CHOBE

Council of Heads of the Built Environment
Heads of Department of Construction, Property and Surveying

ARCOM

ASSOCIATION OF RESEARCHERS IN CONSTRUCTION MANAGEMENT

CHOBE/ARCOM Doctoral Workshop
Going North for Sustainability

WORKSHOP PROCEEDINGS

30th June 2016

London South Bank University

London South Bank University

University of Salford MANCHESTER

CONTENTS

INTRODUCTION

This Doctoral workshop hosted by the London South Bank University with the support of the University of Salford is jointly sponsored by the Council of Heads of the Built Environment (CHOBE) under the **CHOBE Small Grant Scheme** and the Association of Researchers in Construction Management (ARCOM). The workshop is building on the CIB 2015 conference organised at London South Bank University but focusing on **doctoral students and early career researchers**. The aim of the workshop is to explore how doctoral researchers are addressing the emerging sustainability issues. For doctoral students the event will provide a stimulating and comfortable platform where thorough presentations and discussions are held on specific sustainability topics of interests. It will explore the following specific themes:

- Sustainable Procurement
- Culture and Sustainable Development
- Public Private Partnerships and Sustainable Construction
- Sustainable Design
- Construction Management
- Sustainable Retrofit and Technologies
- Education for Sustainable Development
- Sustainable Housing etc.

Workshop Convenors:
Dr Alex Opoku; London South Bank University
Dr Chika Udeaja; University of Salford

Name	Affiliation	Topic	Time
Dr Alex Opoku	London South Bank University (LSBU)	Registration /Tea	**10:00**
Prof. Charles Egbu	Dean of School of Built Environment & Architecture	Welcome Address	**10:30**
Keynote Speaker:			
Prof. Andy Ford	Director of the Centre for Efficient and Renewable Energy in Buildings-LSBU	The role University as Sustainability exemplar	**10:45**
Presentation Session 1			
Solomon Adewumi	University of Dundee	Problematising a conceptual assessment framework for sustainability at the neighbourhood level in sub-Sahara Africa: a case study of Nigeria	**11:05**
Zoe De Grussa	London South Bank University	A literature review outlining the importance of blinds and shutters as a sustainable asset that has the potential to enhance the productivity of occupants in the UK	**11:20**
Kehinde Bamdupe	University of Salford	The prospects of public private partnership in creating oil refineries in Nigeria	**11:35**
Discussions Session: **Chaired by Dr Chika Udeaja-Salford University**			**11:50**
LUNCH BREAK & NETWORKING			**12:25**
Guest Speaker			
Dr Deborah Andrews	Associate Professor, London South Bank University	Sustainability for Education	**13:25**
Questions and Answers session: : Moderation by Dr Alex Opoku			**13:45**
Presentation Session 2			
Amadi Alolote	University of Salford	Exploring geologic-cost factors in flood prone housing construction in coastal communities of the Niger delta	**14:00**
Inara Watson	London South Bank University	External costs affecting sustainability of transport systems	**14:15**
Tariq Umar	A'Sharqiyah University, Oman	Improving safety performance in construction using safety climate factors	**14:30**
Discussion Session: **Chaired by Dr Alex Opoku- London South Bank University**			**14:45**
CLOSING REMARKS – Dr Chika Udeaja/Dr Alex Opoku			**15:20**
Closing at 15:30			

PROBLEMATISING A CONCEPTUAL ASSESSMENT FRAMEWORK FOR SUSTAINABILITY AT THE NEIGHBOURHOOD LEVEL IN SUB-SAHARA AFRICA: A CASE STUDY OF NIGERIA

Solomon Adewumi - University of Dundee

Neighbourhoods are regarded as the most important scale of spatial development as they form the building blocks of a nation. The economic, social and environmental prosperity of a nation is an extension of what plays out in its neighbourhoods. However, the sustainability challenges that currently dominates the neighbourhood corridors of sub-Saharan African countries due to rapid urbanization calls for urgent concern. This paper attempts to problematise a conceptual assessment framework for sustainability at the neighbourhood level using Nigeria as a case study in order to steer the delivery of safe, healthy, and prosperous neighbourhoods by providing a practical method for evaluating the performance of a masterplan against an array of sustainability indicators. Using the Driving force Pressure State Impact Response (DPSIR) framework, the paper assesses the current state of urban neighbourhoods in Nigeria while also highlighting the past efforts in terms of legislations to abate this unpleasant scenario. The findings show that although there are lessons to be learnt from existing assessment frameworks, an indigenous assessment framework for the peculiar Nigeria content is imminent. A conceptual assessment framework for sustainability at the neighbourhood level in Nigeria is proposed while the applicability is considered. The paper concludes that the role of stakeholders is essential in order to develop a comprehensive, integrated, and strategic Neighbourhood Sustainability Assessment Framework for Nigeria.

Keywords: assessment frameworks, indicators, neighbourhoods, stakeholders, sustainability.

INTRODUCTION

Cities have been regarded as the 'game changer' in the campaign for sustainable development (Berardi, 2011; Girardet, 2015; Komeily and Srinivasan, 2015). Yet the impact of cities have become much more prominent in recent years as more than half of the world population live in urban centres with a projected increase to 72% by 2030 (UNDESA, 2015). This has invariably led to the term sustainable urban development which is defined to mean a desirable state of urban conditions that persists over time (Adinyira *et al*., 2007). Consequently in recent times, several categories of cities have emerged in literature such as, resilient; regenerative; adaptable; low-carbon; zero-waste; biophilic; smart; intelligent; future; and eco-cities among others (De Jong *et*

al., 2015). It has been stressed that the battle for sustainable development will be lost or won in cities.

Building Environmental Assessment Tools (BEA) were introduced towards the end of the twentieth century when it was discovered that the built environment accounts for the largest energy consumption and greenhouse gas emissions (Edwards, 2014). The BEA tool was to assess the environmental credentials of a building which consequently led to the emergence of the term 'green buildings'. However, advanced sustainability studies and lessons from practice reveal that a conglomerate of green buildings is not a guarantee for sustainable urban development (Berardi, 2011).Not until towards the end of the twentieth century, when policymakers and stakeholders began to recognize the neighbourhood as the building block and planning unit of cities, through the development of Neighbourhood Sustainability Assessment Framework, was better progress in the quest for sustainable urban development recorded. Undoubtedly, this is also coupled with surging concern to extend the sustainability discourse beyond environmental concerns but to pressing issues like social wellbeing, quality of life, support for local economy, intra-generational and intergenerational equities which can best be executed and assessed at the neighbourhood scale of spatial development.

Through the establishment of some processes, Neighbourhood Sustainability Assessment Framework has been developed as a distinctive form of integrated assessment which considers the social, economic, and environmental impacts of proposed development, plans, policies, programmes, and other initiatives (Pope *et al*., 2004). It is a process that directs decision towards sustainability (Hacking and Guthrie, 2008). Presently, there are over 43 assessment frameworks visible in the international radar which can be applied at the neighbourhood scale (Joss *et al*., 2015). While further research through monitoring and feedbacks on Neighbourhood Sustainability Assessment Framework continue to thrive in nations where these tools are already in use, most developing countries are yet to evolve a performance-based metrics which can be used to estimate the impacts of medium and large development on the local and global environment. Previous studies (Berardi, 2011; Yigitcanlar *et al*., 2015) have canvassed for the definition of systems and criteria for accessing urban neighbourhoods in developing countries. Therefore, adopting an existing framework elsewhere for application in a different context like in Africa for example will be an exercise in futility, due to some core differences such as

interpretation of terminology, technological needs, market emphasis, identified priorities, and the scales and types of challenges to be faced (Du Plessis, 1999).

However, there is no evidence in literature of any research on developing a context-based Neighbourhood Sustainability Assessment Framework in Sub-Saharan Africa (SSA). Sustainable urban development in this region will be far from being achieved until a comprehensive approach which integrates environmental, social, and economic goals based on the relationship that exists between these goals and in the manner in which they relate with both urban and rural areas is established. This is a fundamental gap in research which calls for a fit-for-purpose assessment framework for enhancing decision making at neighbourhood scale in SSA. Using Nigeria as a case study, the main research question studied in the paper is: can a neighbourhood sustainability assessment framework lead sustainable urban planning in Nigeria? This was examined using the following sub questions: (i) to what extent and in what ways do the current urban neighbourhoods in Nigeria exhibit the characteristics of sustainability? (ii) What are the key criteria for accessing neighbourhood sustainability? (iii) How will the proposed framework fits into the current planning system in Nigeria?

OVERVIEW OF SUSTAINABLE DEVELOPMENT

The term 'sustainable development' can be traced to the early study carried out by Barbara Ward and Renes Dubes (Gibson *et al*., 2005) in response to the 1972 conference on human environment which advocated for the need to begin to chat a new course in reconciling the environment and development. Sustainable development became a household name after the 1987 conference (Brundtland conference) where it was agreed in a consensus that development should above all, aim to enhance systems and conditions where people can sustain themselves and also the environment which is the foundation for their lives and livelihoods (ibid).

According to the International Union for the Conservation of Nature (IUCN), sustainable development is a development that enhances the quality of life while maintaining the carrying capacity of the supporting ecosystem. The benchmark definition which has gained prominence and has widely been cited explains sustainable development as a development which meets the needs of the present without compromising the ability of future generations to meet their own needs. These interpretations distils that fact that concerns for future generations (futurity), preservation of the environment (ecological integrity), equal access to what is available and

wellbeing (equity), and collaborative planning (public participation) are the key principles of sustainable development (Mitchell *et al*., 1995).

CHALLENGES AND INTERVENTIONS FOR URBAN SUSTAINABILITY IN SUB SAHARAN AFRICA AT THE NEIGHBORHOOD LEVEL: THE NIGERIA EXPERIENCE

A neighbourhood is 'an area of dwellings, employment, retail, and civic places and their immediate environment that residents identify with, in terms of social and economic attitudes, lifestyles, and institutions' (USGBC, 2014). Planning at the neighbourhood level dates back to the early twentieth century with Ebenezer Howard's Garden city movement being the pioneer (Farr, 2008). The campaign for urban sustainability at the local level (chapter 28 of Agenda 21) has led to a renewed interest in developing new initiatives at this scale of spatial development in recent times (ibid) with the emergence of the term sustainable neighbourhood. This according to Roberts (2009) is the spatial manifestation of the key principles of sustainability.

SSA geographically, is the portion of the African continent that lies south of the Sahara desert. With about 47 countries, Sub-Sahara Africa (SSA) has experienced appreciable increase in population having an annual growth rate of 2.3% with a projected population of between 1.5 billion and 2 billion by 2050 (UNDESA, 2015). Undoubtedly, the sustainability challenges confronting this region are enormous, ranging from environmental, social, and economic issues which are as a result of so many factors. Using Nigeria as a case study, the challenges for urban sustainability in Nigeria which has resulted to deteriorating physical and living environments, declining quality of life, inadequate housing and basic amenities among others (Owoeye and Omole, 2012) are explained in table 1 using the Driving-Pressure-State-Impact-Response Framework analysis. The DPSIR is an example of the linkage-based frameworks which use the concept of 'causality' or cause-effect relationship (Waheed *et al.,* 2009).

Table 1: The DPSIR framework analysis of state of neighbourhoods in Nigeria

Driving force	Pressure	State	Impact
Rural-urban migration	Urbanization	Pressure on available amenities	Dilapidation of infrastructure and facilities; Inadequate basic amenities, Poor sanitation
Poor enforcement of planning laws	Unapproved development	Slum development	Unhealthy living condition, Urban insecurity, encroachment into biodiversity
Inefficient and outdated planning laws	Urban sprawl	Low density & single-used neighbourhood	Increased infrastructure cost, Increased carbon footprint

Although, there have been several interventions through policies, laws, regulations, schemes, and programmes to salvage this situation, not much progress has been recorded. Some of these interventions are:

1. The National Urban Development Policy formulated to promote dynamic system of urban settlement which foster sustainable economic growth and enhance efficient urban and regional planning coupled with improving standard of living and wellbeing of Nigeria (FMLHUD, 2014).

2. Enactment of some environmental laws and establishment of environmental ministries, department and agencies (e.g. the harmful waste special criminal provision decree 1988, no.42; the Environmental Protection Agency Decree, 1998 no.58; the Environmental Impact Assessment Decree no.86; the Federal ministry of environment established in 1999).

3. Urban regeneration schemes executed in some deteriorating neighbourhoods with a deliberate effort to effect a change in an urban environment by large scale adjustment of existing area to meet the present and future requirements of urban living

4. Sustainable cities programme (SCP) which was developed by the United Nations Centre of Human Settlements (UNHABITAT) with the aim of providing adequate shelter, healthy and safe environment, basic amenities, and job opportunities for man (Olujimi, 2009), This has been executed in some cities like Ibadan, Enugu and Kano.

However, apart from the fact that some of these initiatives are more focused on environmental issues and also reactive in nature, they are also outdated and inadequate to meet the planning challenges of the 21st century neighbourhoods. This calls for a proactive, integrated, strategic model to address urban sustainability challenges by developing a sustainability assessment framework.

SUSTAINABILITY ASSESSMENT AND EVOLUTION OF NEIGHBOURHOOD SUSTAINABILITY ASSESSMENT FRAMEWORK

Overview, definition, and evolution of Sustainability Assessment

Sustainability Assessment which emerged on the basis of the need for sustainable development can be traced to a broader heritage of plan and policy instrument for improving decision making known as the impact assessment instruments (Pope *et al.*, 2004). Available literatures revealed that Sustainability Assessment largely originated from EIA and SEA (Cashmore and Kornov, 2013; Pope *et al*., 2004; Sala *et al*., 2015) which was developed as a result of the need to incorporate both social and economic considerations into Impact Assessment. Sustainability Assessment is a formal process of identifying, predicting, and evaluating the potential impacts of wide range of relevant initiatives (such as legislation, regulations, policies, plans, programmes and specific projects) and their alternatives on sustainable development of society' (Devuyst, 2000). Its application has gained prominence and appreciable acceptance since it emerged. In the year 2010, 650 million square meter of development obtained a sustainability certification worldwide and future projection submits that 4600 million square meters will be evaluated by 2020 (Berardi, 2011). Sustainability Assessment at the neighbourhood level in recent times has been the front banner in the campaign for sustainable urban development (Berardi, 2011; Cashmore and Kornov, 2013). Pioneering the movement of Neighbourhood sustainability assessment framework was the development of HQE2R between 2001 and 2004 and Earthcraft communities in 2003. Subsequently, in 2006-2009, the CASBEE-UD, the U.S. Star community Rating System (STAR-CRS), LEED Neighbourhood Development (LEED –ND), and the UK BREEAM communities (BREEAM-C) were launched. Most recently, the German system

DGNB New Urban Districts and the Australian system Green Star Communities were launched in 2011 and 2012 respectively (Wangel *et al*., 2016)

Key aspects of a Neighbourhood Sustainability Assessment Framework

Although the various assessment frameworks differ in content as they are developed for use for a peculiar context, they share similar architecture and methodology (Al Waer and Kirk, 2015). Indicators, criteria, themes, weighting, scoring, and certification levels are the key aspects of most Sustainability Assessment Framework as further explained.

Themes, Categories, and Criteria

Categories are considered as the main sustainability concern. They are high-level issues of sustainability (Yigitcanlar *et al*., 2015). Examples of categories are smart location & linkages, neighbourhood pattern & design as in LEED-ND.

Indicators

Indicators are presentation of measurements to suit a particular need (Brandon and Lombardi, 2011). They provide information on what is happening in a system as to whether things are getting better or getting worse (Bell and Morse, 2008). It is essential that an indicator is (i) policy relevant (ii) analytically sound (iii) wide in scope (iv) specific, measurable, achievable, relevant, and time-related (Bell and Morse, 2008; Mitchell *et al.*, 1995; Shen *et al.*, 2011).

Scoring and Weighting

The scoring and weighting of particular criteria indicates its significance as the higher the weight, the higher it contributes to sustainable development in that context. Weighting at times may be controversial and highly subjective.

