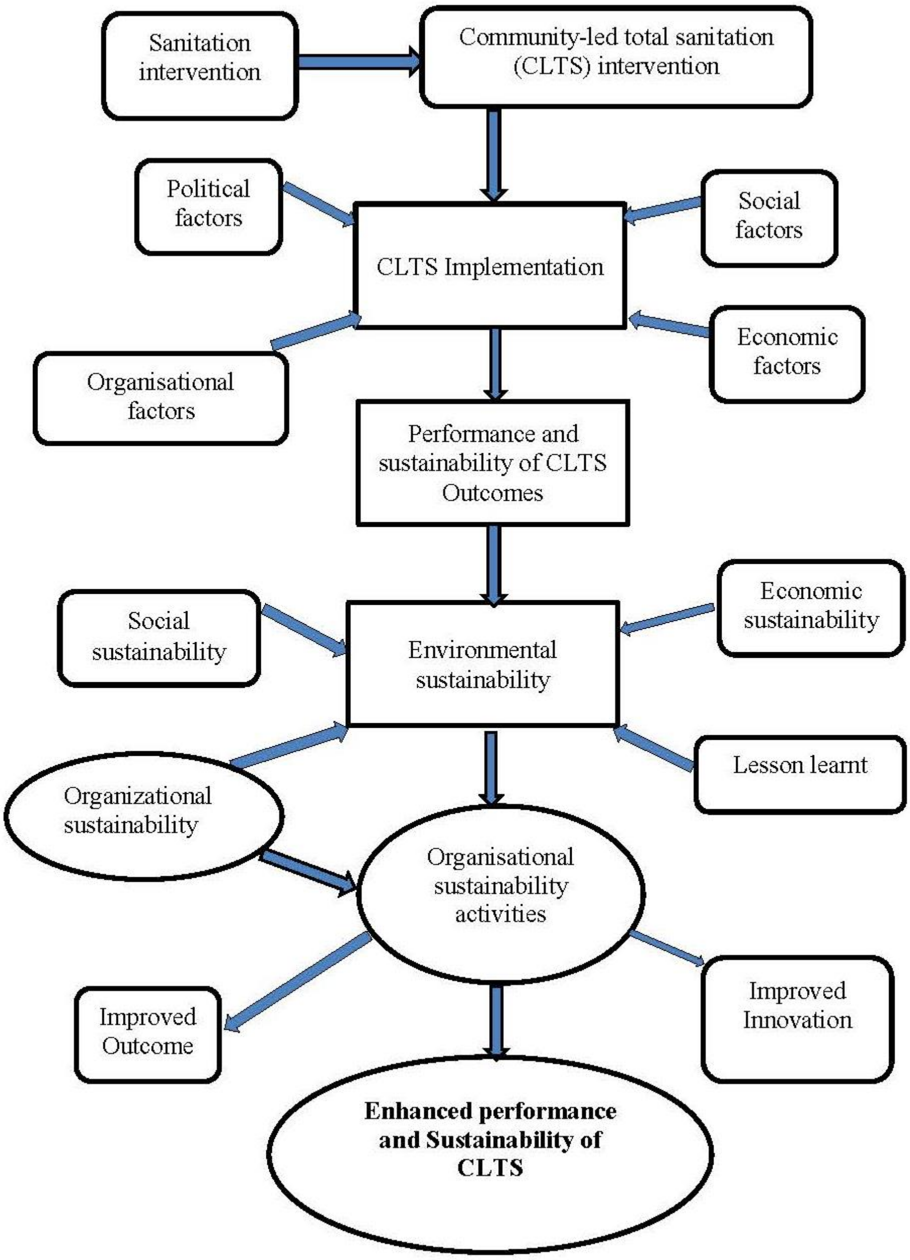

Figure 2: Conceptual Framework

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BARRIERS TO LOW CARBON TRANSITIONS AND ENERGY SYSTEM INNOVATIONS

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Abstract: Addressing climate change is a transformative agenda which requires shifts to clean energy technologies that provide sustainable, secure, adequate, reliable and affordable delivery of energy services with high levels of efficiency and environmental performance. While the transition to low carbon technologies has been identified to be effective in mitigating climate, existing systems establish stable technological trajectories which act as barriers to energy transitions and system innovations. Consequently, energy transitions require disruptions in the established order and a whole system reconfiguration with transformational changes not only in technologies but also in consumer behaviours, policies, infrastructure, production networks, business models and market culture referred to as socio-technical transitions. The aim of this paper is to provide an in-depth analysis of the barriers to energy transitions and system innovations as a step towards the development of effective solutions that will trigger the required transformational change to 100% clean energy mix. This paper adopts a socio-technical approach using technology as an entry point to analyse the dynamics of urban energy transitions through an extensive literature review. The findings in this paper reveal that there are technical, social, infrastructural, geographical, organisational and legal barriers to low carbon transitions in the energy system.

Keywords: Clean energy technologies, climate change, transformational change, socio-technical systems, low carbon transitions.

1. BACKGROUND

The energy sector has had the highest greenhouse gases (GHG) emissions globally, approximately a third of the global energy consumption is derived from fossil fuel which is primarily the world's dominant fuel (BP, 2018). While fossil fuel is undeniably a highly efficient source of energy with a legacy in building and enriching economies since the era of the industrial revolution, its use has become unsustainable. Consequently, energy generation and supply in relation to sustainability-oriented innovation and technological studies are confronted with several challenges which raise health, environmental and economic concerns. These challenges are exacerbated by humanity's over-dependence on fossil fuels, giving rise to environmental concerns such as air pollution, nuclear risks, rise in global greenhouse gas (GHG) emissions, climate change, depletion of natural resources, and uncertainties relating to long- and short-term security of supply and energy poverty (IEA, 2011; Markard, Raven and Truffer, 2012).

The use of fossil fuel which comprises of coal, oil, and natural gas is the main cause of climate change which can be traced to the anthropogenic activities of the industrial revolution era, majorly driven by economic development and population growth (Armaroli and Balzani, 2011). As stated in the 2016 Trends in Global CO_2 Emissions Report, the share of fossil fuels in the global primary energy consumption was at 86% in 2015 and its current use raises environmental concerns (PBL, 2016). It is estimated that the world's population which is currently 7.6 billion, is expected to increase to 9.8 billion by 2050, which projects that energy consumption is expected to rise with the increasing population (United Nations, 2017). The occurrence of various climate change disasters and the prospects of dangerous climate change if carbon emissions continue to rise prompted the United Nations to introduce the international climate regime targeted to reduce the global rise in GHG emissions over the last two decades (United Nations, 2015). The target put forward by the Paris Agreement which is the most recent international agreement requires that global CO_2 emissions are radically reduced to hold temperature rise to well below 2°C above pre-industrial levels and to attempt to limit it to 1.5°C to minimize the prospects of dangerous climate change(UNFCCC, 2018).