Certification and Rating level

This is determined in an assessment framework after the scoring has been carried out. It basically summarises the performance of a proposed or existing development after evaluation of certain sustainability issues against the indicators. The rating level depends on the total score attained in the assessment process. Table 2 shows the key aspects of some selected Neighbourhood Sustainability Assessment Frameworks.

Table 2: Key aspects of selected Neighbourhood Sustainability Assessment frameworks

Assessment frameworks	Developer	Categories and percentage weighting (including innovation credit as applicable)	Total number of criteria	Rating levels
Pearl Community rating system (Estidama), 2010	Abu Dhabi Urban Planning Council	Independent development process (IDP)-6.17%; Natural systems (NS)-8.64%; Liveable communities (LC)-23.64%; Precious water (PW)-22.83%; Resourceful energy (RE)-25.93%; Stewarding materials (SM)-11.11%; Innovating practice (IP)-1.86%	64	1 Pearl; 2 Pearl; 3 Pearl; 4 Pearl; 5 Pearl
Green STAR Community, 2012	Green Building Council of Australia	Governance and design-25.45%; Liveability-20%; Economic prosperity-19.11%; Environment- 26.40%; Innovation-9.09%	33	1 Star; 2 Star; 3 Star; 4 Star; 5 Star; 6 Star
LEED Neighbourhood development 2016 (v4)	US Green Building Council; Congress for New Urbanism; National Defence Council	Smart location and linkages (SLL)-25.45%; Neighbourhood pattern and design (NPD)-37.27%; Green infrastructure and buildings (GIB)-28.18%; Innovation and design process (IDP)-5.45%; Regional priority credit (RPC)-3.63%	56	Certified; Silver; Gold; Platinum
BREEAM Communities	Building Research Establishment (BRE)	Governance (GO)-8.69%; Social and economic wellbeing (SE)- 39.91%; Resources and energy assessment issue (RE)-20.19%; Land use and ecology (LE)-11.78%; Transport and movement (TM)-12.89%; Innovation credit-6.54%	41	Unclassified ; Pass; Good; Very good; Excellent; Outstanding

A CONCEPTUAL NEIGHBOURHOOD SUSTANABILITY ASSESSMENT FRAMEWORK FOR NIGERIA

The development and application of the proposed Neighbourhood Sustainability Assessment Framework for Nigeria is discussed in this section of the paper.

The framework development

Vision

The driving vision of the assessment framework is to enhance the planning and delivery of sustainable neighbourhood that is human and environment friendly where people can live, work, and prosper now and in the future.

Essential consideration of sustainability issues

As argued in literature, addressing the concept of sustainable development using the 'pillar' approach (that is economic, social, and environmental dimensions) will result to an exercise of competition between objectives which sometimes lead to trade-offs, instead of focusing on the needs and opportunities to ensure a positive accommodation of relationship between human and ecological interest (Gibson *et al*., 2005; Pope *et al*., 2004). From the principles of sustainability and sustainable neighbourhoods available in literature (Gibson., 2013; Barton *et al.*, 2010; UNHABITAT, 2015) the proposed Neighbourhood Sustainability Assessment Framework will be based on the following 6 categories from which criteria will be developed as shown in figure 1:

1. Health and social wellbeing: To promote the principles of socio-ecological system integrity; social inclusion; availability of basic amenities; and improved livelihood.
2. Environment and resource efficiency: To promote the principles of intergenerational equity; precaution and adaptation.
3. Economic prosperity: To promote the principle of livelihood sufficiency.
4. Location, land use and site design: To promote the principles of immediate and long-term integration; mixed-land use; limited land use specialization.
5. Transportation: To promote the principles of efficient street network.
6. Governance: To enhance public participation and community engagement.

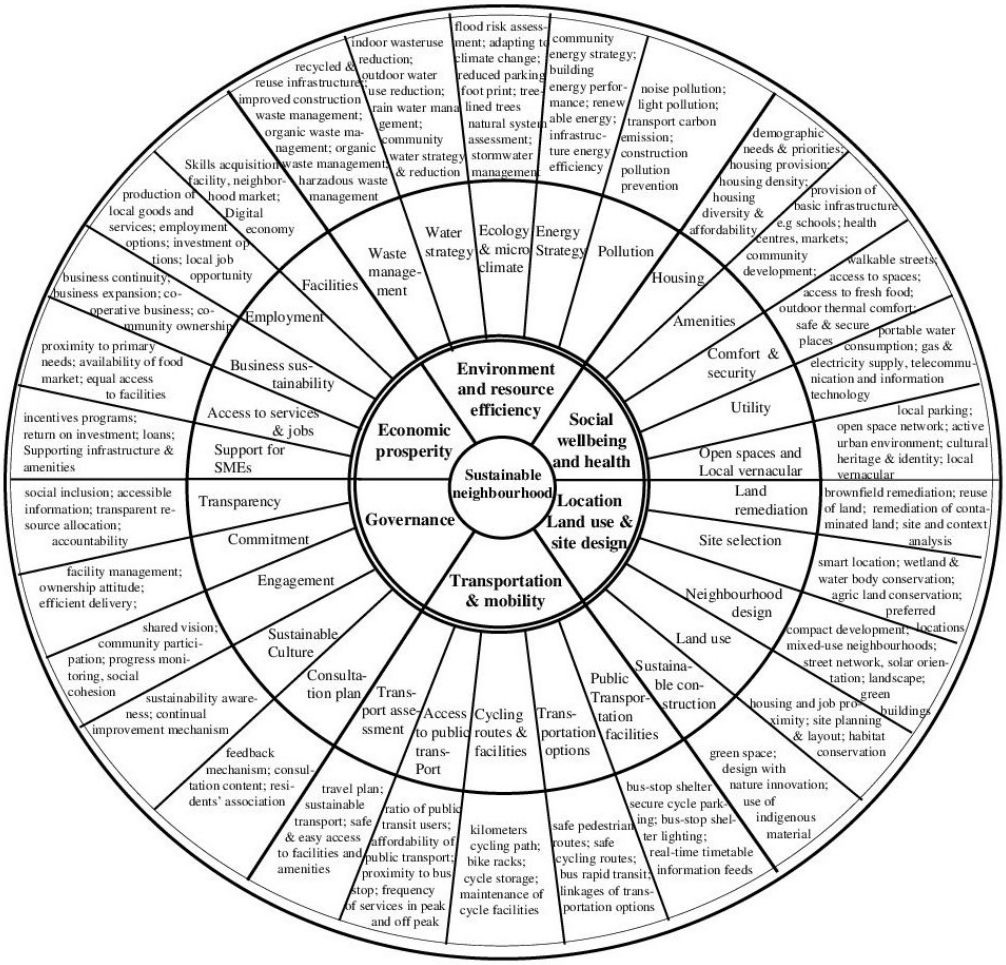


Figure 1: Sustainability criteria and indicators for proposed assessment framework

In addition, to be essentially considered are the existing statutory and legal framework such as planning laws, building regulations, environmental impact assessment among others. These will serve as mandatory criteria in the assessment process.

Adequate coverage of the design process (ex-ante and ex-post evaluations)

The proposed framework criteria and indicators will cover the whole development process from site selection and identification to post construction (operation and maintenance) phases as shown in figure 2.

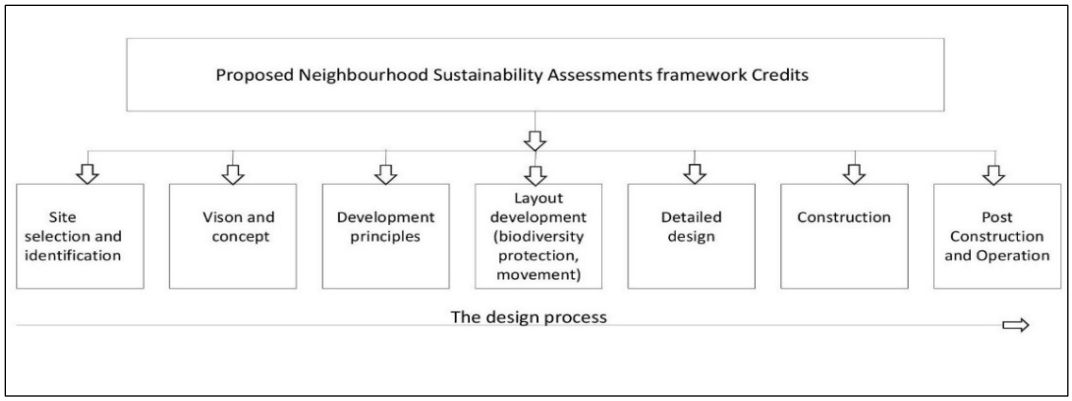


Figure 2: Scope of the assessment framework credit covering the design process

The framework application

The neighbourhood sustainability assessment framework will be used for the following types of places as identified in the study in the study of Robert (2009):

New Places

The framework will be used in this instance to evaluate the sustainability potential of a proposed development in order to establish a sustainable neighbourhood.

Regenerating places

The framework will address certain neighbourhoods where a regeneration exercise is imminent. These are places that are in a deteriorating condition economically, socially, and environmentally. The framework will be used to assess the existing condition of the neighbourhood while also recommending the necessary facilities, amenities, and infrastructures that will need to be considered in the regeneration exercise.

Evolving places

Evolving places are where gradual development are taking place which are not as swift or active when compared to 'new places'. The proposed framework will serve as a monitoring tool in assessing how sustainable outcomes are achieved intermittently in these neighbourhoods.

CONCLUSIONS

The paper has discussed the need for a Neighbourhood Sustainability Assessment Framework in SSA using Nigeria as a case study. Applying the DPSIR analysis, it was discovered that while the challenges for urban sustainability in Nigeria at the neighbourhood level are enormous, the interventions and responses from the various authorities have not been effective enough in delivering sustainable settlements as envisaged. This is attributed to the fact that some of these measures are reactive rather than proactive. This study proposed a conceptual framework which can be used to evaluate proposed and existing developments against an array of sustainability criteria. The determination of priorities and weighting of these criteria is beyond the scope of this paper as it will involve the various stakeholders in a Delphi study and an analysis using the analytical hierarchy process (AHP). This gives a place for a further research to this study. A consensus-based weighting for the different categories and criteria has been argued to have the potential of improving assessment process (Al Ware *et al*., 2008). The way forward is a robust participation of all stakeholders that transcends the building industry in a transdisciplinary and collaborative forum in order to develop a proactive and a consensus-based assessment framework that will stimulate socially responsible and people-oriented decisions in better delivery of places that are economically viable, socially active, and environmentally responsible.

REFERENCES

Adinyira, E, Oteng-Seifah, S and Adjei-Kumi, T (2007) A review of urban sustainability assessment methodology. In: M. Hormer and J. Price, (eds.) "International conference on whole life urban sustainability and its assessment". Glasgow.

Al Waer, H and Kirk, R (2015) Matching a community assessment tools to the requirement of practice. “Proceedings of the institution of civil engineers",doi:10:1680/udap.15.00001

Al Waer, H, Sibley, M and Lewis, J (2008) Different stakeholders' perspectives on sustainability assessment. "Architectural Science Review", 51(1), 48-59.

Barton, H, Grant, M and Guise, R (2010) "Shaping neighbourhoods for local health and global sustainability". 2ed. London: Routledge.

Bell, S and Morse, S (2008) "Sustainability Indicators- Measuring the Immeasurable?”2ed. London: Earthscan.

Berardi, U (2011) Beyond urban sustainability: Upgrading topics by enlarging the scale of assessment. "International Journal of Sustainable Building Technology and Urban Development", 2, 276-82.

Brandon, P and Lombardi, P (2011) "Evaluating Sustainability development in the built environment". Oxford: Wiley-Blackwell Publishing Ltd.

Cashmore, M and Kornov, L (2013) The changing theory of Impact Assessment. In: A. Bond, A. Morrison-Saunders and R. Howitt (eds.) "Sustainability Assessment: Pluralism, Practice, and Progress". London: Routledge.

De Jong, M, Joss, S, Schraven, D, Zhan, C and Weijen, M (2015) Sustainable- smart-resilient-low carbon-eco-knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. "Journal of Cleaner production", 109, 25-38.

Devuyst, D (2000) Linking impact assessment and sustainable development at the local level: The introductory of sustainability assessment system. "Journal of sustainable development", 8, 67-78.

Du Plessis, C (1999) Sustainable development demands dialogue between developed and developing world. "Building Research and Information", 27(6), 378-389.

Edwards, B (2014) "Rough guide to sustainability: a design primer". 4ed. London: RIBA.

Farr, D (2008) "Sustainable urbanism: Urban design with nature". New Jersey: John Wiley and Sons.

FMLHUD (Federal Ministry of Lands Housing and Urban development) (2014) Draft National Report for United Nations Conference on Housing and sustainable urban development.

Gibson, R (2013) Why sustainability assessment? In: A, Bond, A. Morrison-Saunders and R. Howitt (eds.) "Sustainability Assessment: Pluralism, Practice and Progress". London: Routledge.

Gibson, R, Hassan, S, Holtz, S, Tansey, J and Whitelaw, G (2005) "Sustainability Assessment: Criteria, Processes and Application". London: Routledge.

Girardet, H (2015) Ecopolis-The regenerative city. In: S. Lehman (ed.) "Low Carbon Cities: Transforming urban systems". Oxon: Routledge.

Hacking, T and Guthrie, P (2008) A framework for clarifying the meaning of Triple Bottom Line, and Sustainability Assessment. "Environmental Impact Assessment Review", 28, 73-89.

Joss, S, Cowley, R, De Jong, M, Muller, B, Park, B, Rees, W, Rydin, Y (2015) "Tomorrow's City Today: Prospects for Standardising Sustainable Urban Development". London: University of Westminster.

Komeily, S and Srinivasan R (2015) A need for a balanced approach to Neighbourhood Sustainability Assessment. "Journal of sustainable cities and society", 18, 32-43.

Mitchell, G, May, A and McDonald, A (1995) PICABUE: A methodological framework for the development of Indicators of Sustainable Development. "International Journal of Sustainable Development and World Ecology", 2, 104-123.

Olujimi, J (2009) Evolving a planning strategy for managing urban sprawl in Nigeria. "Journal of Human Ecology". 25, 201-208.

Owoeye, O and Omole, F (2012) Effects of slum formation on a residential core area of Akure, Nigeria. "International Journal of Environmental Sciences", 1(3), 159-167.

Pope, J, Annadale, D and Morris-Saunders, A (2004) Conceptualizing Sustainability Assessment. "Environmental Impact Assessment Review". 24, 295-316.

Roberts, P (2009) Sustainable Communities: Policy, Practice and Professional Development: A model for Europe. In: S.M. Cooper (ed.) "Sustainable Urban Development: Changing professional practice" Oxon: Routledge.

Sala, S, Ciuffo, B and Nijkamp, P (2015) A systematic framework for sustainability assessment. "Ecological Economics", 119, 314-325.

Shen, L, Ochoa, J and Shah, M Z (2011) The application of urban sustainability indicators: A comparison between various practices. "Habitat International" 35, 17-29. doi:10.1016/j.habitatint.2010.03.006.

UNDESA (2015) "World population Prospects: The 2015 Revision, Data Booklet". Retrieved on 12/12/2015, from http://www.esa.un.org.

UNHABITAT (2015) "A new strategy for sustainable neighbourhood planning". Retrieved on 03/02/2016 from http://www.unihabitat.org.

USGBC (2014) "LEED 2009 for Neighbourhood development". Washington: US Green Building Council.

Waheed, B, Khan, F and Veitch, B (2009) Linked-Bases Frameworks for Sustainability Assessment: Making a case for Driving force-Pressure-State-Exposure-Effect-Action (DPSEEA) frameworks. "Sustainability Journal", 1, 441-463.

Wangel, J, Wallhagen, M, Malmqvist, T and Finnveden, G (2016) Certification systems for sustainable neighbourhoods: What do they really certify?. "Environmental Impact Assessment Review", 56, 2000-2013.