Building sustainable societies involve the provision of clean energy for housing and transportation which necessitates the reduction in the over-dependence on fossil fuel to more sustainable forms of energy (United Nations, 2015). Transitions towards more sustainable forms of energy require transformational shifts to low carbon technologies in the energy system with the integration of innovative technologies and services that will address the energy sustainability challenge (Markard, Raven and Truffer, 2012; Papachristos, 2014; Geels, 2018). The sustainability challenge is that existing systems serve as barriers to innovation as a result of the prevalence of well-established technologies, strong path dependencies as well as multi-dimensional coevolutionary interactions and interrelationships. These interrelationships often take several years to develop and are intertwined with values, culture, business models value chains, organisational structures and political structures which provides coordination and stability in existing systems (Rip and Kemp, 1998). As a result of established technologies existing socio-technical systems often undergo incremental changes rather than radical changes. Incremental change involves the optimisation of existing technologies to become more efficient or scalable. Existing systems form barriers to innovation and are resistant to radical innovations (Frantzeskaki and Loorbach, 2010). Before radical innovation can occur there must be instability and disruption in the system. The prevailing sustainability challenges require transformational changes that can not be addressed by incremental innovation. Consequently, issues relating to promoting and governing transformational change towards sustainable methods of energy production and consumption has received tremendous attention in the area of policy, social science research and technological innovation systems (Markard, Raven and Truffer, 2012).

The aim of this paper is to provide an in-depth analysis of the barriers to energy transitions and system innovations as a step towards the development of effective solutions that will trigger the required global transformation to 100% clean energy mix. This paper is a part of the undergoing research on energy system transitions in Greater Manchester.

1.1. History and Challenge of Mitigating Climate Change

Climate science has been able to identify a cause and effect relationship between anthropogenic activities and the change in the climate system. In recent years, there have been growing concerns regarding the occurrence of human-induced climate change as anthropogenic activities across the economic sectors cause the release of large amounts of greenhouse gases which have continued to pose risks to the environment and human existence See Figure 1 (IPCC, 2014). The accumulation of these gases in the atmosphere increases the natural greenhouse effect, and have continued to alter the earth's climate, giving rise to climate change which is regarded as the largest and most pervasive threat to the environment in recorded history (Uma Lele, Aaron Zazueta, 2010; Seneviratne *et al.*, 2018). Climate scientists have revealed that it is extremely important for global GHG emissions to peak by 2020 at the latest, after which it should continue to decrease (Summit, 2018). This means that global emissions must stop rising by 2020 and should continue to decrease thereafter while sustaining population growth and advancing economic growth which is an essential step towards delivering on the Paris Agreement goals (C40 Cities Climate Leadership Group, 2017).

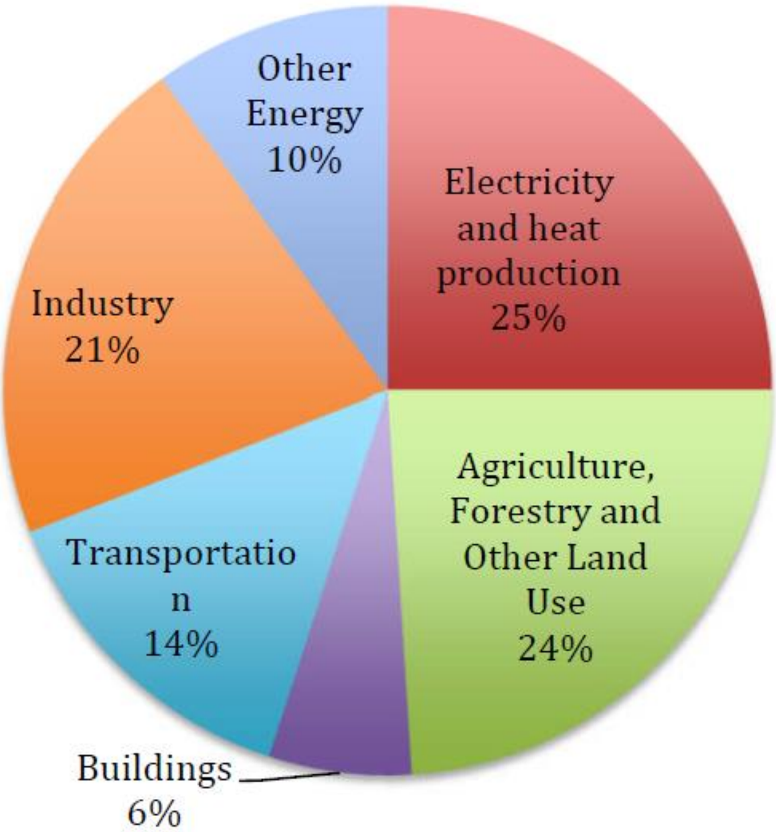

Figure 19: Global Greenhouse Gas Emission by Economic Sector (IPCC, 2014).

In the past, the main concern was providing energy for economic growth and development. Then a different approach was induced by the United Nations introduction of the Intergovernmental Panel on Climate change (IPCC) established in 1988 which is responsible for the assessment of science as it relates to the social, environmental, and economic impacts of climate change. This gave insights to the risk associated with human-induced climate change which has led to various international climate change negotiations (Armaroli and Balzani, 2011). The stark findings in the IPCC Special Report on 1.5 Degrees revealed that the 2°C mark which is yet to be achieved by any nation is not even sufficient to combat climate change and could lead to disastrous consequences. IPCC recommends that the temperature goal of 1.5°C should be the preferred temperature goal as it will reduce the impacts of climate change however, it will not completely eradicate the impacts of climate change (IPCC, 2018). It is therefore widely debated that it is crucial to accelerate actions to reduce GHG emissions for effective climate change mitigation.