Yigitcanlar, T, Kamruuzaman, M and Teriman, S (2015) Neighbourhood Sustainability Assessment: Evaluating Residential Development Sustainability in a Developing Country Context. "Sustainability Journal", 7, 2570-2602.

A LITERATURE REVIEW OUTLINING THE IMPORTANCE OF BLINDS AND SHUTTERS AS A SUSTAINABLE ASSET THAT HAS THE POTENTIAL TO ENHANCE THE PRODUCTIVITY OF OCCUPANTS IN THE UK

Zoe De Grussa[1], Deborah Andrews[1], Elizabeth. J. Newton[1], Gordon Lowry[1], Andrew Chalk[2] and Dave Bush[2]

[1]London South Bank University, UK

[2]The British Blind and Shutters Association (BBSA), UK

Blinds and Shutters in the UK are still thought of as an optional window dressing rather than a low cost sustainable building asset that can enhance a window/glazing system's performance and in return, save energy through passive thermal measures and measurable solar performance. Although the array of benefits is validated for blinds and shutters there are historic barriers to realising the potential for saving energy. Simple behavioural change related to the use of existing products would be a no cost productivity and energy benefit. Use of blinds and shutters is based on the need of a variety of factors in both commercial and domestic markets. These factors can be categorized into three broad areas namely energy savings, comfort (inclusive of visual, thermal and acoustic preferences) and occupant satisfaction which contribute to improving the health, well-being and productivity of occupants. In recent publications it has been demonstrated how thermal, visual, acoustic and controllability of occupants' working environments impacts productivity. The business case for linking productivity to 'green' working environments has been made by the World Green Building Council (WGBC) highlighting how productivity of staff is a greater incentive for commercial buildings to become more sustainable. This study incorporates a literature review of the sustainable benefits of shading and illustrates how they are an asset to the building façade in creating dynamic, comfortable and potentially productive environments for the commercial sector. However, we highlight the difficulties of this research and outline a potential future study.

Keywords: acoustic comfort, behaviour change, blinds and shutters, energy saving, health and well-being, low cost, productivity, sustainability, thermal comfort, visual comfort.

INTRODUCTION

In the EU (28 member states) the existing building stock currently accounts for 40% of the total energy consumed (Publications Office, 2010). Globally space heating and cooling is reported to account for over one third of all energy consumed by buildings, rising to as much 50 -60 % in cold climates (IEA, 2013a). Energy demand in buildings is expected to increase globally by 50%

by 2050 if no action is taken to improve the energy efficiency in the building sector. This is due to the increase in the number of households, residential and services buildings required higher ownership rates of electronic devices and increasing demand for new products (IEA, 2013b). Part of this increase in energy consumption is attributed to a substantial requirement for cooling within buildings, which is expected to inflate by 150% globally by 2050 (IEA, 2013a). Within the EU (28 member states) there has been an estimated increase of 63% in sub-sector services between 2000 and 2010 (IEA, 2013b). The building envelope is highlighted as an area where substantial improvements resulting in energy savings and lower CO_2 emissions can be made. The 2010 recast of the Energy Performance Buildings Directive (EPBD) emphasised the potential of passive cooling techniques such as shading to enhance the thermal performance of buildings during summer and reduce issues regarding overheating in favour of the use of air-conditioning systems (Publications Office, 2010). The challenge for Europe is that whilst new buildings can be built to higher performance levels in OECD member countries, 75 – 90% of the current building stock will still be standing in 2050 and currently renovations are being carried out at only 1% per year across Europe (IEA, 2013a).

Abroad shading is common place in warm and colder countries and is incentivised through government. In Austria and Belgium VAT reductions are applied to the purchase of blinds and shutters, in Italy there are allowances for corporation tax and income tax that allow companies and individuals to offset the capital costs against their tax liabilities. Furthermore, in Norway shading is favoured in Building Regulation models and in Denmark a multiplier is applied to the mechanical cooling energy consumption (Seguro and Palmer, 2016). Energy consumption is a well-established contributor to Green House Gas (GHG) emissions, which is a direct contribution to climate change. It has been reported by the Committee on Climate Change (2015) that commercial buildings and public sector buildings in the UK were responsible for 26% of these emissions in 2014. Although CO_2 emissions fluctuate due to annual weather conditions, it has been noted that there has been little change in the commercial sector's emissions since 2007 in comparison to residential emission rates.

Further triggers to drive change within the commercial sector are needed. Particularly because recent research shows that improving productivity can incentivise improvements to be made to the building envelope (WGBC, 2014). This paper reveals how improvements in productivity and

energy savings can be met through the installation and correct usage of blinds and shutters. Although the research considered primarily focuses on office environments it can be assumed that the implications will be similar for other work environments.

BLINDS AND SHUTTERS AND ENERGY SAVING

Blinds and shutters have been shown to be an important method in reducing heat loss through the building envelope whilst also preventing heat gain via the window system in summer and simultaneously offering dynamic daylighting strategies to reduce electricity consumption (BBSA, 2015). Seguro and Palmer (2016) recently explored this by identifying that when a range of shading methods (comprised of external and internal screen fabrics) were combined with low-e double glazing, the U-values can be reduced by 13 – 25% and G -totals 13 – 85 % depending on the type of shading selected. Previous studies have shown how blinds and shutters can provide heating energy savings of up to 35% in the case of single glazing and by 25% with double glazed windows and could feasibly reduce energy CO_2 emissions by 31 million tonnes per year as was the conclusion from a simulation study that incorporated the climates of four European countries, Brussels, Stockholm, Budapest and Rome (ES-SO, 2015).

Blinds and Shutters are a passive cooling method that can reduce window surface temperatures, which in turn help maintain operative temperatures below maximum thresholds. It has been highlighted how external shading needs to be dynamic to improve energy savings throughout the year. A study carried out by Dubois (2011) investigated the differences in energy savings when a fixed awning was positioned year round on a south facing window in Stockholm and when a seasonal awning was only used in summer. The seasonal awning reduced annual cooling energy by 80% where the fixed awning increased heating by 31%. The dynamic ability of blinds and shutters in comparison to fixed shading is important when considering different seasons and should not be overlooked or energy penalties will incur.

Implementing external shading is not always possible although it is most effective at preventing solar radiation from entering the building in summer. Interior shading can also be effective in improving internal temperatures and reducing energy consumption a simulation study carried out by Seguro and Palmer (2016) evidenced that internal venetians could reduce total energy end use by 5% (-£1.40 per m²) and internal rollers by 12% (-£3.2 per m²). These energy savings could be potentially higher if the side of an internal blind that faces the glazing was coated with a

reflective layer that returns more of the solar radiation before it is absorbed by the internal environment (BBSA, 2015).

ENERGY CONSUMPTION IN COMMERCIAL BUILDINGS

Within an analysis of CO_2 emission savings in Europe a potential of 17% of the 3.2 $GtCO_2$ savings can be met through improving the building envelope (IEA, 2013b). It is approximated that in the UK there are 2 million non-domestic buildings that contribute to producing one fifth of the nation's annual CO_2 emissions (Armitage *et al*., 2015). In the EU (27 members as at 2013) the largest energy end-use is space heating in terms of final energy consumption. This totalled to 40% of the total energy used in the non-residential sector in 2010, cooling accounted for 6% and lighting contributed to 8% (IEA, 2013b). The non-residential building sector is complex to understand in terms of end-use energy consumption as there are a variety of uses depending upon the purpose of the building. Hospital and hotels have considerably longer usage patterns compared to schools and offices which are only used within term-time or between regular working hours. Each building category having different requirements for lighting, ventilation, heating, cooling, refrigeration, IT equipment and appliances (Atanasiu *et al*., 2013). Energy savings have stagnated in the commercial sector (Committee on Climate Change, 2015). Even though various incentives/policies have been introduced to highlight the importance for energy saving in the commercial market to encourage business owners to make investments.

DRIVERS FOR COMMERCIAL BUILDINGS TO SAVE ENERGY

The EPBD policy created in 2002 and which was recast in 2010 (Publications Office, 2010) required the UK to make new policies and incentives to encourage energy saving within the built environment these are outlined within Committee on Climate Change (2015). To rectify this most recently the Energy Savings Opportunity Scheme has been introduced which requires organisation of 250 or more employees or those in excess of €50 million annual turnover to participate. They are required to complete energy audits that are repeated every four years, the first report was required in 2015 (EA, 2016). Within the scheme there is no direct requirement to make improvements, despite the audit having to highlight energy saving measures (Fry and Hubbard, 2016). We wait to see the impact this will have on the commercial market, yet it is still

only likely to influence those larger organisations, leaving little drive for change within small to medium size organisations.

A driver that has been realised and spoken about widely is the link between green building design and productive workplaces. The WGBC (2013) produced a 'business case' for green building design to highlight the financial benefits. Various incentives were revealed such as lower operating costs; increased marketability and asset value; potential equal cost comparison between sustainable and conventional builds; and improved health, well-being and productivity of staff. Productivity yields many benefits for commercial organisations that hold almost immediate financial benefits. When staff costs tend to account for 90% of a business's expenditure and energy costs account for 1% you can understand why CEOs are not swayed by the idea of investing in energy efficient solutions (WGBC, 2014). In addition, the pay-back time of investments in improving the indoor environment quality (IEQ) is generally less than 2 years. It has been quantified that very little increases in work performance, 1%, can off-set the costs of the annual costs of ventilating a building (Wargocki *et al*., 2007).

BARRIERS TO BLINDS AND SHUTTERS

Part L of the building regulations addresses solar gains by saying that non-domestic buildings must either limit solar and internal heat gains or otherwise show that they will not over heat. This is addressed by providing evidence that total internal gains will not be more than 35 W per m² on peak summer days or they can show that the building will not exceed a threshold (that are dependent on building activities) for more than a number of hours each year, which only supports the use of solar shading by ensuring that naturally ventilated buildings do not over heat in summer. Compliance via SBEM fails to identify the full extent of energy savings that can be made with use of blinds and shutters as the climate datasets are averaged (Seguro and Palmer, 2016). The National Building Specification also under-value blinds and shutters by classifying them as a general fixture/ fitting element (NBS, 2016). Coinciding with this, in the pre-design phase these savings are often neglected in building modelling packages as the vast majority of leading mainstream whole-building simulation packages do not conform to internationally recognised EN/ISO Standards, such as ISO 15099 (Seguro and Palmer, 2016).

Cost saving benefits of implementing shading are hard to predict due to the large variables within each building environment (including the type of blind, type and orientation of building, type of glazing, and location) and therefore has to be assessed on a case by case basis. A simulation study of an air-conditioned 1960's open-plan office in London showed that it required 55kWh/m² a year to operate the air-conditioning which accumulated to a running cost of roughly £15/m² year. An alternative measure could have been reached through the use of mid-plane or external blinds alongside the management of night time ventilation, a common passive design strategy. The study also showed how in offices where air-conditioning had already been fitted that the shading could pay for itself in under five years (Littlefair, 2002).

PRODUCTIVITY BENEFITS AND BLINDS AND SHUTTERS

The impact of shading is not limited to these cost saving and environmental energy saving benefits. An area that is somewhat overlooked is the impact they can have on an individual's performance (Seguro and Palmer, 2016). Blinds and shutters in commercial offices are generally installed to prevent glare issues and control daylighting to conform with BS EN12464-1 (BSI, 2011) and EN14501. Shading can also be used to improve other factors that impact on the productivity of staff.

Visual Comfort

Uncomfortable visual environments can have harmful effects on an individual's productivity and more importantly on an individual's health and wellbeing (Seguro and Palmer, 2016). The importance of this issue has become impossible to ignore when people now spend more than 90% of their time indoors (ES-SO, 2015). In recent years it has become a popular topic specifically within offices, schools and hospitals due to the changes in technology we use to perform work activities. Poor visual comfort is created by poor daylighting relating to a lack of contact with the outdoors, discomfort glare, and poor colour rendition (Ticleanu *et al*., 2015).

Daylight affects an individual's circadian rhythm and triggers positive emotional, cognitive and attitudinal responses. A study performed on office workers showed that workers who worked in close proximity to windows got an average of 46 minutes more sleep per night and overall a

better quality of sleep than other workers (Boubekri *et al.,* 2014). Occupant dissatisfaction of individuals' workstations has been associated with the lack of access to a window through a study carried out in 2008 of 779 workstations in 9 different buildings (WGBC, 2014). Work stress and dissatisfaction was quantified as being reduced if nurses were exposed to daylight for at least 3 hours a day (Alimoglu and Donmez, 2005). Several studies have also identified the healing effects of daylight which have been carried out by examining patients in healthcare facilities (Aries *et al*., 2013). Joarder and Price (2012) investigated 263 coronary artery bypass graft surgery patients and revealed that a patient's length of stay in hospital was reduced by 7.3hrs per 100 lux increase of daylight exposure. Provisions were made to exclude other environmental factors such as outdoor view and room status.

Daylight contributes to an association of access to the outside world although a view out can also have a psychological cost due to a lack of privacy (Boyce, 2014). Evidence has highlighted that individuals with scenic views will be more satisfied with their workplace irrespective of their access to daylight. A study cited by Boyce (2014) and Marwaee and Carter (2006) found that 65% of people working in spaces with windows were satisfied but only 45% of those working in windowless spaces were satisfied even though they had access to daylight delivered through a tubular guidance system. In addition, a study by Ulrich (1984) concludes that patients in a ward with a view of trees will recover quickly in comparison to those with a view of a brick wall. However, it has also been established by Boyce (2014) that the window view is more appreciated when the occupant's environment is small and has little possibility of leaving the space suggesting that worker's dissatisfaction can be associated with the lack of variety within the space. It is suggested that in office spaces where there are little visual stimuli the view out becomes a primary focus for environmental stimulation, where in larger work environments school classrooms (Larson, 1965) and factories the lack of windows has a variable impact.

Glare can cause eyestrain, headaches and postural problems. Each individuals experience differs considerably depending on their own personal sensitivities. Discomfort glare is the most common type of glare and is caused by an uneven distribution of luminance within the visual field (Ticleanu et al. 2015). BS EN12464-2011 (BSI, 2011) requires lighting to be considered at the work plane, walls, ceiling and vertical planes (Boyce, 2014). Ticleanu *et al* (2015) identifies

how discomfort glare can contribute to symptoms of eye irritation, dry or watery eyes, itchiness, tense muscles, blurred or double vision, headaches or fatigue and in turn such symptoms can lead to discomfort and stress.

Similarly, poor colour rendition can have detrimental effects upon stress levels and productivity (Seguro and Palmer, 2016). The colour rendition index is an indicator of the quality of light from electric sources in comparison to natural daylight ranging up to 100, with 100 considered ideal. This quality is defined by the ability of a light source to render an objects' colour accurately (Ticleanu *et al*., 2015). Within our buildings we place a filter between ourselves and the incoming daylight. Clear single and double glazing are associated with good quality colour rendering. Double glazing can achieve a CRI of 97% which is equal to double glazing with shading, where products such as 2-pane solar control glass are reduced to a CRI of 86% (ES-SO, 2015) which can negatively affect the quality of light. The preference for daylight as opposed to artificial lighting is proven in buildings (Seguro and Palmer, 2016). Due to the variability, intensity and thermal impacts which we will address shortly, excessive daylight can lead to serious health issues. For office buildings a level of 500lux is recommend (BSI, 2011). When daylight starts to cause either thermal or visual discomfort the requirement for daylight diminishes (Boyce, 2014).

Blinds and shutters are able to perform dynamically in relation to daylight exposure throughout the year, allowing for comfortable limits to be maintained (Seguro and Palmer, 2016). The selection of the type of blind is imperative when considering visual comfort and Visible Light Transmittance (Tvis) and Openness Coeffcient (Co) are the most important design parameters to consider when trying to enhance visual comfort with the use of fabric blinds. When lower openness coefficients are chosen, such as in the case of dim-out blinds, there is less visible light transmittance as this is an indicator of the number and size of holes within the fabric. When a higher openness coefficient is chosen more daylight is allowed to pass through but there is an increased risk of glare, this is commonly present in screen blinds (BBSA, 2015). BS EN14501:2005 (BSI, 2005) gives guidance on shading product classifications for opacity and glare control, which is of particular importance when computers or visual screens are used. The standard also gives classifications for visual contact to the outdoors, night privacy and daylight

utilisation. Fabric colour is also of equal importance as it can be used to control reflected light, by utilising daylight whilst reducing glare (Dalke *et al*., 2004). Lighter colours can increase the illumination of interiors but can cause increased surface brightness which can be equally problematic for visual comfort. Where darker colours combined with a higher openness coefficient (screen fabric) can provide adequate lighting control and are able to provide a view to the outside whilst the blinds are down (BBSA, 2015).

Thermal Comfort

An individual's thermal comfort is driven by the need to maintain a constant internal temperature of 37°C which is essential for our health and well-being. ASHRAE's generally accepted definition of thermal comfort describes this as "That state of mind which expresses satisfaction with the thermal environment" (Nicol *et al*., 2012, p.44) while CIBSE Guide A (2015) recommends that there are physical and personal factors that will lead to thermal comfort. The physical environmental factors are air temperature, Relative Humidity (RH), Mean Radiant Temperature (MRT) and relative air speed and personal factors include clothing levels and metabolic heat rate.

Air temperature is generally the most important environmental variable affecting thermal comfort (CIBSE, 2015). Changes in air temperature and MRT affect the way the body reacts and how occupants interpret thermal sensation is highlighted in ASHRAE 55:2010 and is defined as the operative temperature (Wargocki *et al*., 2007). Air temperature has a direct effect on an individual's performance of office tasks; the best temperature range is between 20°C – 24°C, with an optimum of 22°C (Seppänen *et al*., 2006). Heschong Mahone Group, Inc (2003) identified that the performance of call centre staff slowed by 2% when temperatures increased from 23°C to 24°C. High indoor temperatures also contribute to an increased risk of symptoms associated with Sick Building Syndrome (SBS) (Wargocki *et al*., 2007, Seppänen *et al*., 2006).

A study carried out by Fang *et al* (2004) who reviewed the effects air temperature and humidity on the perceived air quality, SBS and performance of office staff found that although performance was not significantly affected several symptoms of SBS were alleviated when occupants worked at the lower air temperature of 20°C and RH of 40%. The study resolved that

if the occupants in the study were subjected to longer exposure times there may have been a significant difference in work performance. Humidity is directly linked with air temperature. Within the UK humidity is of little concern; levels within the range of 40 – 70% are considered acceptable. (CIBSE, 2015).

Low air temperatures have an impact on manual tasks due to reduced dexterity of hands and sensitivity to air movements and draughts. Similarly, with high temperatures the perception of draughts is increased (Seguro and Palmer, 2016) alongside the sensation of dryness of the air (Wargocki *et al*., 2007). MRT encompasses the average temperature of all surfaces within an environment. It is a simplified method in order to understand the full radiant landscape which varies significantly across a room and would requires surface temperatures to be recorded for each surface within the view of each occupant. Within a furnished open-plan office this is excessive and impractical to consider (Nicol *et al*., 2012). The MRT can be influenced by a multitude of factors including lighting, glazing exposed to solar radiation, ventilation and electronic equipment dependant on its positioning within the room. Air temperature adjustments are recommended by CIBSE Guide A in the case of lighting, ventilation and electronic equipment and with the recommendation to install shading for solar radiation exposure to prevent local discomfort and to account for asymmetric radiant temperature differences (CIBSE, 2015). Asymmetric thermal radiation is found at the perimeter of a room which can be caused by local cooling, local heating and intrusion of short-wavelength radiation. This is cause for concern when seating occupants close to glazing as mechanical air-conditioning cannot address the issue of radiant thermal exchange (Seguro and Palmer, 2016).

The glazing area of a workspace can have a great impact on the thermal comfort of a room due to the consistently changing weather conditions we experience in the UK and the thermal properties of the window system (Seguro and Palmer, 2016). The weather affects the external temperature and solar radiation which in turn has an effect on the interior wall/glass surface temperatures and transmitted solar gains (Bessoudo *et al*., 2010). It is widely predicted that climate change will inflict more frequent and intense heatwaves (ZCH, 2015) with the potential to cause further discomfort to occupants positioned close to windows. This has been a prevalent feature within research from Cambridge University, where it has been reported that 90% of UK hospitals are

susceptible to overheating because of how they have been designed (Iddon, 2014). Although temperature can be controlled by installing a blind or shutter, as solar gains can be reduced from the window surface and the inner space, the positive effects of shading systems on the indoor environment are undervalued in colder climates where as they are widely recognised in warmer climates (Curcija *et al*., 2013, Seguro and Palmer, 2016, Taleb, 2014, Tzempelikos *et al.*, 2007).

Highlighting this study carried out by Bessoudo *et al* (2010) evidenced how blinds and shutters impact asymmetric thermal radiation. On a cold (<15°C) but sunny day the interior surface of low e glazing without shading reached 30°C, Radiant Temperature Asymmetry (RTA) exceeded 15°C and operative temperatures exceeded 25°C to a maximum of 31°C. When internal roller blinds were installed the blind and glazing reached a surface temperature of 41°C, yet the operative temperature during the working day remained within the comfort zone and the RTA stayed below 5°C. The alternative solution, other than installing solar shading is addressed by occupants opening windows or decreasing office air temperatures, which decreases thermal uniformity or costs energy, and sometimes is pre-planned by building managers by positioning desk space and occupants further away from windows. Although this is a costly expense to companies as it reduces the number of employees they can have in a given area.

The cooling effect of air movement is also well established and often welcomed through a variety of methods when occupants experience warm conditions (CIBSE, 2015). Radiation heat loss to a large cold surface, as in the case of glazing, can generate cool air movement that is often unwanted in winter. The cooling affect is often misinterpreted as a draught (Nicol *et al*., 2012). But an additional thermal barrier could prevent this.

Acoustic Comfort

Acoustic comfort of buildings is often forgotten during project planning and design when other aspects such as functionality, aesthetics (Seguro and Palmer, 2016) and utilisation of space come into play. It is a key contributor to work performance and well-being in the workplace GSAPBS, 2011). Acoustic comfort has been highlighted of importance to performance particularly within schools in a study carried out in London Primary Schools external noise was found to have a negative impact upon performance and this was greater within older children (Shield and Dockrell, 2008). Within the work environment noise is a leading contributor to employee

dissatisfaction a study carried out by GSA Public Building Service (2011) in America found this to be true in a pre and post design evaluation of seven federal buildings. In addition, a study carried out in the UK looked at office layouts and occupant satisfaction and found that when an office had been transformed from a cellular office space to an open-plan office space in order to increase occupancy. Noise levels were highlighted as a leading contributor to occupant dissatisfaction (Bunn and Marjanovic-Halburd, 2016).

Acoustic comfort can be achieved by controlling the external noises commonly produced from traffic, motorways, rail and air traffic, and from high-reverberation times within the office which is due to sound reflecting of surfaces. Glazing units and other light weight building components have low sound insulation factors, which allows for sound propagation due to the material properties of the glass, frame and installation (Seguro and Palmer, 2016). Through selecting appropriate shading fabrics, a reduction in noise can be achieved but further research is needed to identify the full potential different shading mechanisms can have when combined with different glazing systems.

Occupant Satisfaction

Psychological factors created by environments are also important to consider. In the WGBC (2014) report individual control over environmental constraints can increase satisfaction. For example, by providing personal control of light levels with an option to use dimmers satisfaction, mood, comfort, motivation and task performance can be improved. In terms of temperature a study carried out by Wyon (1996) showed how control over a 4°C range can increase logical thinking performance by 3% and typing performance by 7%. Acoustic control is still hard to control post design phase. But good acoustic control can be addressed by users and organisations in the planning stages by creating “quiet zones”. Within the GSA WorkPlace 20.20 program a survey of 50% of work staff said noise keeps them from being productive, yet 60% said they will often stop and talk to colleagues at work stations. Implementing protocols to make colleagues aware of noise issues are additional control methods that can be put in place (GSA Public Buildings Service, 2011).

The perception of controllability is vital to occupant satisfaction although a wave of new technologies has been produced that reduce their control. With the rise of “smart homes” and the pressure to improve energy savings it is important for designers of future innovations to embed the user at the centre of the design process. Blinds and shutters have addressed this through the integration of motorised systems. A study carried out by Paule *et al* (2015) shows that motorised systems encourage users to open and close blinds at the touch of a button. Within automation systems, improved algorithms have been calculated involving sun/shade modelling that communicate with exterior and/or internal lighting and temperature sensors to instigate the opening and closing mechanism. In order to satisfy a large number of users and room types (for example, office spaces and meeting rooms that have very different requirements) raises new challenges for the industry. Maintenance and tweaking of control systems after installation is now essential to ensure that the systems in place are working to the benefit of users and do not cause interference that could lead to system overrides that could lead to energy saving opportunities being wasted. Examples include users leaving blinds closed and turning electric lighting on, potentially wasting thermal gains and daylighting opportunities. Several methods have been produced to ensure their effectiveness through implementing strategies such as movement of blinds occurring during work breaks, systems where occupants can override the systems for a set period of time (Littlefair *et al.*, 2006) and graduation of blind opening and closing.

A simulation study which evaluated the energy saving potential of automatic systems reflected how an air-conditioned building in London could save an additional 3% in CO_2 when automatic blind control was implemented. These savings accumulated to 9% with automatic internal blinds and 8% with external blinds. Within the same study a comparison was made with an office located in Scotland where automated external shading caused an energy penalty of between 3% and 9%. Yet internal automated shading still provided a benefit of reducing CO_2 emissions by 2% compared to no shading or manual controls. This highlights how situation and longitudinal location is still important to consider when considering control mechanisms (Littlefair *et al*., 2006).

Throughout the industry it is recognised that the utmost has to be done to ensure satisfaction of users with their living and working environment. Predicted Mean Vote (PMV) is a calculation methodology that can be applied during the design phase and is the basis for a majority of thermal comfort measures in the UK and has been introduced through EN ISO 7730:2005 based on (Fanger *et al*., 1988) as cited by Nicol *et al* (2012). It combines the physical and personal factors in relation to a subjective vote, Ashrae's Thermal Sensation Scale, which was carried out in laboratory, steady-state conditions. It is used to identify the Predicted Percentage Dissatisfied (PPD), the percentage of people who likely to feel too hot or too cold among a group of people assuming their activity (metabolic rate) and clothing level is the same (CIBSE, 2015). The criteria for an excellent PPD index is ≤ 6% within EN 15251:2007, IS0 7730:2005 and ASHRAE Standard 55 (Wargocki *et al*., 2007).

Obtaining complete satisfaction of all users is unrealistic due to the number of variables within the built environment when considering people. The environmental constraints alone are confounded by variables which are hugely influenced by an individual's physiology, how they themselves produce heat or how they interpret light depending on their health, age, or gender. Secondly their psychophysics would need to be considered; how their brain regulates the body to cope with the surrounding environmental factors. Thirdly, the physics between the environment and each occupant, for example air moisture or wind chill amongst many other environmental factors are too broad to measure independently, reliably or accurately. Finally, the behaviours of the occupant which are dependent on what clothes they choose to wear, how they use and feel about available controls and what posture and activity they impose on themselves and the environment. It is also worth mentioning that there are a large number of psychological constraints, in particular what an individual expects from an environment and in turn how they adapt to it (Nicol *et al*., 2012).

TESTING PRODUCTIVITY

Productivity is very difficult to test and is often defined in terms of elements that are indicators of productivity. The WGBC (2014) highlights how absenteeism and staff turnover are indicators

of productivity; however, this can only really represent the productivity lost because someone is not at work. Rather than associating it with a poor work environment (Sullivan *et al*., 2013).

A meta-analysis of studies that analyse the effect of temperature on task performance conducted by Seppänen *et al* (2006) found 24 studies that used a variety of objective indicators of performance (excluding industrial work performance studies). There were two main categories, namely those that are carried out in the field, and those that are conducted in laboratories. It is assumed that field studies have more weighting as they give a reference of performance relating to real work. This is also supported by CIBSE (2015) as field studies have more relevance to normal living conditions. Call centres are ideal scenarios to test the impact of an environmental constraint as organisations often record an objective value of productivity through the number of calls taken, time required to talk with customers and processing time between calls (Seppänen et al. 2006).

Another strategy is to combine laboratory and field study methods. The Heschong Mahone Group, Inc, (2003) utilised the existing work environment but used a performance test battery as the objective measure that was able to gauge aspects of work performance. Lan *et al* (2011) and Wargocki *et al* (1999) have carried out performance test batteries previously within laboratory settings. The tests given have associations with work performance as they rely on cognitive functions (Sullivan *et al*., 2013). Cognitive performance test batteries include replication of office tasks; typing, mental arithmetic (Miyake *et al*., 2000, Wargocki *et al*., 1999, Lan et al., 2011), short term memory, long term memory (Heschong Mahone Group, Inc, 2003, Lan *et al*., 2011), problem solving and speed of information processing (Lan *et al*., 2011, Wargocki *et al*., 1999). One of the issues with this form of testing is practicality as the testing battery process is time consuming when combined with subjective surveys (Sullivan *et al*., 2013).

Subjective surveys are a well-known method in assessing psychometric measures which include mood (Lan *et al*., 2011, Terry *et al*., 2003), fatigue (Tanabe and Nishihara, 2004), mental workload (Lan *et al*., 2011), job satisfaction, job engagement and intention to quit (Sullivan *et al*., 2013). These give another indication into whether well-being and productivity are affected by environmental constraints. These factors are important to identify as there are many other

variables that could affect a person's subjective choice that are unrelated to the environment. Subjective questionnaires in relation to the environment are used to ask occupants to assess what they perceive the environmental impacts to be. The areas that are assessed are thermal, visual, acoustic, controllability, indoor air quality and satisfaction of the workplace (WGBC, 2014). This type of survey is used in Post Occupancy Evaluations and is vital to correlating dissatisfaction with the work environment with an objective performance measure and subjective psychometric measures to produce a triangulated dataset of results which is considered to provide corroborative evidence.

CONCLUSION

This paper clearly shows the energy saving benefits that blinds and shutters can make in the building environment. In conjunction with this it has been highlighted how the associated effects of blinds and shutters can contribute to improving the Indoor Environment Quality (IEQ). This correlates to a substantial body of evidence that relates improvements with the IEQ to improved health, well-being and productivity of staff. The productivity benefit has been quantified as a cost and energy saving measure in commercial organisations and has been represented as a valued driver to commercial companies to retrofit or design specifically "green" environments.

It is apparent that providing evidence for this is difficult due to the large range of blinds and shutters available, because they have very different characteristics; alongside this the built environment is well known for its complex variables that all need to be recorded and monitored and then compared against the complexity of producing justifiable evidence for productivity. There are a number of barriers to this research including optimising research to include thermal, visual and acoustic characteristics of blind and shutter systems, in depth behavioural studies of the use of blind and shutters with different control systems and further validation of the relationship between productivity and the built environment. However, the authors will endeavour to overcome some of these barriers in order to further assess the impact of blinds and shutters on productivity.

REFERENCES

Alimoglu, M.K. and Donmez, L. (2005) 'Daylight exposure and the other predictors of burnout among nurses in a university hospital', *International Journal of Nursing Studies*, 42(5), pp. 549–555. doi: 10.1016/j.ijnurstu.2004.09.001.

Aries, M., Aarts, M. and van Hoof, J. (2013) 'Daylight and health: A review of the evidence and consequences for the built environment', *Lighting Research and Technology*, 47(1), pp. 6–27. doi: 10.1177/1477153513509258.

Armitage, P., Godoy-Shimizu, D. and Palmer, J. (2015) *The Cambridge non domestic energy model the Cambridge non- domestic energy model domestic energy model*. Available at: http://www.carltd.com/sites/carwebsite/files/CNDM%20Report%20260215.pdf (Accessed: 15 May 2016).