Currently, the focus is centred on environmental sustainability which involves safeguarding the environment from anthropogenic climate change through global emission reduction commitments and transition to clean energy. To keep global temperature rise to below 1.5°C global emissions need to be reduced to zero emissions by 2050 (Le Quéré *et al.*, 2018). Developing strategies that are effective in driving decarbonisation within specified timescales is critical to meeting this target. However, the challenge is how to collectively decarbonise the individual economic sectors through the deployment and diffusion of clean energy technologies without having adverse effects on the economy, environment and society using well-informed policy decisions to drive the required transformational shift to a low carbon economy (García-Olivares, 2015). The main drivers for energy transition originate from the numerous Global Summits on climate change, the most recent (at the time of writing) and perhaps the most significant being COP21 led to the introduction of the Paris Agreement in 2015 (United Nations, 2015).

Numerous plans and plausible scenarios proposing technologies and system innovations to achieve decarbonisation in the energy system have been developed which points to the fact that sustainable forms of energy from renewable energy sources will increasingly form the backbone of the global energy system (C40 Cities Climate Leadership Group, 2017; Julia *et al.*, 2019). Considerable evidence confirms that several cities around the world such as Stockholm, Copenhagen, Vancouver, Oslo, and Melbourne have made significant growth successes towards the transition to clean energy technologies in order to achieve green growth and sustainable low-carbon development in cities. This is raising hopes that renewable energy generation at local levels is achievable as policymakers are seeking to adopt more enabling policies that aid low-carbon economic growth and development (Julia et al., 2019).
Energy scientists are also exploring several ways to generate energy from clean energy sources for the transition to a sustainable energy future in the pursuit of sustainable environmental development, clean energy access and energy security envisioned for a decarbonized highly efficient and more resilient world(Tyndall Centre for Climate Change Research, 2018). Therefore, it can be argued that the challenge is no longer about finding a plan on how to achieve decarbonisation in the energy system but rather how to set in motion the processes for delivering decarbonisation in a timely manner while ensuring secure, efficient, affordable, adequate and sustainable delivery of energy services.

2. SOCIO-TECHNICAL TRANSITIONS

This paper draws on the socio-technical transitions literature to analyse the barriers to socio-technical transitions in the energy system. It provides a deep understanding of the social, institutional changes and the role of actors in shaping system innovations and socio-technical transitions and system innovations. It gives valuable insights into the dynamic nature of socio-technical systems, the barriers to socio-technical transitions as well as its complexity and multifaceted nature.

2.1 Technological Transitions and System Innovation

Sociotechnical systems comprise of people, culture, technology, infrastructure, regulation, practices, market culture, production systems, maintenance networks, and goals which are integrated to achieve functionality, have multi-level perspectives on transitions (see figure 2). This is as a result of the varied agendas values, priorities, views, strategies and resources (finance, skills, knowledge and networks) of multiple social groups and actors which occur at various levels, from organisations to local, regional, and central governments. (Geels, 2005; Papachristos, 2014).

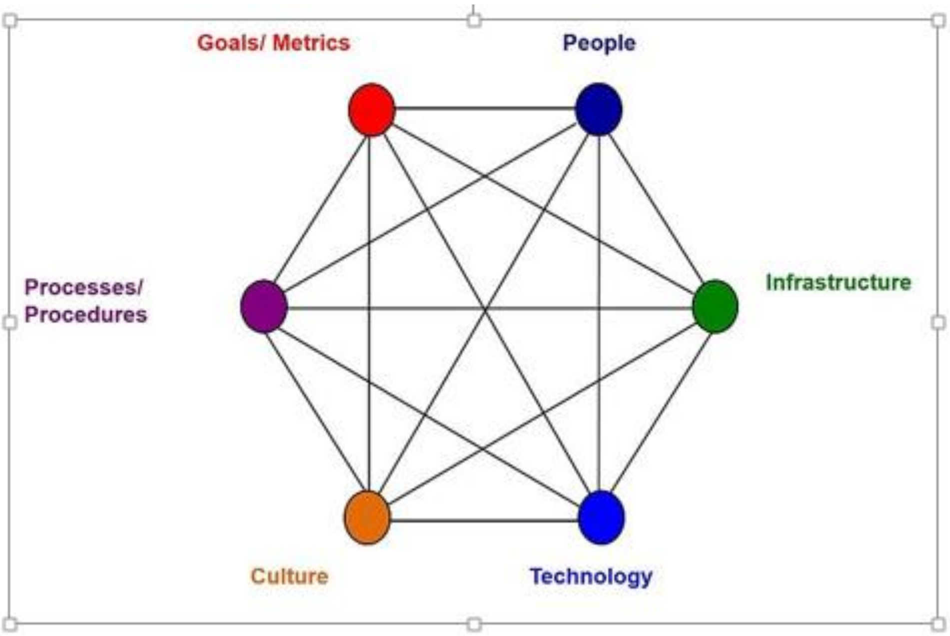

Figure 20: A Socio-technical System

Socio-technical transitions require a change from one socio-technical system to another which involves the transition to another technology and other elements of the socio-technical system. As a result of the configuration and alignment between the elements of a socio-technical system, such transition processes do not easily occur. Transitions to new technologies are more difficult due to the array of elements such as user practices, regulations, infrastructure, and maintenance networks aligned with each other and coordinated to operate with the existing technology. However, evidence has shown that it is possible to undo socio-technical configurations to allow for the transition to radically new technologies. The big question is how do technological transitions occur and how can the barriers and limitations be overcome? (Geels, 2002). Socio-technical transitions involve the shift, substitution, and reworking of assemblages of coordinated elements. The substitution of one element can induce changes in other elements of the socio-technical system (Geels, 2005). However, radically new technologies do not have existing markets and user preferences in place, these simultaneously evolve with the new technology (Geels, 2002).

Technological transitions pertain to changes in the way societal functions such as communication, transportation, energy supply, recreation, healthcare, and housing are achieved while the transition from one socio-technical system to another is referred to as system innovation. System innovation involves the co-evolutional change of component elements of socio-technical systems (Geels, 2005). The transition to low carbon technologies requires the wides spread deployment and diffusion of low carbon technologies as well as changes in institutional frameworks and policies. Studies on socio-technical transitions seek to understand technological and social change through the analysis of the factors that enable or inhibit them. A huge part of the studies on socio-technical transitions involves proposing policy recommendations and strategic direction that can drive socio-technical transitions (Papachristos, 2014). However, the major challenge is how to leverage policies to support sociotechnical transitions and what policy instruments can effectively support low carbon

transitions as policies must address the need to support the widespread deployment and high diffusion of low carbon technologies throughout the entire energy system (Berkhout, 2002).
The component elements of socio-technical systems are created and managed by human actors entrenched in social groups. Socio-technical systems cannot function or achieve functionality without human actors.

The social groups in modern societies are often designed to interact with the elements of socio-technical systems. Social groups influence the stability and trajectory of socio-technical systems by adhering to specific sets of rules referred to as sociotechnical regimes. Regimes can be described as a partially consistent set of rules connected to each other making it extremely difficult to change a rule without modifying the others. Socio-technical systems often take several years to develop, establishing coordination, stability and path dependencies that become resistant to change (Papachristos, 2014; Geels, 2018).
Existing socio-technical systems, regimes and infrastructures often serve as barriers to technological change owing to the lock-in and path dependencies to unsustainable mechanisms which cannot meet the challenge of climate change. As such, transitions will involve adjustments in the established order and changes in technology, consumer habits, markets, business models, policies, infrastructure and cultural significance. This will include embedding strategies that can foster structural changes in technology, institutions and practices all through the economic sector while aligning policies to drive the transition to a low carbon economy to meet the challenge of climate change (Geels, 2011, 2018; Geels *et al.*, 2017). The following sections discuss the barriers to low carbon transitions.

2.2. Resistant Regimes

Regime actors can wield power and influence to enable or hinder a new technology from diffusing into the regime (Späth and Rohracher, 2012). For example, the resistance of the fossil fuel regime to transitions to clean energy sources significantly threatens green development, the actualisation of the Paris Agreement's carbon reduction target and temperature goal to well below 2°C above pre-industrial levels (Berners-Lee and Clark, 2013).
Geels (2014), builds on the concepts of the regime "lock-in," and identifies four ways in which existing regimes actors (mostly incumbent firms and policymakers) can wield power and politics to resist transitions (towards low carbon technologies) in order to take account of the role of politics and power in socio-technical transitions.

a) **The use of instrumental forms of power**: In this situation, actors make use of resources which include money, access to media, capabilities and personnel in their interactions with other actors in order to achieve their own interests and goals. Regimes actors generally have more access to resources than niche actors as a result of the availability of resources in regimes which is used to promote regime reproduction and incremental adaptation (Avelino and Rotmans, 2009).
b) **The use of discursive strategies**: In this case, regime actors use their powers to shape the narratives of what is being discussed (which is used as a strategy to set their agendas), how it is discussed, what is important and the most suitable solutions to challenges.
c) **The use of broader institutional powers**: This pertains to broader institutional powers ingrained in the frameworks of political cultures ideologies and government structures which enable the agendas of incumbent actors.

d) **The use of material strategies:** Regime actors use their technical expertise and economic resources to improve the technical performance of socio-technical regimes in order to make the need for radical innovations appear less necessary. Such technical innovation actions are often associated with discussions and possibilities of effective solutions (Van Lente, 1993), which can be used to attract attention, funding opportunities and resources to steer clear of opposing regulations. Notable examples include supercritical pulverized coal technologies and carbon capture and storage (CCS). (Geels, 2014)**.**

2.3. Geographical Scale and Geographical Unevenness of Transitions

Studies on geographical spaces have identified the impact of geographical location on transitions. For example, in reality, some locations possess abundant reserve of natural resources that can be used to generate sustainable forms of energy in their locations (Smith, Voß and Grin, 2010).

Coenen, Benneworth and Truffer, (2012) posit that in reality, actors at different geographical scales (international, national, regional or urban) may differ significantly in their access to resources. It was discovered that there is a connection between the spatial embeddedness of institutions and the approaches used by actors in the development and deployment of innovations. Building upon this concept Bridge *et al.*, (2013) defines embeddedness as the sunk costs which include the built environment and energy infrastructure networks as well as the place-based consumption cultures associated with certain energy technologies. Spatial embeddedness act as barriers to transitions by becoming resistant to the widespread deployment of radical innovations. The "geographical unevenness of transitions" is another aspect of the geographical scale to be considered in the MLP framework (Coenen, Benneworth and Truffer, 2012). While some areas are suitable for niche creation some other areas can be resistant to niche creation as a result of the differences in their physical, political and institutional attributes which give rise to unequal development and penetration of new innovations (Coenen, Benneworth and Truffer, 2012; Bridge *et al.*, 2013). Based on the discussions it is therefore important to consider the geographical contexts in socio-technical transitions.

3. METHOD

This section provides a brief explanation of the adopted method for achieving the aim of this paper. An extensive analysis of the secondary data, through literature reviewing of the current state of the art on energy transitions, was carried out to understand how and why transitions to clean energy technologies are not occurring as urgently as it is required to safeguard the environment from the harsh effects of climate change.

4. DISCUSSION

Climate change may continue to be a prevalent global issue for several generations to come if effective policies and strategies are not developed to combat it. Energy innovation requires a vast knowledge of science and technology as well as informed policy making which will support the deployment and penetration of low carbon technologies in order to aid the transition to low carbon technologies. According to BP Energy Outlook (2018, 2019), the creation of effective policies that support the deployment and penetration of low carbon technologies with less support for fossil fuel production and consumption is pivotal to achieving significant emissions reductions in the energy sector over the next two decades. This will include energy/climate policy alignment with wider policy goals, reducing effects on low-income groups and ensuring well-defined compensation. It also involves making changes to the economic conditions (through taxes, regulations, subsidies, standards) so as to provide incentives to firms, consumers and actors, as well as the coordinated integration of operational activities between the individual sectors in the energy system (Geels et al., 2017; Geels, 2018).

Continued awareness on environmental sustainability and the reality of climate change has intensified the need for strategic actions that can aid the transition to low carbon technologies as well as the research and development of sustainable clean energy options (Armaroli and Balzani, 2011). The United Nations Sustainable Development Goals advocates for clean energy, global objectives on climate change, air quality and universal access to modern and affordable energy to foster the transition to sustainable forms of energy to achieve sustainable growth and development in the energy sector. It also advocates for responsible consumption and production patterns for sustainable growth and development (United Nations, 2015; World Bank, 2016).

Evidence increasingly reveals that a local decentralised smart energy system could be the path to a clean energy future as more cities are becoming successful at taking actions to meet the challenges of climate change (Geels, 2005; Wolfram, 2018). Urban energy transitions in contemporary cities in developed nations are often well documented as several cities around the world such as Stockholm, Copenhagen, Vancouver, Oslo, and Melbourne have made significant growth successes towards the transition to clean energy technologies in order to achieve green growth and sustainable low-carbon development in cities (Julia et *al.*, 2019). It is increasingly evident that renewable energy generation at local levels is achievable and it is gradually becoming cheaper than carbon fuels (Tyndall Centre for Climate Change Research, 2018).