Atanasiu, B., Despret, C., Economidou, M., Maio, J., Nolte, I., Contributions, O.R., Laustsen, J., Ruyssevelt, P., Staniaszek, D., Strong, D. and Zinetti, S. (2013) *EUROPE'S BUILDINGS UNDER THE MICROSCOPE A country-by-country review of the energy performance of buildings*. Available at: http://bpie.eu/wp-content/uploads/2015/10/HR_EU_B_under_microscope_study.pdf (Accessed: 17 May 2016).

Bessoudo, M., Tzempelikos, A., Athienitis, A.K. and Zmeureanu, R. (2010) 'Indoor thermal environmental conditions near glazed facades with shading devices – part I: Experiments and building thermal model', *Building and Environment*, 45(11), pp. 2506–2516. doi: 10.1016/j.buildenv.2010.05.013.

Boubekri, M., Cheung, I.N., Reid, K.J., Wang, C.-H. and Zee, P.C. (2014) 'Impact of windows and daylight exposure on overall health and sleep quality of office workers: A case-control pilot study', *Journal of Clinical Sleep Medicine*, doi: 10.5664/jcsm.3780.

Boyce, P.R. (2014) *Human factors in lighting, Third edition*. United States: CRC Press.

BBSA (British Blinds and Shutters Association) (2015) *Guide to Low Energy Shading*. Issue 2 edn. United Kingdom: BBSA.

BSI (2005) *Blinds and shutters - Thermal and visual comfort - Performance characteristics and classification. BS EN12464-1:2005*.

BSI (2011) *Light and Lighting: Lighting of work places. Indoor work places. BS EN12464-1:2011*. London: BSI.

Bunn, R. and Marjanovic-Halburd, L. (2016) 'Occupant satisfaction singatures: Longitudinal studies of changing comfort perceptions in two non-domestic buildings', CIBSE Technical Symposium: CIBSE. Available at: http://www.cibse.org/knowledge/cibse-technical-symposium-2016/occupant-satisfaction-singatures-longitudinal-stud (Accessed: 18 May 2016).

CIBSE (2015) *CIBSE Guide A: Environmental design*. 8th edn. CIBSE.

Committee on Climate Change (2015) *Meeting Carbon Budgets - Progress in Reducing the UK's emissions - 2015 Report to Parliament*. Available at: https://documents.theccc.org.uk/wp-content/uploads/2015/06/6.737_CCC-BOOK_WEB_030715_RFS.pdf (Accessed: 30 April 2016).

Curcija, C.D., Yazdanian, M., Kohler, C., Hart, R., Mitchell, R. and Vidanovic, S. (2013) *Energy savings from window attachments*. Available at: http://energy.gov/sites/prod/files/2013/11/f5/energy_savings_from_windows_attachments.pdf (Accessed: 18 May 2016).

Dalke, H., Littlefair, P., Loe, D. and Camgöz, N. (2004) *Lighting and colour for hospital design*. Available at: http://www.wales.nhs.uk/sites3/Documents/254/B(01)02%20Lighting%20and%20colour.pdf (Accessed: 18 May 2016).

Dubois, M. - C. (2011) *Solar shading for low energy use and daylight quality in offices. Report No TABK--01/1023*. Lund University.

EA (2016) *LIT 10094 complying with the energy savings opportunity scheme*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/509835/LIT_10094.pdf (Accessed: 18 May 2016).

ES-SO (2015) *A NEW VISION ON SOLAR SHADING*. Available at: http://www.verozo.be/sites/verozo/files/files/Brochure_SolarShading_screen_LR.pdf (Accessed: 17 May 2016).

Fang, L., Wyon, D.P., Clausen, G. and Fanger, P.O. (2004) 'Impact of indoor air temperature and humidity in an office on perceived air quality, SBS symptoms and performance', *Indoor Air*, 14(s7), pp. 74–81. doi: 10.1111/j.1600-0668.2004.00276.x.

Fanger, P.O., Melikov, A.K., Hanzawa, H. and Ring, J. (1988) 'Air turbulence and sensation of draught', *Energy and Buildings*, 12(1), pp. 21–39. doi: 10.1016/0378-7788(88)90053-9.

GSAPBS (2011) *Sound matters*. General Services Administration Public Building Service, Available at: http://www.gsa.gov/portal/mediaId/172515/fileName/GSA_Sound_Matters_(Dec_2011)_508 (Accessed: 18 May 2016).

Heschong Mahone Group, Inc (2003) *Windows and offices: A study of office worker performance and the indoor environment*. Available at: http://h-m-g.com/downloads/Daylighting/A-9_Windows_Offices_2.6.10.pdf (Accessed: 19 April 2016).

Iddon, C. (2014) *Climate change, hospitals and patient well-being*. Available at: http://www.secontrols.com/news/item/climate-change-hospitals-and-patient-well-being/ (Accessed: 17 May 2016).

IEA (2013a) *Technology Roadmap energy efficient building envelopes*. Available at: https://www.iea.org/publications/freepublications/publication/TechnologyRoadmapEnergyEfficientBuildingEnvelopes.pdf (Accessed: 17 May 2016).

IEA (2013b) *Transition to sustainable buildings - strategies and opportunities to 2050*. Available at: http://www.iea.org/publications/freepublications/publication/Building2013_free.pdf (Accessed: 30 April 2016).

Joarder, A. and Price, A. (2012) 'Impact of daylight illumination on reducing patient length of stay in hospital after coronary artery bypass graft surgery', *Lighting Research and Technology*, 45(4), pp. 435–449. doi: 10.1177/1477153512455940.

Lan, L., Wargocki, P., Wyon, D.P. and Lian, Z. (2011) 'Effects of thermal discomfort in an office on perceived air quality, SBS symptoms, physiological responses, and human performance', *Indoor Air*, 21(5), pp. 376–390. doi: 10.1111/j.1600-0668.2011.00714.x.

Larson, T.C. (1965) *The Effect of Windowless Classrooms on Elementary School Children*. Available at: http://files.eric.ed.gov/fulltext/ED014847.pdf (Accessed: 19 May 2016).

Littlefair, P. (2002) *Retrofitting solar shading*. United Kingdom: IHS BRE Press.

Littlefair, P., Ortiz, J. and Das Bhaumik, C. (2006) *THE ENERGY EFFECTS OF CONTROLLING SOLAR SHADING*. Available at: https://www.somfysystems.com/file.cfm/Controlling-Solar-Shading.pdf?contentID=278064 (Accessed: 18 May 2016).

Marwaee, M.A. and Carter, D.J. (2006) 'A field study of tubular daylight guidance installations', *Lighting Research and Technology*, 38(3), pp. 241–258. doi: 10.1191/1365782806lrt170oa.

Miyake, A., Friedman, N.P., Emerson, M.J., Witzki, A.H., Howerter, A. and Wager, T.D. (2000) 'The unity and diversity of executive functions and their contributions to complex "Frontal Lobe" tasks: A latent variable analysis', *Cognitive Psychology*, 41(1), pp. 49–100. doi: 10.1006/cogp.1999.0734.

NBS (2016) *Fixtures and fittings, or FF & E*. Available at: https://www.thenbs.com/knowledge/fixtures-and-fittings-or-ff-e (Accessed: 7 March 2016).

Nicol, F., Nicol, F., Humphreys, M. and Roaf, S. (2012) *Adaptive thermal comfort: Principles and practice*. New York, NY: Taylor & Francis.

Paule, B., Boutillier, J. and Pantet, samuel (2015) *Global Lighting Performance*. Available at: http://static.wm3.se/sites/45/media/29281_ESTIA_Study_English_ver_3_0.pdf?1426675541 (Accessed: 18 May 2016).

Publications Office (2010) *Directive 2010/31/EU of the European parliament and of the council of 19 may 2010 on the energy performance of buildings*. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF (Accessed: 17 May 2016).

Seguro, F. and Palmer, J. (2016) *Solar Shading Impact Report*. National Energy Foundation.

Seppänen, O., Fisk, W.J. and Lei, Q. (2006) *Effect of temperature on task performance in office environment*. Available at: https://indoor.lbl.gov/sites/all/files/lbnl-60946.pdf (Accessed: 7 March 2016).

Shield, B.M. and Dockrell, J.E. (2008) 'The effects of environmental and classroom noise on the academic attainments of primary school children', *The Journal of the Acoustical Society of America*, 123(1), p. 133. doi: 10.1121/1.2812596.

Sullivan, J., Baird, G. and Donn, M. (2013) *Measuring Productivity in the Office Workplace*. New Zealand: Centre for Building Performance Research.

Taleb, H.M. (2014) ‘Using passive cooling strategies to improve thermal performance and reduce energy consumption of residential buildings in U.A.E. Buildings’, *Frontiers of Architectural Research*, 3(2), pp. 154–165. doi: 10.1016/j.foar.2014.01.002.

Tanabe, S. and Nishihara, N. (2004) ‘Productivity and fatigue’, *Indoor Air*, 14(s7), pp. 126–133. doi: 10.1111/j.1600-0668.2004.00281.x.

Terry, P.C., Lane, A.M. and Fogarty, G.J. (2003) ‘Construct validity of the profile of mood states — adolescents for use with adults’, *Psychology of Sport and Exercise*, 4(2), pp. 125–139. doi: 10.1016/s1469-0292(01)00035-8.

Ticleanu, C., King, S. and Howlett, G. (2015) *Lighting and health*. United Kingdom: IHS BRE Press.

Tzempelikos, A., Bessoudo, M., Athienitis, A. and Zmeureanu, R. (2007) *The impact of shading on thermal comfort conditions in perimeter zones with glass facades*. Available at: http://www.inive.org/members_area/medias/pdf/Inive%5CPalencAIVC2007%5CVolume2%5CPalencAIVC2007_V2_096.pdf (Accessed: 18 May 2016).

Ulrich, R.S. (1984) *View through a window may influence recovery from surgery*. Available at: https://mdc.mo.gov/sites/default/files/resources/2012/10/ulrich.pdf (Accessed: 18 May 2016).

Wargocki, P., Andersson, J., Boerstra, A., Clements-Croome, D. and Olaf Hanssen, S. (2007) *Indoor climate and Productivity in Offices How to integrate productivity in life-cycle cost analysis of building services: Guidebook No 6*. Edited by Pawel Wargocki and Olli Seppänen. Second edn. Finland: REHVA.

WGBC (2013) *THE BUSINESS CASE FOR GREEN BUILDING A review of the costs and benefits for developers, investors and occupants THE BUSINESS BENEFITS*. Available at: http://www.worldgbc.org/files/1513/6608/0674/Business_Case_For_Green_Building_Report_WEB_2013-04-11.pdf (Accessed: 18 May 2016).

WGBC (2014) *Health, wellbeing & productivity in offices*. Available at: http://www.worldgbc.org/files/6314/1152/0821/WorldGBC__Health_Wellbeing__productivity_Full_Report.pdf (Accessed: 17 May 2016).

Wyon, D. (1996) ‘Indoor environmental effects on productivity.’, Atlanta, Procceeding of IAQ ’96 ‘ Paths to Better Building Performance’: ASHRAE. pp. 5–15.

ZCH (2014) *ZERO CARBON HOMES AND NEARLY ZERO ENERGY BUILDINGS*. Available at: http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCHomes_Nearly_Zero_Energy_Buildings.pdf (Accessed: 17 May 2016).

ZCH (Zero Carbon Hub) (2015) *Overheating In Homes - The Big Picture*. Available at: http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingInHomes-TheBigPicture-01.1.pdf (Accessed: 17 May 2016).

Zhang, H., Arens, E., Fard, S.A., Huizenga, C., Paliaga, G., Brager, G. and Zagreus, L. (2007) ‘Air movement preferences observed in office buildings’, *International Journal of Biometeorology*, 51(5), pp. 349–360. doi: 10.1007/s00484-006-0079-y.

THE PROSPECTS OF PUBLIC PRIVATE PARTNERSHIP IN CREATING OIL REFINERIES IN NIGERIA

Kehinde Bamdupe and Peter McDermott

The scarcity of petroleum products in Nigeria has spurred the need for oil refineries within Nigeria. At the moment Nigeria is has four refineries with a capacity of 445,000 barrel per stream day (BPSD). However, only one refinery is working at the moment producing less than 150,000 BPSD. Petroleum products in Nigeria are mostly imported and the country's capacity to produce more products is currently limited due to the inefficient refineries. There is a great need for new refineries in Nigeria at the moment. Considering the cost of procuring new refineries, the government has decided to issue sixty five (65) licences to private investors for refinery construction. These refineries will be modular and mini refineries which can refine crude oil at a faster rate. The challenge most of these private investors may face will be finance. Financing refinery construction is a herculean task for most private investors in Nigeria considering the prevailing economic challenges. This paper has addressed the prospect of implementing PPP for private refinery procurement. Literature review and case study strategy was used for this data collection and analysis. The case study involved five interviews in two oil and gas companies. The findings revealed collaboration, affordability, bureaucratic delays, corruption with the government, environmental impact, creation of enabling environment, negative attitude towards PPP and technology are the major barriers towards PPP implementation for refinery creation in Nigeria.

Keywords: Government, Nigeria, Oil refineries, Refinery, Public private partnership.

INTRODUCTION

The paradox that exists in Nigeria whereby an oil rich nation lacks necessary public infrastructure and a net importer of petroleum products led the government to undergo an initiative in 2002 by the granting of preliminary licenses to 18 investors for the sole purpose of constructing a refinery (Okafor, 2007). This move was seen as a scheme to involve and expand private domestic investments within the downstream sector, Obi (2010) thus addressing the shortfall of locally demanded products. Oduniyi (2006) explained that in January 2006, a partnership between the government in Nigeria and five major oil companies within Nigeria was announced by the head of NNPC to construct refineries within Nigeria to a cumulative capacity of 1,000,000 BPD. As at 2010, this partnership was void of results (Obi, 2010).

Of the 18 preliminary licenses issued in 2002, only a few investors fulfilled the least conditions of the guidelines and the failures of others was tagged to finance as their major hindrance as well as lack of awareness, interests and power play (Okafor, 2007). With the price of an average to a large refinery ranging from $200 million to $1.5 billion (Obi, 2010), most banks within Nigeria could not intervene as their total financial structure is lower than $100 million (Kupolukun, 2005). Some salient issues have to be considered in the oil and gas industry some of which are the factors which may affect the development of new refineries in Nigeria. This has therefore prompted expanded inclusion of the private sector in the procurement of public infrastructure, utilising different types of Public Private Partnerships.

FORMS OF PPP

Grimsey and Lewis (2005) indicate that PPP projects are long term contracts where the government retains ultimate responsibility. The evolution of PPP forms is with the end goal of attaining more proficient, high quality and creative service delivery in an evolving industry Alternatively, De Bettignies and Ross (2009) argues that incomplete contracts of PPP projects might have accounted for the changes due to project complexity, vulnerability and unpredictability, coupled with the long term of the partnership and a wide range of risks that might affect the partnership, consequently the need for consistent revision and re-negotiations (Yin, 2014). There are various PPP models described by joint working and risk sharing between the public sector and the private sector (Treasury, 2012). As at 2008, the UK government endorsed eight models of PPP for public services and infrastructure procurement (Li and Akintoye, 2008). They include: Joint Ventures; Partnership Investments; Policy Partnerships; Sales of Business (by flotation or trade sale); Partnership Companies; Asset Sales; Private Finance Initiatives; and Wider Markets.

Table 1-PPP forms and their definitions

S/N	PPP Forms	Definition
1	Private Finance Initiative	The public sector contracts which are meant to procure quality services, with well-defined goals, on a long term basis from the private sector, inclusive of maintaining and constructing the necessary infrastructure. The term also encompasses financially free standing projects, where the private sector supplies, designs, builds, finances and then operates an asset.
2	Joint Venture	Partnership whereby the public and private sector pool their assets, finance and expertise under joint venture management to ensure the realisation of a long term growth in value for both partners.
3	Partnership Investment	Partnership whereby the public sector contributes to the funding of investment projects by the private sector thereby ensuring the public sector shares in the returns generated from such investment.