Although, the initial investment for renewable energy might be capital intensive as opposed to the existing fossil fuel structures that require no capital for energy generation however transitioning to clean energy technologies would lead to enormous cost savings in the long run. This is raising hopes that renewable energy generation at local levels is achievable as policymakers are seeking to adopt more enabling policies that aid low-carbon economic growth and development. Also, energy scientists are exploring several ways to generate energy from clean energy sources in order to secure a sustainable energy future in the pursuit of sustainable environmental development, clean energy access and energy security envisioned for a decarbonized highly efficient and more resilient world (Tyndall Centre for Climate Change Research, 2018).

5. CONCLUSION

According to García-Olivares (2015), low carbon transitions have been identified as a feasible strategy to combat climate change. However, the challenge is how to accelerate and expand low carbon technology and system innovations throughout the economy in an economically, environmentally and socially sustainable manner using well-informed policy decisions aligned to drive the required transformational shifts for the transition to a low carbon economy. Furthermore, evidence increasingly shows that policies alone have not aided the transition to low carbon technologies and have also not been effective in combating climate change as industrial economies have been locked into fossil-fuel-based energy systems. This lock-in to existing fossil fuel-driven developmental path creates resistance to new technology markets and policy failures which inhibit the widespread deployment and diffusion of low carbon technologies in spite of the evident environmental and economic benefits of low carbon development. It is therefore important to evaluate the key elements and economic processes that should be replaced with new processes that are compliant with low carbon transitions, 100% energy mix and energy flows (García-Olivares, 2015). This will aid in determining the degree of compatibility with the industrial economy in the post-carbon society. To overcome the barriers to low carbon transitions the following must be achieved:

- Proper alignment of policies to drive low carbon transitions.
- Diversified energy supply for greener more resilient and inclusive growth and development.
- Co-evolutionary development of low-carbon technologies in the energy system and the interconnected sectors (energy sector, transport sector, and the heat and cooling sector).
- Coordination, stability, and alignment that synergises the interactions of the key elements, networks, and actors that contribute to fulfilling the functions in the energy system such that it meets the demands of the industrial economy in the post-carbon society.
- The provision of incentives to firms, consumers and actors, as well as the coordinated integration of operational activities between the individual sectors in the energy system.

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OIL AND GAS INDUCED-DISPLACEMENT AND RESETTLEMENTS IN SOUTH-SOUTH NIGERIA

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Abstract: The extraction of oil and gas has been identified by many authors as a mixed blessing for oil producing countries. The impact of oil spills, gas flares and air pollution on the environment and the relationship with existing policies has remained a contentious issue in the handling of involuntary resettlements in the South-South region of Nigeria International recognition that development-induced displacement has many of the same effects upon the displaced as groups forcibly displaced due to oil and gas activities is growing. The argument is that the disastrous ecological consequences caused by oil and gas have the potential of increasing internal migration. The challenge here is that regulatory agencies have failed to protect communities against the impacts of environmental degradation and the consequences of oil and gas exploration from the multi-national corporations and the government. Also, rehabilitation policies designed to mitigate the impact of resettlement have been unsuccessful mostly due to failure of policies and non-participation as in the case of the involuntary resettlement of Finima community, located in the Island of Bonny. This study will adopt the mixed methods combining both semi-structured interviews and questionnaires which will provide a framework whereby guidelines in existing regulatory policies for oil and gas-induced resettlements can be improved.

Keywords: Displacement, environmental, Finima, oil & gas, resettlement.

1. INTRODUCTION

This paper examines the linkage between oil and gas extraction, environmental degradation, multi-national corporations, governments policies and resettlement of communities in the South-South region of Nigeria. The environmental and economic consequences of uncontrollable gas flaring and oil spillages in the region are grave, as these processes result in very serious degradation on the human population, air quality and livelihood of the affected communities. According to Ajide et al (2017), Nigeria is one of the world's major exporters of liquefied natural gas (LNG), while endowed with these vast fossil fuel resources, the South-South region in particular, has proven to be a very challenging context for government (national, state and local), foreign oil corporations, and communities alike. Indeed, Ajide et al (2017), further reiterates that communities often report that they have failed to benefit adequately from the wealth created from oil and gas extraction, and claims of corruption and nepotism amongst governmental and corporate players has soured relationships. Within this context, it is important to identify and review the aspect of the existing policies that empowers the multinational corporations and its responsibility to the affected communities who have experienced displacement and subsequent resettlement.

1.1. Context and Background

The discovery of oil in the South-South region of Nigeria in 1956, created some sense of hope and expectation of the people in knowing that the accruable revenue would lead to the development of local economies and better the lives of the people. In most cases however, this has remained illusory as the exploration of the oil resources has led to diverse environmental destruction of local communities and internal anarchy and involuntary relocation in oil-producing communities according to Fubara et al (2019). According to Andrews (2015), crude oil and natural gases and these minerals are explored in the South-South region by the oil companies such as SPDC, Chevron, Texaco, Agip, Exxon, Total Elf, Addax and NLNG amongst others. And despite the immense wealth generated by oil production in the South-South region of Nigeria, it has remained one of the most impoverished parts of Nigeria.

The Niger Delta Human Development Report's (2006) findings indicate "inadequate, unavailable and poor-quality infrastructure" and high unemployment rates. Environmental and human rights dimensions of petroleum exploration and development in Africa are particularly acute in the densely populated South-South region of Nigeria, where the bulk of Nigeria's onshore petroleum operations takes place. Fubara et al (2019), describes the South-South region of Nigeria, as the petroleum-rich and major hub of all oil and natural gas extractive activities, that this region contains enormous amounts of petroleum resources located onshore, shallow offshore and deep offshore. There have been some major ecological and internal problems as a result of the exploration of oil and gas in the region which has been a pain on the affected communities and according to Agbonifo, (2016), the petroleum industry being a complex combination of interdependent operations has generated a mixed blessing of wealth and fortune on the one hand, and environmental injustices and hopelessness on the other hand. Below is a map showing the nine-oil producing arears that comprises the South-South region of Nigeria as seen in figure 1.

Figure: 1: Map showing the South-South region of Nigeria (Nigerian-Eye, 2015)

2. INTERNATIONAL AND NIGERIAN LEGISLATIONS ON OIL AND GAS

According to Petz (2015), the United Nations (U.N.) Guiding Principles on Internal Displacement ("Guiding Principles" 1998), which is the core, albeit soft law for international framework on displacement within national borders are the core international framework identifies the rights and guarantees relevant protection of internally displaced persons (IDPs) and also extends to persons displaced by both man-made and natural disasters (which includes those displaced by the effects of climate change . Also, The African Union Convention for the Protection and Assistance of Internally Displaced Persons ("Kampala Convention 2009"), a binding regional treaty on internal displacement is the first legal framework on internal displacement that legally binds an entire region. It explicitly includes displacement from natural and manmade disasters, including climate change.

Nigeria's environmental legislation especially related to the oil and gas industry is fragmented as it consists of several legislative acts, regulations and decrees, beyond this, several reviews of these laws have revealed problems that militate against the achievement of environmental sustainability, the primary objective of legislation. According to Kingston et al (2018)., The federal government of Nigeria owns and controls the ownership of mineral resources. Laws, such as the Constitution of Nigeria, the Land Use Act and Petroleum Act, amongst others, vest the total ownership and control of mineral resources in the federal government to the detriment of the states, local governments and the local communities wherein the mineral resources are situated. Therefore, all licenses and leases for the exploration, prospecting or mining of petroleum are granted by the Federal Government. Kingston et al (2018), further remarked that the irrational choice of the Nigerian government which creates laxity in the laws to accommodate the oil companies is a race to the bottom with consequential permanent damages to the growth and development of the national economy. The minerals underneath the earth surface are excluded from the meaning of land. The effect is that, the surface occupier is dispossessed of the mineral interests. This means that the government's claim to mineral interest of all lands in the country is firmly rooted in the theory of eminent domain which emphasizes that the government or the supreme monarch of a country can compulsorily take private lands for public use with or without compensation. The effect of this theory is that, the Federal Government of Nigeria can pass coercive laws and regulations to empower its agencies compulsorily acquire private properties for the purpose of capturing the minerals for public good. It should be noted here that the current system of some of the existing polices especially the Land use act that covers areas like oil and gas is devoid of any clear or comprehensible direction. From the foregoing, such policy is economically unproductive as well as undemocratic, as too much power is vested in the hands of the government thereby making it impossible for owners of the land to have a say and concerning any land benefits that is naturally accruable to them. Therefore, it is imperative that these polices be reviewed and improved in line with present realities to ensure fairness and equity. A call to all stakeholders as a matter of urgency to adhere to standard operational procedures and reduce the negative impact on the environment whilst protecting the communities against the resultant environmental degradation and future displacements.

3. EXTRACTION AND DISPOSSESSION ISSUES

The premise of the study is based on the argument that oil based environmental degradation has exacerbated internal displacement and resettlement in the South-South region of Nigeria. The analysis whereby globalized oil extraction activities result in the dispossession of local people's land, livelihood, health hazards amongst others have fueled violent resistance in the country's oil-rich but impoverished region, thus, the crisis of environmental degradation as a proviso for internal displacement and relocation in the region. According to Obi (2010), It is therefore imperative to acknowledge that the manifest and continuing environmental problems in the South-South rural communities in Nigeria, point towards weaknesses in policy and regulation, or even policy failure caused by several factors including weak enforcement and over centralization which provides a fertile ground for environmental degradation to persist. As Akpomuvie (2011,) would argue that government control and direct involvement in oil and gas exploration activities and environmental protection are limited because of passive partners like the multi-national companies operating in the area. Which brings Vanclays's (2017) argument that that the requirements of international standards are not always observed when project-induced displacement and resettlement occurs. In Nigeria, the oil industry and its activities has led not only to physical displacement but also to occupational, financial and cultural displacements. As Gill et al (2016) also opines, oil spills in many parts of the world have been reported to have impacted on the physiological health of the people, the consequences of exposure to oil pollution have included abnormalities in hematologic, hepatic, respiratory, renal, and neurologic functions and the exposed individual may experience frequent asthmatic attacks, headache, diarrhea, dizziness, abdominal pain, back pain, and other symptoms. As a result, people are forced to migrate because there are no alternatives due to environmental degradation like oil spillages and gas flares, among other factors. These activities have led the region to be aggravated by a serious level of poverty and loss of identity as the dislocation of local economies by oil induced environmental activities has diminished the capacity of individuals and groups to pursue their interests because it has necessitated migration either voluntary or involuntary. According to Akitoye et al (2016), The construction of the NLNG project included road building for the project and community uses, laying of gas transmission pipelines, through relatively undisturbed areas such as areas to secondary invasions. The subsequent on-site activities involved the relocation of Old Finima by the Federal authorities and a purpose-built new town was provided. Relocation to New Finima town took place in 1991, after which the site was levelled and covered with hydraulic fill to raise the site to the correct levels for construction. The relocation of indigenous populations and confiscation of coastal areas, especially known to be breeding grounds for marine species, portends major ecological danger and cultural trauma to man and loss of vital habitat used for centuries by animal species. The table below shows some prominent oil spill incident in Nigeria, the date of the spillage, the terrain, the site, the estimated spill volume and the cause(s) of the oil spill.

Table 1: Oil spill incident in South-South, Nigeria (Mba, et al., 2019)

Date reported	Incident site	Terrain	Cause	Estimated spill volume (
September 03, 2018	24'' Nkpoku-Bomu Pipeline at Bera.	Land	Sabotage	19
September 04, 2018	Imo River 2 Well 31L Flowline at Odagwa-Umuadeokwara	Land	Sabotage	0.1
September 06, 2018	14'' Okordia-Rumuekpe Pipeline at Akaramini	Land	Sabotage	81
September 08, 2018	20'' Otumara - Escravos Pipeline at Ugboegungun	Swamp	Sabotage	172
September 09, 2018	36'' Nkpoku - Bomu Pipeline at Rumuesara Eneka	Land	Sabotage	622
September 11, 2018	Imo River Well 59T Flowline at Igiriukwu_Owaza	Land	Sabotage	0.2
September 14, 2018	6'' Obigbo North - Ogale Pipeline at Ogale	Land	Sabotage	72
September 15, 2018	16'' Egbema - Assa Rumuekpe Pipeline at Assa	Land	Sabotage	34

3.1 Aims and Objectives

The aim of this study is to propose a framework by which existing policy implementation guidelines for oil and gas-induced resettlements within the South-South region can be improved. It will also:

- Explore the nature of oil and gas- induced displacements.
- Examine the characteristics of oil and gas-induced involuntarily resettlement
- Identify the associated policies and governance structures in managing oil and gas induced resettlements in South-South Nigeria.
- Identify the gaps in policy requirement associated with integration of the resettled people to the new environment.
- Develop a strategy to address the identified policy gaps for sustainable policy implementation.