(Source: Li and Akintoye, 2008)

Sharma and Bindal (2014) and Zhang (2014) indicate that the different models of PPP contrast in their designation of risks, obligations, duration and in the assigning of asset ownership. Table 1 shows the 3 forms of PPP from the 8 recognised forms of PPP which are most relevant to Oil Refineries Projects in the Nigerian context and this paper. Private Finance Initiatives (PFI) seem to be the most attractive option for private investment for new developments (Li and Akintoye, 2008). According to Li and Akintoye (2008), Asset sales, partnership companies and Sales of business (by flotation or trade sale) are directly related to the sale or relinquishing of (part) public assets. These could be achieved either through sales of shares whereby the private individual or company has a major or minor stake in the asset or a direct sale of the asset. Furthermore, wider markets involve the private sector to improve a particular government asset.

These indicate the availability of assets and the need to improve efficiency of the same assets hence differs from the focus of this paper.

THE NEED FOR REFINERY PROCUREMENT IN NIGERIA

Li and Akintoye (2008) indicate that governments have looked to expand the inclusion of the private sector in the delivery of public infrastructures. Governments' readiness to reduce borrowing and spending, and in addition, the mindfulness that the private sector can supply infrastructure and services at a lower cost and in a more effective manner, have brought about the various forms of Public Private Partnership (RajaaAlasad and Ogunlana, 2011). PPP's are generally implemented to minimise budgetary stipulations and to encourage effectiveness and quality in the procurement of public infrastructure in order to achieve social welfare PPP's can be characterised as co-operation between the public sector and the private sector with a sturdy character in which the involved parties create mutual products and services and in which benefits, expenses and profits are shared (Klijn and Teisman, 2003). Skelcher (2010) describes PPP as instruments of the public interest that actively utilise the availability and willingness of the private sector and investors to participate. Furthermore, Rossi and Civitillo (2014) explain that PPP's combine the resources of governments with that of the private sector to deliver services.

Lately, the endeavour to adopt a PPP form of procurement has failed in Nigeria because of the absence of recognition of PPP principles amongst the majority of participating stakeholders (Oyedele, 2012). This can be linked to the currently unsuccessful implementation of the PPP initiative stipulated by the Nigerian government for oil refineries projects.

In Nigeria, there is a huge number and contradictory set of laws controlling PPP (Nwangwu 2012). This is further complicated by a group of competing agencies attempting to manage the same transaction prompting regular clashes between these agencies (ibid). According to the NNPC (2010), the four refineries in Nigeria have a combined maximum refining capacity of 445,00 Barrels Per Day. Sule (2004) and NNPC (2010) both indicate that these refineries function at 23% of their production capacity. The Nigerian citizenries' present demand for refined petroleum is estimated as 270,000 barrels of oil per day (Mordi, 2014). At a 23% rate of average output for refined petroleum, the average output is 102,000 Barrels Per Day. This

exposes a shortfall of refined petroleum which in turn has necessitated the need to refine crude oil outside Nigeria to meet domestic demand. Furthermore, in the month of January 2014, 345,000 Metric Tonnes of dry crude oil, condensate and slop was received by three of these refineries with an opening stock of 297,000MT, thus the total crude oil reserves available for immediate processing was 642,000MT (NNPC 2014). The 69,000MT was processed and this occurred only at Kaduna Refining and Petrochemical Company Limited which produced 507,000 barrels of oil for the month of January 2014 (NNPC, 2014). This exposes a 50% shortfall in supply thus indicating a serious threat to the domestic supply of refined petroleum to the Nigerian populace, hence the need for additional refineries in Nigeria.

Okafor (2007) relates the issues affecting the petroleum industry in Nigeria as being similar with that affecting the electricity supply sector in Nigeria. Failures in the electricity supply sector are blamed on the ineptitude and poor responsibility of the public sector in overseeing enterprises and a weak technological base. Okafor (2007) stated that the four refineries in Nigeria are in a state of disrepair despite the significant investments in maintenance contracts.

Based on this data, it is clear that for a prolonged period into the future, Nigeria will need to import a substantial amount of its Premium Motor Spirit (PMS) needs (Hart, 2006). This emanates as a result of the predicted increases in the domestic demand for PMS that surpasses even the full operational capacity of domestic yields from the current oil refineries.

Obi (2010) highlights that the governments divestment from the oil and gas sectors in Nigeria between 2000 to 2002 saw a removal of oil subsidy from petroleum products and the announcement of plans for the privatisation of the Nigeria National Petroleum Commission's (NNPC) marketing arm and the Pipelines and Products Marketing Company (PPMC). This resulted in an invitation for bids from investors to establish private refineries in Nigeria. Okafor (2007) stated that only five of these preliminary investors successfully completed the first stages of the bid which involved achieving a technical solution presentation deadline, inclusive of fully detailed engineering drawings, procurement and construction plans. The absence of any noticeable progress on the award of the 18 licenses issued by Government for private refineries in 2002 led to the establishment of Greenfield Refinery Projects Division (NNPC, 2010). The Government in Nigeria has also expressed its interest to partner with new, old, local and foreign investors to achieve a viable, workable route to achieving a world class refinery provision within Nigeria. This in turn would create competition in the downstream sector by encouraging the

involvement of more companies whereby supply to the market would be at competitive prices. It would also reduce the annual cost of subsidising the oil and gas sector which is currently $1.5 billion, enabling funds to be freed for other socio-economic needs of the Nigerian citizenry (Mordi, 2014). suggested that the skills required amongst civil servants to enhance productivity in the different sectors of the Nigerian economy is lacking. A Public Private Partnership incentive was advised to reduce the skills gap rate of Nigeria's current IT implementations in government which was predicted to increase beyond a 15 year deficit. The PPP oil refinery project is seen as a fundamental part of addressing the specific government skills gap, (including IT) that will enhance the effectiveness and efficiency of managing the oil and gas sector.

PROCUREMENT OF OIL REFINERY

A project is a unique undertaking for basically a solitary reason which is characterised by scope, quality, time and cost objectives (Ahuja et al., 1994). Consequently, a construction project is characteristically a capital venture which subsequently requires a well-defined start and end point (ibid). For a some years, the partnering rationale has been a significant vehicle in the global effort of making noteworthy enhancements in the construction industry (Brown et al., 2001). Hoppe *et al* (2013) mentioned that an important feature of PPP's is that the tasks of building and maintaining an infrastructure is packaged and assigned to a solitary private contractor. In the same vein as argued by Bennett and Iossa (2006), when the same contractor is in charge of development and operation of a public infrastructure, there exists the inclination to invest more during the construction phase so as to lessen the expenses acquired in the consequent operating phase.

A refinery is a substantial industrial complex, with broad piping to transport distinctive liquids between extensive reactor units Speight (2014) thus enabling the transformation of crude oil feedstock to saleable products (Speight, 2014). Refineries change crude oil into petroleum products basically through a refining process that divides crude oil into various fractions focused around boiling point ranges (Walls, 2010).The choice to embrace another process or assemble a greater amount of existing units in a refinery must be taken in foresight of market requirements and patterns (Plummer, 1973). The complexity, throughput, and location as suggested by(Fahim et al., 2009) decides the capital investment for a new refinery. Hence, the complexity of an oil refinery is dependent on the type of crude oil processed therein and the type of manufactured

products (Speight, 2014). The demand for refined products by the market (local and international) has an exact quality and variety expectation (Plummer, 1973). Speight (2014) suggests that the relative complexity of a refinery is dictated by the number and nature of the process units. Most refineries operate on a regular basis which makes process optimization and process control a necessity. According to, there are two types of costs that can be linked with a refinery. The capital cost and the operating cost. The operating cost of a refinery is also divided into variable cost and fixed cost

It is claimed by Favennec (2001) that the amount of capital invested in exploration and production of crude oil is dependent on the future oil price. Refining comes in as the third most costly segment of the oil and gas sector explaining the need for a change of investment prospects.

Apart from the complexity, throughput and location of a refinery, the capital cost of a refinery is also dependent on the long time required for preliminary and feasibility studies, acquiring the essential licenses (environmental and any other), designing the structures with the commissioning of the same(Fahim, *et al*. 2009).. The capital costs could be broken down into process units; utilities; security and environmental facilities; storage and handling facilities; civil works, buildings and other infrastructure. The level of investment and capital that has gone into the oil sector globally between 1970 and 1996 exceeds $100billion. Furthermore, OPEC'S on-going efforts to bolster market stability by supplying required products to consumers have resulted in the siting of new refineries globally; notably in Saudi Arabia (Saudi Aramaco). A cumulative investment required for to meet on-going plans for the realisation of these projects till 2018 is estimated at $60billion (OPEC, 2014).

Profession	Code	Job Role	Years of experience	Highest Qualification	Project type
CASE A					Industrial installation
Civil Engineer	CV1	Managing Director	31	MSc	
Civil Engineer	CV2	General Manager	28	BSc	Procurement/ Civil Engineering
Petroleum Engineer	PE1	Managing Director	25	MSc	Services/Building construction
CASE B					
Civil Engineer	CV3	Chairman	26	HND	Procurement/ Civil Engineering
Civil Engineer	CV4	General Manger	21	MSc	Procurement/ Civil Engineering

Table 1: An example of setting out a table with column headings

Refineries are capital intensive, long-lived and highly specific assets which require large initial investments whereby the choice to invest in capacity is complex and depends primarily on expectations of return on investment exposing such investments to financial risks (Gary, 2007).The oil industry is a huge capital intensive corporation and has most of this investment spent on the upstream sectors (exploration and production) (Favennec, 2001). A cost that changes with production yield can be termed as a variable cost. Variable costs are those expenses that differ relying upon an organization's generation volume; they increase as production expands and fall as production reduces.

RESEARCH METHODOLOGY

The case study approach was adopted for the assessment of the prospects of PPP for refinery creation in Nigeria. The multiple case study approach was used to address inter and intra-case analysis of the public sector (government agency for oil and gas in Nigeria) and the private sector. The unit of analysis is termed “PPP for refinery procurement”. Five interviews were

conducted between the two cases out of a proposed fifteen interview session. The respondents were chosen based on purposive sampling. Therefore, interviewees have the right experience and belong to the oil and gas industry, both in the public and private sector. The interviewees have a minimum of twenty one years of experience. The case study interviews were transcribed with the aid of NVIVO software. The analysis was also carried out with the help of NVIVO software. The case study interviewee background has been highlighted in the table below. The years of experience of the interviewees ranged from twenty one to thirty one years. They are also oil and gas industry experts in the field of procurement, civil engineering, building construction and engineering services.

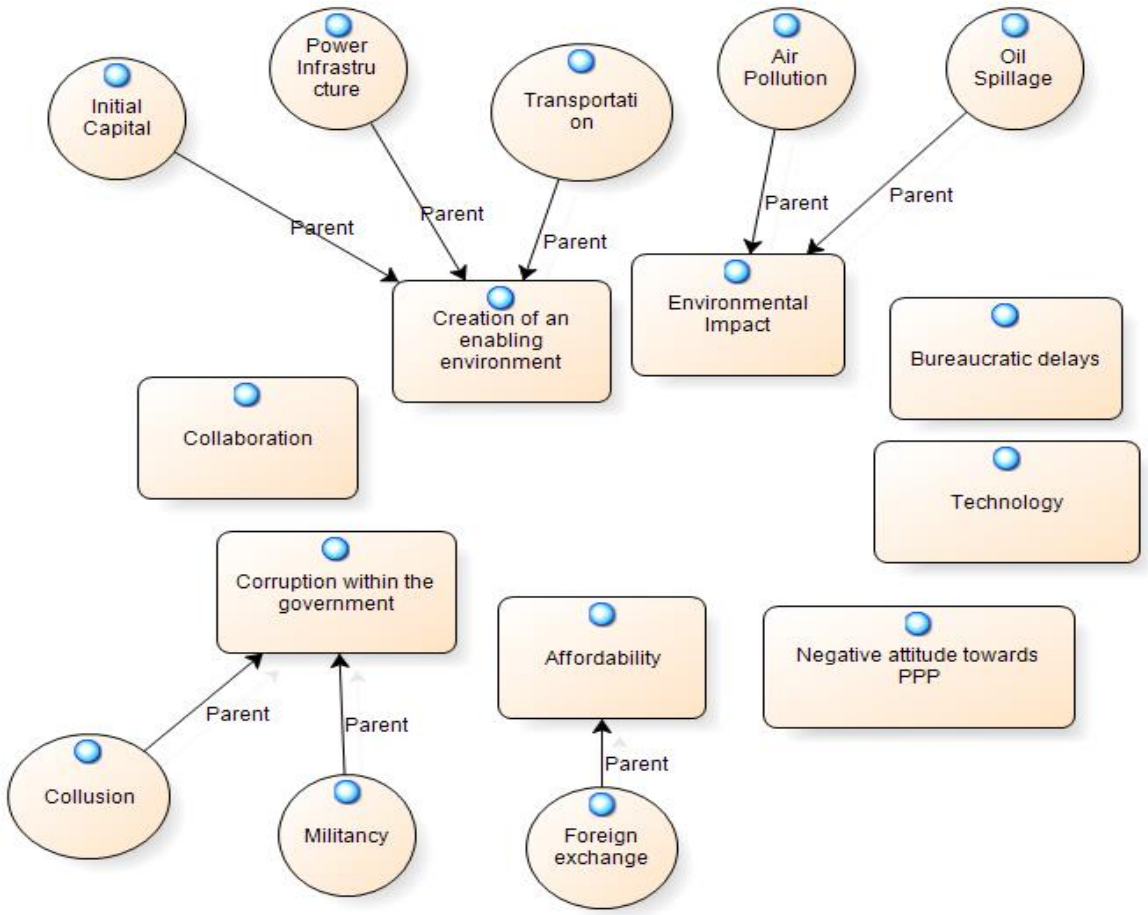
FINDINGS AND DISCUSSION

Based on the data from existing literature, web articles and case study interviews, the findings of the case study revealed the existential challenges PPP implementation may face. Some of the issues raised by the interviewees in the oil industry revealed eight (8) themes which may have a negative impact on PPP as a procurement strategy for refinery. Collaboration is a major challenge for refinery construction according to one of the respondents from a government agency. The term collaboration was used many times to describe public private partnership. Interviewee CV1 stated that *"Public private partnership is the collaboration between government and private investors with the aim of achieving a deal such that private organizations can provide certain services while the government is representing the public."* PE1 also addressed the concept of PPP as *"Public private partnership is collaboration between the state and government at different level in the state with the aim of achieving a deal such that private organizations can provide certain refineries while the government is representing the public."* Therefore, every level of government which maybe local, state or federal may be involved in public private partnership for developmental purposes. Collaboration is the most occurring word which the respondents used.

The affordability concept is divided into affordability on the path of the company to procure the refinery, affordability of fuel which will be sold from the refinery and affordability on the path of the government to relinquish the upstream sector through privatisation. The concept of

affordability was discussed by the interviewees as some of the issues or challenges which the investors in the industry may face. Interviewee PE1 noted that *"the cost of establishing and running a refinery in Nigeria is very high. Government has to be involved"*. At the moment the foreign exchange of Nigeria's currency to naira is a major challenge because the government finds it very difficult to release dollar into the economy.

Figure 1. The themes from the case study findings of PPP as a procurement method for the oil industry in Nigeria.



The various agencies in Nigeria such as the Nigeria National Petroleum Commission, Department of Petroleum Resources, Ministry of Petroleum, Bureau of Public Procurement and the Infrastructure Concession Regulation Commission are in charge of approving licenses for oil refineries. These approvals have a time impact on the approvals and development of refineries in Nigeria. Interviewees CV1 opined that *"bureaucracy of public procurement means delay. It is a necessary evil for us to be able to know what we are getting but the process causes delay"*. The

delays are always involved but these types of delays are required in the Nigerian system because of the level of corruption within the government. Corruption was mentioned many times by the respondents. Interviewee CV2 noted that *"Corruption is a major challenge of PPP. It is a packaged deal when it comes to PPP."* The interviewee also noted that *"corruption is primary in the oil and gas sector"*. This may be as a result of the perception of a lot of local and foreign investors outside the oil and gas sector who feel that it is an easy access to gaining wealth. The interviewees noted that environmental impact of oil refining in the Niger Delta is a problem which new investors will have to address. PE1 stated that *"Oil spillage is a problem in Nigeria. The oil companies get away with anything. They bribe the chief. We are not green conscious. We have to consider our environment."* This factor is also related to corruption in the oil and gas sector.