4. DISPLACEMENTS AND RESETTLEMENTS CHALLENGES

Terminski (2013), describes population displacement or resettlement caused by the extraction of oil as a common phenomenon in many regions of the world, that the extraction and transportation of mineral resources presents an increasing social problem leading to environmental damage and the violation of human rights. Crude oil extraction also leads to massive environmental devastation, which clearly affects the living conditions of local communities. Global protests against the expansion of mining, oil exploitation and the topic of environmental destruction has led to violent clashes with authorities and forced evictions of entire villages and communities. Fearing for the safety of pipelines, national authorities often force the violent displacement of local communities, sometimes involving many thousands of people, and for several reasons, displacement associated with the extraction of oil is a unique and interesting issue. According to Kumar (2018), Displacement has become an outcome of modern developmental process worldwide. Displacement of people from their habitat occurs almost in all countries due to development projects. No precise data exists on the number of persons affected by development-induced displacement throughout the world. For an indication of magnitude, most scholars, like Cernea (2000) reports that it is estimated that each year around the world approximately 10 million people are displaced by various development projects. Over the last decade some 90 to 100 million people have been forced to move from their homes, 40 to 80 million of whom have been displaced by large dams, while policy-makers and activists rely on the World Bank Environment Department's (WBED) Report. As estimated by the World Bank, on an average 300 large dams that enter into construction every year displace 4 million people. According to Kadafa, (2012), Oil and gas extractive activities have come under scrutiny for a number of environmental infractions, for instance oil spillage, which is associated with the sector and globally discussed, often cause displacement of people. As, Lyall (2017) states, that involuntary resettlement is central to state-led development throughout the twentieth century, because it still paves the way for agroindustry, hydroelectric, urban, and other forms of development in around the world today. In asserting the magnitude of problems as a result of mineral extraction, Cernea (2015) explains that environmental consequences of oil extraction are becoming a growing social problem, unfortunately, according to many scientific studies, oil production in developing countries almost never contributes to improving the situation of local communities. Loss of land lead to loss of economic base functioning of the whole community. He further explains that where resettlement planning is done well and the stress experienced by people minimized, these stages would arguably occur. However, when resettlement is done poorly, and especially when the impoverishment of people occurs, the phases do not play out like this – people do not cope well and fail to adjust; economic development and community reformation do not occur; and instead of an independent, resilient community taking full control, the community remains dependent on the project and/or government and struggles to cope with inadequate service provision.

4.1. Impact of Oil and Gas Activities in the Region

According to Kadafa, (2012), oil and gas extractive activities have come under scrutiny for several environmental infractions, for instance oil spillage, gas flaring and air pollution which is associated with the sector and globally discussed and has often cause displacement of people. The income from crude oil and gas and other associated products accounts for about 80% of the Nigeria’s government's revenue and 90% of foreign earnings and one would expect that proper attention would be given to the region that lays the golden egg in terms of sustainable resettlement programs for the displaced people. Critical to mention, is the conceptual debate of identifying the definitions of involuntary resettlements, relocation of indigenous populations and confiscation of coastal areas. Increased activities by the multinational oil companies has also brought in its trail economic dislocation, intra and inter-ethnic migration and internal conflict due to benefit sharing, moral decadence especially among youths, female depravity, male crime and revolution of induced needs. The UNDP (2006), report on oil spill is a common fallout of oil exploitation and exploitation in Nigeria, with an estimated total of over 7000 oil spill incidents reported over a 50-year period, consequently, there are no consistent figures of the quantity of crude oil spilled in the South-South region of the country, but it is widely believed that an estimated 13 million barrels (1.5 million tons) of crude oil have been spilled since 1958 from over 7000 oil spill incidents; a yearly average of about 240,000 barrels. The oil spills affected at least 1500 communities in the eight-crude oil-producing states in Nigeria, and often resulted in contamination of surface water with hydrocarbons and trace metals, reduced soil fertility and smothered economic trees. Oil spills in the Niger Delta have been a regular occurrence, and the resultant degradation of the surrounding environment has caused significant tension between the people living in the region and the multinational oil companies operating there.

Another major degradation caused by the activities of oil and gas industries is gas flaring as Ogbonda (2017), reports, it states that Nigeria flares about 2.5 billion cubic feet per day and has an estimated 106 Trillion of proven natural gas and these flared gases release hazardous substances into the atmosphere resulting in adverse effects on the health of the population such as cancer, asthma and other lung related diseases. The writer further states that and also while oil exploration and exploitation continue to help nations with needed manpower for economic growth and stabilization, residues from flaring have become an environmental, physical, economic and social concern. Thus, the federal government formally declared gas flaring illegal since 1984, but multinational oil companies continue to treat compliance as a matter of convenience and not of necessity. Despite persistent protests environmental degradation by the oil-producing communities, the refusal of the oil companies to end gas flaring and complicity of the government remained sources of concern. Below are example images of gas when flared into the atmosphere and the resultant air pollutant effect on the people.

Figure 2: Gas flares in the South-south region (The Niger Delta in Pictures, 2019)

An example of the construction of the NLNG project according to Akintoye et al (2016) included road building for the project and community uses, as well as the laying of gas transmission pipelines, through relatively undisturbed areas, had often open up such areas to secondary invasions. The industries in rural areas have been implicated for the introduction of new population of non-indigenous construction laborers and management staff, the introduction of new land seeking cultivators, immigrants, inflationary trends, new diseases, high crime rate, increased noise level from motorized equipment's and other heavy duty vehicles, alcoholism, prostitution, disregard for local culture and dissemination of alien ideas and information. The presence of construction crews and non-indigenous workers may also increase local population which can make high demand on existing infrastructural facilities. It is thus argued that environmental degradation caused by the activities of oil and gas is responsible for the many displacements experienced in these communities under review. The introduction of poverty caused by oil spillages, gas flaring and internal conflict resulting from inadequate structure of development programs has caused huge displacements of people in the South-South region of Nigeria. According to Maxwell (2013), the creation of a theoretical framework will result in a tentative theory about the phenomena under investigation (Maxwell, 2013). The researcher will produce a tentative theoretical framework guidance by Ceanea (2000) and Scudder-Colson (1984), which identified some risks associated to development induced displacements including; landlessness, homelessness, joblessness, food insecurity, loss of access to common property resources, increase in diseases, social disintegration. Impoverishment. The findings of the review through the IRR model indicated that displacement and resettlement expose project affected people to some opportunities, but largely associated with more risks and Scudder-Colson (1982) in his four stage model, stated that for a community to be said to be successfully resettled, it is when it is no longer dependent on outside management and has fully become integrated by attaining economic and administrative self-sufficiency.

5. RESEARCH METHODS AND DESIGN ADOPTED

The philosophical perspective adopted for this research will be the pragmatic assumption driven by an abductive approach with sequential mixed-methods. This is because the use of mixed methods will create the possibility for the plurality of paradigm which is well supported by pragmatic assumption according to Creswell (2003). The mixed method approach will be considered most suitable to meet the objectives of this research and to answer the research questions that have been proposed. As this study recognizes the relationship between social actors and socio-economic systems, and in other to understand the role of active regulatory frameworks in development-induced resettlements but in this instance oil and gas, this paper will employ the use of mixed methods which by Clark at al (2008) defined as the use of both qualitative and quantitative approaches in a single study, not only to collect and analyze data but also to integrate the findings and draw inferences. This study will employ the use of both quantitative and qualitative data collection methods and will be driven by Saunders (2011) recognition of some prominent strategies such as case study, survey, Narrative Inquiry as this approach will enable the researcher gain access to detailed information required from all stakeholders involved in the displacement and resettlement process.
Figure 3, below, illustrates the mixed method design showing the logical description of how data for this study will be collected and analyzed.

Figure: 3: Mixed methods design for data collection (Yilmaz, (2013)

5.1. Semi-Structured Interviews

In other to achieve the aim and objectives of this study, primary data will be collected via interviews from key players in the industry. This interview will be conducted with selected stakeholders from the Multi-national companies involved with the resettlement process, representatives from the government and members of the communities. The interview will help to identify the key issues relating to the oil and gas industry and on resettlements.

5.2. Questionnaires

Kumar (2011) defines a questionnaire as a written list of questions, the answers to which are recorded by respondents. Where the questionnaire is completed by the respondents in the absence of the researcher, it is referred to as a postal questionnaire, but where it is completed verbally by responding to questions in the presence of the researcher, it is a structured interview. This study will employ the use of questionnaires in other to gather the input of all stakeholders involved in the resettlement process. As Etikan et al. (2016) suggests, purposive sampling is useful for this study as when if it is not possible to take a random sample, and the sample size is too small, there is a need to focus on people who possess sufficient experience and knowledge and who will be better able to make assessments relevant to the research.

5.3. Case Study Analysis

According to Saunders (2016), a single case study may be selected purposively because it provides an opportunity for the study to observe and analyze a phenomenon that few have observed before. Case studies provide opportunity to describe, understand, and explain a phenomenon. According to Yin (2009), this strategy is mostly used in explanatory and exploratory research, it may also use quantitative or qualitative methods to collect and analyze data. This will be a comparative case study analysis, using cases identified during stage one data collection. It is believed that case study research is an appropriate methodology in which to answer "how" and why," questions in research problems according to Yin, (2009).

The case studies that will be investigated will be the NLNG-Finima resettlement projects located in the island of Bonny, Rivers state, South-south region Nigeria. According to Akintoye et al (2016), The Nigerian Liquefied Natural Gas (LNG) project is thus, strategically designed to utilize the abundant gas resources of the nation, which are paradoxically currently being wasted through decades of flaring, and associated with adverse consequences on the regional and invariably international climates. Thus, the existing cleared plant site and residential area on Bonny Island were allocated to Nigeria LNG Ltd. (NLNG). The subsequent on-site activities involved the relocation of Old Finima by the Federal authorities and a purpose-built new town was provided. Relocation to New Finima town took place in 1991, after which the site was levelled and covered with hydraulic fill to raise the site to the correct levels for construction.

6. UNIT OF ANALYSIS

The unit of analysis in this study is the implementation of existing policies in supporting steady development in the oil and gas-induced resettlements. The reason for choosing this unit is to investigate the barriers that mitigate against successful implementation of these policies towards the affected communities within the South-South region Nigeria.

6.1. Contribution to Knowledge

Several studies have reviews gaps in development-induced displacements and the activities of oil and gas environmental degradation, but there is a dearth in literature regarding the resettlement process induced by the activities of oil and gas, plus the existing policies that empower the resettled people after the huge challenge of being displaced. Therefore, it is expected that this study will offer recommendations for the guidelines for oil and gas-induced resettlements process to be improved in line with present realities.

7. CONCLUSION

Although much of this work has provided a litany of problems generated by the oil and gas industry, it is important to note that in some cases, mostly in the global West, the discovery and exploration of oil have engineered development in local communities. In summary, the intended focus of this paper is to build on the essentials of good practices that would encourage successful resettlements programs, and to suggest useful recommendations that would improve the standards of living using natural resources without compromising the future of the people. Currently, according the World Bank (2006) report, the consensus is that in countries of the global south such as Nigeria where the discovery of oil has had little or no effect on the population, corruption is the culprit. In attempts to minimise corruption, in conjunction with several other civil society groups have put together the Extractive Industries Transparency Initiative (EITI). This initiative supports improved governance in resource-rich countries through the verification and full publication of company payments and government revenues from oil, gas and mining. At the international level, the revision of the World Bank's Environmental and Social Framework (World Bank 2014) has drawn harsh criticism from civil society organizations (CSOs), which accuse the largest development bank of weakening land rights protection for poor and vulnerable communities. Indeed, the draft safeguards seem to be at odds with the spirit of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Forest and Fisheries. Connell (2015) believe that the World Bank's attempt to exonerate itself from its obligations to people at risk of displacement and resettlement, and to give its borrowers more discretionary power in dealing with the displaced, is a reflection of its aim to enhance funding of private and public mega-projects and a response to growing competition from newly emerging lenders, such as China and India, and private investors not tied to safeguard regimes. And as Akintoye, O.A et al (2016), opines that there is a need to assess the retrospective benefits and demerits of the oil and gas projects in these communities. Thus, this analytical effort is aimed at examining the impact of displacements and resettlements and also the socio-economic contributions of the natural oil and gas industries in the South-South region of Nigeria. It is anticipated that this paper will suggest recommendations for a better involvement of all stakeholders which includes the multi-national corporations, the government and the communities in other to reduce the level of dependency of the affected communities in terms of compensation, lack of policy implementation and inadequate benefits in other to create a sense of self-sufficiency and self-worth amongst the affected communities.

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