For investors to procure oil and gas refineries with the government, there needs to be an adequate infrastructure to encourage them. Some of the infrastructures include power, access roads to the site, access to water, security and bridges. The oil rich Niger Delta area is in dearth of these facilities. CV2 stated that *"government needs to provide the enabling environment for private investors to establish private refineries.* The provision of an enabling environment within a country will promote more investment. This notion may have back up based on the level of corruption and false transparency in the procurement system. CV1 also noted that *"people think the oil sector brings cheap money and there is a lot of corruption"*. The general belief of many civil servant working in the procurement department is that it is an opportunity for them to get access to quick money through the demand for bribes. Access to technology is necessary for construction of refineries. Therefore, if the technology is unavailable, they will find it difficult to procure. This will imply that some elements of the refinery will be procured abroad. PE1 noted that *"technology is what is required to get to the bottom of the pile. Technology is a major success factor"*. All the respondents apart from PE1 highlighted the importance of technology in refinery procurement. A lot of foreign manpower will be required when the construction starts.

CONCLUSIONS

The eight (8) factors identified through the case study are the main challenges with PPP may face during implementation for refinery creation. Corruption seems to be the major issue of PPP

implementation in Nigeria. However, so far the procurement policies in Nigeria do not encourage foreign investors to come into the industry. Also, there is a need to review the present laws and regulations and also pass the petroleum industry bill for further development of the oil and gas sector. The presence of oil cartels which is a resultant effect of corruption has grounded the refineries in Nigeria because these groups of people have refineries outside Nigeria. The dearth of viable private sector participation in the midstream sector is not attributable to the incompetency present in this sector such as the inability of the local refineries to cater for local demands of petroleum product. PPP requires more private sector participation in Nigeria oil and gas sector. At the moment, the oil and gas industry in Nigeria seems not ready for PPP hence the current refinery procurement system is based on selective tendering.

REFERNCES

Ahuja, H. N., et al. (1994). Project management: techniques in planning and controlling construction projects, John Wiley & Sons.

Aniebonam, M. (2005). "Nigerian Skills Gap." International Journal of Productivity and Performance Management **54**(4): null.

Bennett, J. and E. Iossa (2006). "Building and managing facilities for public services." Journal of Public Economics **90**(10–11): 2143-2160.

Brown, D. C., et al. (2001). "New Project Procurement Process." Journal of Management in Engineering **17**(4): 192.

Christiano, T., et al. (2011). "Implementation of safety based incentives in Public Private Partnerships (PPPs): an empirical analysis for the case of Spain."

De Bettignies, J.-E. and T. W. Ross (2009). "Public–private partnerships and the privatization of financing: An incomplete contracts approach." International Journal of Industrial Organization **27**(3): 358-368.

Fahim, M. A., et al. (2009). Chapter 16 - Refinery Economics. Fundamentals of Petroleum Refining. M. A. Fahim, T. A. Alsahhaf and A. Elkilani. Amsterdam, Elsevier**:** 403-421.

Favennec, J.-P. (2001). Oil and Energy. Refinery Operation and Management. J.-P. Favennec, Editions Technip. **5**.

Gary, J. H. (2007). Petroleum refining : technology and economics. Boca Raton, Fla. : London, Boca Raton, Fla. : CRC

London : Taylor & Francis distributor.

Grimsey, D. and M. K. Lewis (2005). "Are Public Private Partnerships value for money?: Evaluating alternative approaches and comparing academic and practitioner views." Accounting Forum **29**(4): 345-378.

Hart (2006, 6 June, 2014). "Process audit 1994-2004: Refineries and Product Importation. ." from http://www.neiti.org.ng/sites/default/files/documents/uploads/downstream201206.pdf.

Hefetz, A. and M. E. Warner (2012). "Contracting or Public Delivery? The Importance of Service, Market, and Management Characteristics." Journal of Public Administration Research and Theory **22**(2): 289-317.

Hoppe, E. I., et al. (2013). "Public–private partnerships versus traditional procurement: An experimental investigation." Journal of Economic Behavior & Organization **89**(0): 145-166.

Klijn, E.-H. and G. R. Teisman (2003). "Institutional and strategic barriers to public—private partnership: An analysis of Dutch cases." Public money and Management **23**(3): 137-146.

Kupolukun (2005). Reforms at NNPC: The Journey so far. The Guardian**:** 51-53.

Li, B. and A. Akintoye (2008). An Overview of Public-Private Partnership. Public-Private Partnerships, Blackwell Science Ltd**:** 1-30.

Mordi, M. C. (2014). "Nigeria Refineries: The case for Privatisation." Retrieved 3 June, 2014, from http://businessdayonline.com/2014/04/nigeria-refineries-the-case-for-privatization/#.U5HFKKLKZ8F.

NNPC (2010). "Refineries and Petrochemicals." Retrieved 6 June, 2014, from http://www.nnpcgroup.com/NNPCBusiness/MidstreamVentures/RefineriesPetrochemicals.aspx.

NNPC (2014). "January 2014 Petroleum Information." Retrieved 5 June, 2014, from http://nnpcgroup.com/PublicRelations/OilandGasStatistics/MPIFigures/MonthlyPetroleum/tabid/130/FolderID/176/Default.aspx

Nwangwu, G. (2012). "The Legal Framework for Public-Private Partnerships (PPPs) in Nigeria: Untangling the Complex Web." European Procurement & Public Private Partnership Law Review **7**(4): 268-277.

Obi, C. I. (2010). "The petroleum industry: A paradox or (sp)oiler of development?" Journal of Contemporary African Studies **28**(4): 443-457.

Oduniyi, M. (2006). FG, oil majors to build $1M BPD Refinery. THISDAY. Lagos.

Okafor, E. E. (2007). "Rethinking African development: a critical overview of recent developments in the petroleum sub-sector in Nigeria." J. Soc. Sci **15**(1): 83-93.

OPEC (2014). "Downstream Capacity Additions and Investments in OPEC Member Countries." Retrieved 8 May, 2015, from http://www.opec.org/opec_web/en/650.htm.

Oyedele, O. A. (2012). "Public-Private Partnership (PPP) and Infrastructure Provision in Nigeria."

Plummer, D. P. (1973). The Petroleum Refinery. Modern Petroleum Technology. G. D. Hobson and W. Pohl. Barking, Barking : Applied Science Publishers**:** 220.

RajaaAlasad, I. M. and S. Ogunlana (2011). "IDENTIFYING DEMAND RISK IN PUBLIC PRIVATE PARTNERSHIP (PPP) INFRASTRUCTURE PROJECTS." Public Private Partnerships: 31.

Rangel, T., et al. (2011). "Implementation of Safety Based Incentives in Public Private Partnerships (PPPs), An Empirical Analysis for the Case of Spain." Public-Private Partnerships: 15-29.

Rossi, M. and R. Civitillo (2014). "Public Private Partnerships: A General Overview in Italy." Procedia-Social and Behavioural Sciences **109**: 140-149.

Sclar, E. D. (2001). You don't always get what you pay for: The economics of privatization, Cornell University Press.

Sharma, M. and A. Bindal (2014). "Public-Private Partnership." International Journal of Research **1**(7): 5.

Skelcher, C. (2010). "13 Governing partnerships." International Handbook on Public-Private Partnership: 292.

Speight, J. G. (2014). Chapter 2 - Materials of Construction for Refinery Units. Oil and Gas Corrosion Prevention. J. G. Speight. Boston, Gulf Professional Publishing**:** 3-37.

Speight, J. G. (2014). The chemistry and technology of petroleum, CRC press.

Sule, A. (2004). Developments in Nigeria's Refinery Industry. 8th Africa Oil and Gas Trade Finance Conference and Exhibition. Marrakech, Morocco. 30 April, 2004.

Treasury, H. M. (2012). A new approach to public private partnerships.

Walls, W. D. (2010). "Petroleum refining industry in China." Energy Policy **38**(5): 2110-2115.

Yin, W. (2014). "Evolution of public–private partnership models in American toll road development: Learning based on public institutions' risk management." International Journal of Project Management(0).

Zhang, Y. (2014). "From State to Market: Private Participation in China’s Urban Infrastructure Sectors, 1992–2008." World Development **64**(0): 473-486.

EXPLORING GEOLOGIC-COST FACTORS IN FLOOD PRONE HOUSING CONSTRUCTION IN COASTAL COMMUNITIES OF THE NIGER DELTA

Amadi Alolote – University of Salford

The right to adequate housing is one of the key sustainable development goals of the United Nations, and a fundamental human right. Community-based adaptation is also a central theme in building resilience to flooding. The Niger Delta Region of Nigeria is the 9th largest wetland in the world, through which the River Niger discharges into the Atlantic Ocean. As such, the geotechnical and hydrological characteristics of most parts of the Niger Delta area dictate the necessity for effective practical measures to satisfy the engineering demands of the highly compressible silty clay soils for housing construction in coastal communities. Field work data gathered from local builders in Bonny Island reveal the implied technicalities of managing and coping with terrain related factors, which translate into additional cost for projects in riverine areas, and whose prohibitive cost has been termed 'unfeasible'. Considering the numerous cases of building failure and collapse in the Niger Delta region, it is thus worrisome that private speculative developers may resort to taking shortcuts, which may undermine the safety of building inhabitants. Due to the scarcity of suitable lands, the recognition that coastal communities in the Niger Delta can only cope with issues of flooding by devoting funds to adequate structural adaptation mechanisms in buildings has thus become pivotal. Against the backdrop of the astronomical cost of housing in the Niger Delta, this study analyses the geo-environmental factors contributing to the high cost of construction, as a basis of creating heightened awareness of the need to institute relevant policy driven technical checks and capital incentives to small scale developers, who provide the bulk of housing in coastal communities.

Keywords: Building cost, geology, housing, Niger Delta, private developers.

INTRODUCTION

The Niger Delta region has a steadily growing population estimated to be over 30 million people as of 2005, accounting for more than 23% of Nigeria's total population. The population density is also among the highest in the world with 265 people per kilometre-square and is expanding at a rapid 3% per year (NDDC, 2006). The oil boom of the seventies has helped increase the volume of construction activities in the region and this has attracted the influx of foreign multi-national firms into the nation's construction industry. That firms executed most large government

contracts to provide good quality civil engineering and building works, which today largely form the bulk of the existing infrastructural capital base. Among the major infrastructural developments in the coastal sub-environments are the Liquefied Natural Gas project at Finima, the National Fertilizer Plant at Onne, the Petrochemical Plant and Bonny Refinery, all located within the coastal plain sands as well as the Gas reinjection Plant at Soku which is located on the mangrove swamp (Abam, 2001).

Housing however has generally remained the exclusive preserve of the private sector, mostly speculative developers, who over the years have provided more than 90% of the housing stock (Olatubara, 2007). The small scale speculative builders in the riverine areas of the Niger Delta, cannot on their own enjoy the services of these multinational firms, due to the high profits and over heads these firms are expected to pass onto them. The respondents reveal that they are therefore forced to make use of direct labour and sometimes small contracting firms are engaged. This type of contractual arrangement and execution may encourage the use of inadequate foundation designs, poor workmanship and inconsistency in the quality of building output resulting in poorly finished and nondurable components of substructure and superstructure. Consequently most houses in the riverine areas show premature sign of failure, soon after construction. Extreme case scenarios are the reported cases of building failure and subsequent collapse, and which has become increasingly experienced in the region, following the recent episodes of flooding that swept away several houses along waterfronts.

Most of these projects do not undergo any cogent engineering assessment of the underlying soils or rock. In better case scenarios, the literature revealed that builders resort to the use of crude tests to assess soil conditions (Abam *et al*., 2005). Typically the growth of certain types of vegetation such as cassava, are considered indicative of subsoils with adequate bearing capacity. The primary objective of such assessment is the identification and subsequent avoidance of sites with poor soil conditions. These practises were usually satisfactory for small scale construction built away from obviously poor sites. However, the current high cost of real estate coupled with population explosion especially in the upland urban areas, dictates the need to build on these coastal sites with poor soil conditions; sites that in the past would have been rejected. Historic literature shows that the swamps although rich in crude oil, used to support little or no population (Allen, 1976). Due to the scarcity of suitable lands, marginal lands in the coastal areas are increasingly being considered for the construction of residential accommodation.

These “difficult sites” however pose problems which require specialised construction materials, increased labour requirement and techniques such as ground improvement methods with the accompanying cost implications, which may not be in the financial interest of speculative private investors. Also such problems as transportation of construction resources such as materials, labour and equipment, and access difficulties in unfavourable terrain, are some of the factors to which increased construction cost in coastal areas have been attributed. Typically, Abam *et al* (2005) stated that the problem of construction in the area is also worsened by lack of labour due to geologic environment and also the lack of construction materials. Sometimes a new settlement has to be built for the labour force, with construction materials like concrete aggregates brought in barges, and transported from distances over two hundred kilometres away. Transportation is by small boats and barges which sometimes find it very difficult to penetrate the swamps. Against the backdrop of the geologic setting of the Niger Delta area, this study analyses geo-factors contributing to housing construction cost in the Niger Delta, and the builders' approach to cost management.

NIGER DELTA: HYDRO-GEOMORPHOLOGY

The Niger Delta is the 9th largest delta in the world with an area of 19,135 square kilometres. It is one of the largest wetlands in Africa (NDES, 1997). Like all deltas, the Niger Delta has a bird foot configuration with the inclusion of catchment areas of over 20 rivers, that are partly connected with each other and covers an area of about 70,000km, consisting of over 20,000km of wetlands” (Teme, 2002). The whole basin is dissected by numerous creeks, streams, marshes and lagoons with extensive back-swamp flood plains”. Oguara, (2002) in attempting to qualify the landscape of this terrain describes the Niger delta as being mostly: “A flat swampy basin made up of a vast plain, built up by the accumulation of weak and highly compressible alluvial sedimentary deposits, from the Niger and Benue Rivers and exposed to floods, crisis-crossed by a myriad of rivers, and creeks. The banks of these rivers and creeks are made of levees bordered by areas mainly consisting of back swamps of equatorial forests, and numerous lake-like water-logged depressions where rainfall and surface water flow can hardly be drained by gravity” (p.7).

Back-swamps in the Niger Delta occur from the inundation of the adjoining lowlands which usually lie behind streams’ natural levees due to the relief of the Niger Delta region, which has a

broadly flat, gently steeping topography, from a height ranging from 40m to 8m above sea level, inland to the coast.

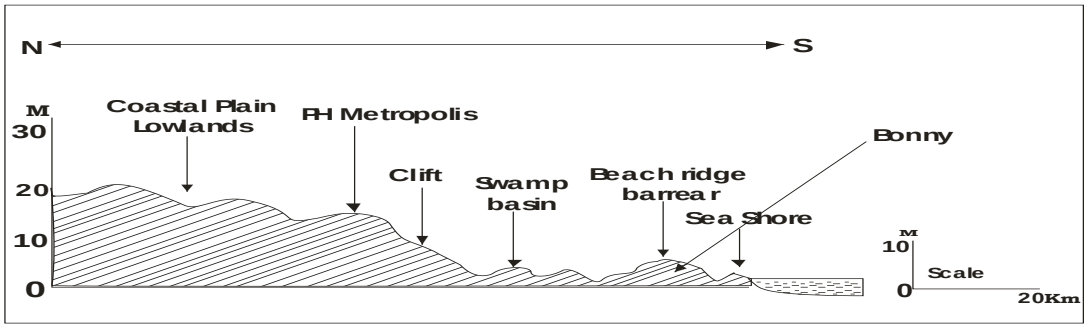


Figure 1: A North–South Profile of the Niger Delta passing through Bonny (Source: Aisuebeogun, 1995, p 43)

Rainfall is typically high in the area with a progressive increase, southwards towards the coastline, as evidenced by regular heavy downpours (Ngah and Youdeowei, 2013). The Nigerian Meteorological Agency (NIMET) records reveal very high levels of annual average rainfall (5000 mm), with a reduction towards the middle delta, while the upper delta experiences the lowest values ranging between 2000 mm to 3000 mm. Table 1 shows the average rainfall amount for some locations in the Niger Delta.

Table 1: Average Rainfall Amount for some Locations in the Niger Delta.

Location	Recorded Period (Years)	Mean Annual Rainfall (mm)
Bonny (Coastal)	45	4366
Opobo (Coastal)	52	3698
Brass (Coastal)	11	3573
Oloibiri (Middle)	24	3173
Degema(Middle	51	2433
Port Harcourt (Inland)	28	2384
Ahoada (inland)	16	2073

Source: Author, 2016

The quantity of overland flow over the region, evacuating via a reticulate network of meandering system (creeks, streams and rivers), 18 of which discharge directly into the Atlantic ocean, is determined by this weather pattern and relief (Ngah and Youdeowei, 2013). During the rainy

season which last all year long in coastal communities, floods and bank erosion failure are extensive. Construction sites in coastal areas are thus almost always under water, due to flooding further compounded by sea level rise from the Atlantic Ocean. “The depth of ground water table thus exists within the reach of conventional foundation types” (Nwankwoal, and Oborie, 2014, pp 236). Also due to this geologic setting, the Niger Delta region is mostly underlain by a complex stratigraphic succession of soft silty clays and, sands and present foundation problems, which is representative of the difficulties of undertaking any construction in the area.

Problematic Expansive Soils of the Niger Delta: The ‘Chikoko’ Clay

Sub-soils in the Niger Delta area of Nigeria, predominantly consists of extremely soft deltaic marine clay locally referred to as ‘Chikoko’, with a dark grey, dark brown to black coloration (Otoko and Precious, 2014). According to Oguara, (2002:8) “The erratic soil condition with swelling and shrinkage problems in the freshwater swamp and lowland rainforest zones and excessive settlement of the ‘Chikoko’ deposits in the mangrove forests and coastal barrier zones hinder development”. Otoko and Precious (2014) described the ‘Chikoko’ clay as a highly fibrous organic soil and peat consisting mainly of vegetative matter in various states of decomposition, having high compressibility and volume instability. These soils according to Craig (2006) are distinct from organic silts and clays which are produced from deposits of lacustrine and marine sediments. In the Niger Delta Region, Fatokun and Bolarinwa (2009) revealed that these soil types occur as clayey peat over the mud plains and have been shown to be highly undesirable in their natural forms for construction. This is due to their characteristic swelling and shrinkage potential with corresponding changes in water content as seasons change from rainy to dry. Thus any structure constructed with or placed on such soils exists to grapple with such typical geotechnical problems. Abam (2001) opined that construction in these riverine and coastal zones is difficult and expensive and in some areas, very nearly unfeasible.

CONSTRUCTION COST IN THE NIGER DELTA

The environmental condition of most parts of the Niger Delta makes the use of conventional designs, materials and construction methods particularly in the swampy and coastal zones, inappropriate. This implies that construction in these zones would ideally require expensive specification for works, ultimately increasing the cost of construction projects so many folds.

Several other cost related issues abound in carry out construction work in the riverine areas: inadequate or short construction season, and inclement weather mainly due to recorded high rainfalls throughout the year; increasingly high cost incurred in transporting construction resources; additional cost incurred in the management of the construction resources; absence/poor road network between the riverine areas and the upland areas of the region.

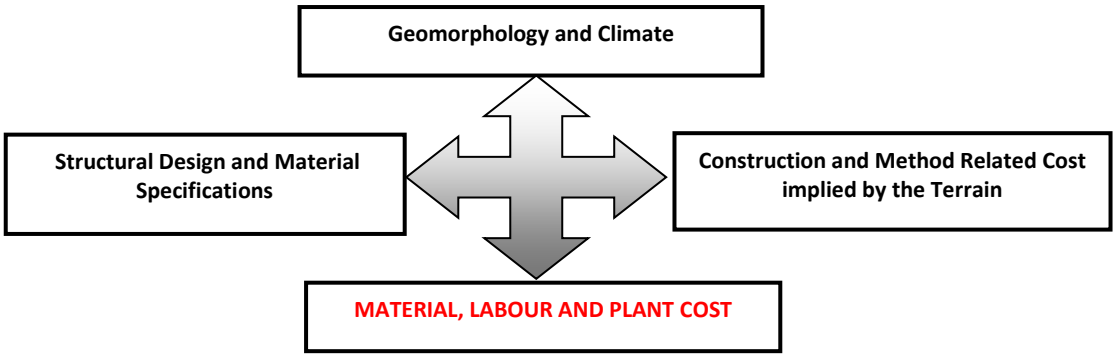


Figure 2: Geo-environmental Construction Cost Implications in the Niger Delta

The key financial inputs of material, labour and plant costs requisite for the construction of housing must therefore be reflective of this as graphically illustrated by the researcher in Figure 2. By implication, the geomorphology/geotechnical characteristics subsoils compounded by climate, will thus form the primary set of predictive environmental variables shaping the cost profile of the various financial inputs of material, labour and equipment necessary for housing construction, in terms of the: Relatively more expensive design and specification requirements; and additional expenditure incurred during the construction phase.

METHODOLOGY

Interviews with local builders as well as observation of the physical condition of housing structures were carried out in Bonny, a typical rural coastal island in the Niger Delta region. Bonny and its district towns and villages are situated in the Niger Delta zone along the Nigerian coastline. Bonny geologically falls between the mangrove swamps and regional marshes of the Niger Delta. This together with the rising and falling of the sea level in response to precipitation and evaporation gives rise to a heterogeneous and complex set of subsoil predominantly made of organic clays, silts and sand deposits. The subsoils also contain naturally occurring sulphates and

peat which often causes serious damage to foundations of buildings in the area. A review of the local literature on the geology of Bonny, and archival records past collapsed buildings in the Niger Delta is also carried out, and shows that the use of substandard building materials, poorly workmanship, non-compliance with specifications/standards, and non-enforcement of existing laws primarily accounted for this trend. Based on the fieldwork findings, the paper analyses the increased financial implication of the geology of the Niger Delta, as it relates to the practicalities of housing construction, from the perspective of the small scale speculative builder.

COASTAL COMMUNITIES: CONSTRUCTION COST

Stabilisation and Compaction Requirements: Cost Implications

Abam *et al* (2005) stressed that the geologic difficulties inherent in Bonny, call for measures to ensure an adequate margin against the behaviour of the naturally weak soils, by using advanced methods to cope with the weak compressible soils on very poor sites. Most of these methods, it was advocated, should focus primarily on the settlement problem, because it often has the

Figure 3: Niger Delta Mangrove Swamp Forest (Source: Youdeowei and Nwankwala, 2013, p.60)

Youdeowei and Nwankwala (2013) analysed the suitability of soils as bearing media at a freshwater swampy terrain in Bonny typically captured in Figure 3 and recommended excavation of the soft expansive soils, and replacement with suitable locally available fill material such as sharp sand. However problematic swelling soils existing to irreplaceable extents both laterally and vertically within Bonny, is also an established fact (Ngerebara *et al*., 2014). Several authors

in the literature have thus advocated for soil stabilization measures of these soils using varying material specification ratios of additives. Typically, Otoko and Precious (2014) advocated the need for soil stabilisation using environmentally sustainable alternatives such as Waste Shredded Rubber Tyre Chips to alter the engineering properties of the soils to increase the strength and stiffness of the original weak soils or removal where such soils exist to replaceable extents. The latter basically entails importing good quality laterites from burrow pits, subject to the availability of source sheds and the distance from these source locations, often situated in the coastal plain soils of the upper Delta. The swampy and coastal regions which are often cut off by lack of existing roads to transport materials are indicative of the prohibitive cost. The additional costs of loading of materials at source, spreading and compacting and backhaul (return of empty vehicle) equally push up the cost of this subgrade improvement technique.

Table 2: Haulage Distances to Riverine Locations in the Niger Delta

Town	Via Existing Roads (Kilometres)	Via Water Ways (Nautical Kilometres)
Bonny	N/A	25
Brass	N/A	114
Degema	N/A	28
Ekeremor	N/A	501
Ndoni	N/A	438
Ogbia	N/A	113
Opobo	N/A	83
Oporoma	N/A	168
Sagbama	N/A	434
Yenegoa	128	140

Source: Author, 2016

Table 2 shows the distances of Bonny and other riverine locations in the Niger Delta from Ahoada, via Port Harcourt situated in the coastal plain soils of the upland regions, which has estimated lateritic deposits in excess of 15 million tonnes. In consideration of this haulage cost, Otoko and precious (2014) opined that stabilisation in place as opposed to excavation and replacement is a more economical alternative for riverine locations in the Niger Delta which can lead to substantial savings. The authors further stated that due to the significantly higher cost of utilising chemical additives which are not locally available, use can be made of bitumen, cement and lime as stabilizing agents. Preloading with sharp sand is also a common practice in the

region due to its permeability and availability (Oguara, 2002). The availability of sands for this purpose however is subject to vast quantities being dredged from the existing waterways at high cost. It was further recommended that in the absence of suitable materials within the marginal haul (economic hauling distance beyond which it becomes cheaper to dig out from a borrow pit if within proximity), using alternative foundation types such as raft, pile or piers become mandatory.

The literature thus shows that the Niger Delta terrain has direct cost undertones which correlate with the geotechnical properties of the soils and the location of the site. The remedial improvement measures as noted would thus imply additional costs of either:

- Excavation to remove such poor soils and replacement with adequate fill;
- Compaction and preloading with locally available free draining material;
- Stabilisation in place with chemical additives;
- Resorting to the use of more expensive foundation types

Ground Water Conditions (Depth and Salinity): Cost Implications

The relatively high level of the water table in coastal communities and its interference with other aspects of construction activities on site has its cost implications. The cost of pumping or dewatering trenches is an additional cost item during excavation works in Bonny which is generally carried out in soft grounds. Under these conditions timbering also becomes imperative, as the sides of trenches generally lose the ability to retain their original vertical position in soft soils. This behaviour is rectified by timbering with poling boards placed side by sides, walled and strutted along the sides of the trench. Alternatively the trenches may also be sheeted. The associated cost of timbering or sheeting of excavations is a further cost item.

Saline water conditions in Bonny either directly/indirectly affect construction cost. Brackish or saline water flow through the creeks and rivers, as a result of which mangrove forest predominately grow in the swamp forests in Bonny. The major problem associated with the salinity of rivers and creeks borders on rust and corrosion. Dissolved sulphates or chlorides, which are carried in solution by capillary water from the Atlantic Ocean have the capacity to cause failure of concrete pavements. The local builders revealed that water from most of the

rivers and creeks in Bonny cannot be used for construction work or for cleaning of plants or tools such as rotating drums of concrete mixers or buckets of mechanical excavators, after the day's work, due to the high salt content which encourages rusting. This can be as a result of chloride being either in the raw materials such as use of brackish water for mixing. The builders explained that this thus requires that they seek sources of pure potable water that can be used on site at extra cost, mostly by drilling of boreholes of the adequate depth. Also to increase the acid resistance of the concrete, NBRRI (1998) recommended that super-sulphated cement, high aluminium cement and sulphate resistant cement should be used. However, the builders explained that ordinary Portland cement was still used for concrete works in foundation. Preventing the corrosion of embedded steel reinforcement would ideally also entail using well compacted concrete of extra thickness than the norm, to ensure good cover, all of which will translate into extra cost for housing construction in Bonny Island.

Transportation and Accessibility of Construction Sites: Cost implications

One of the most outstanding problems confronting constructions projects and activities in Bonny and other riverine areas in the Niger Delta is transportation. Bonny is surrounded by a vast expanse of water. The nearest urban city, Port Harcourt, is not linked by road. It follows that a greater percentage of communication is by creeks, rivers and seas, via maritime transportation. The size of this cost on construction projects in coastal areas is thus very significant. The builders explained that the major and only available means of transport in the region is by the use of locally built wooden canoes, and speed boats which are faster and able to ply the twenty-five nautical kilometres for a typical locations such as between Bonny Island and Port Harcourt (upland coastal plain soils) within a time lag of 1 to 2 hours. The local boats travel at a much slower pace and for longer time but are used more in the transportation of construction materials. This is made possible because they are built in very large sizes, which conveniently carry forty people (Labour and craftsmen).

It was explained by the builders that a few specialized firms that handle the ferrying of construction plants, materials and labour, across the rivers and creeks using speed boats, also exist. Barges powered by tug boats or self-driven (propelled), and equipment transporters can also be employed for transporting plant and materials. For the specialized firm, their fees vary and depend on a range of factors. These include, the site location, the distance of the site from

their departure base in Port Harcourt, the quantity of materials, the number of trips, type and size of plant, size of the labour to be transported. It was also explained that occasionally, these firms are employed to handle construction items on a standing offer basis.

Apart from the problem of transporting materials, labour and plant via rivers, creeks and seas, the builders explained that the issue of climate further compounds the problem by rendering available track roads within Bonny completely inaccessible during the rainy season. As such footpaths and tracks that might have been accessible during the dry season may become flooded, and thoroughly degraded during the rainy season. Accessibility of such sites thus becomes very difficult during inclement weather conditions, as such some plant and heavy equipment that may be required to be used as such sites may be left for the use of labour directly, and materials may have to be carted in wheel barrows at extra cost.

Cost of Transportation - Labour

The builders explained that they often needed to employ skilled labour in Port Harcourt and transport them to Bonny, but did not, due to the high cost. It was explained that as small scale speculative builders, they have no transportation department capable of handling marine transportation needs. It necessarily follows that this aspect of its construction arrangements has to be carried out by specialized firms for a fee or in the alternative, use the ferrying boats available at the departure points in Port Harcourt in conveying skilled craftsmen. The builders explained that they could also request for these services from firms that own and hire the boats. Alternatively, these boats could be chartered. It follows that the builder will now have to pay additional amount for the number of seats available in the boat. In recent times, the cost of transportation per seat of these ferrying boats to Bonny has been on the increase. Data obtained during the field work reveal occasional sharp increases in cost of fares per seat by the ferry boats plying the Bonny-Port Harcourt route. Small scale developers thus have to bear the burden of paying for the additional costs of maritime transportation of labour, or make do with the less skilled locally available artisans.

Cost of Transportation- Materials (Haulage)

Transportation of materials via maritime transport across the sea to Bonny Island implies a huge financial risk, as the waves may threaten the safe delivery of the materials on the turbulent waters. Some of the local builders explained that they had suffered huge losses from loaded boats

capsizing in the sea. Therefore transporting equipment such as barges with high operational safety performance is advocated for. However, most of the small scale builders explained that they still resort to the use of local boats to transport building materials from urban centres, despite the increased risk due to the prohibitive cost of hiring barges. The builders thus explained that the cost of transporting building materials to Bonny is not just the market price at Port Harcourt where they are bought, but also the additional costs incurred in transporting the goods by land to a departure point in Port Harcourt, but also the cost of off-loading at Bonny waterside from the boats, and loading into vehicles to transport to sites, which may not be accessible. Transportation costs will thus further include unloading of the building materials, from the vehicles, and carting manually using hired labour through the swampy terrain at the nearest accessible point to the site. It was thus explained that at delivery, the material cost would be double or triple the market price.

Cost of transportation- plant

Transportation of plants can be done by engaging "specialized firms" or by using barges, as the available boats at the "Bonny waterside" can only be used to transport small plants and hand. Thus plants such as mechanical excavators, bull-dozers, scrappers, graders and cranes of all types cannot be conveyed as a result of the size of these boats. However due to the prohibitive cost of hiring barges, the builders explained that most of the site works were carried out using manual labour.

CONCLUSION

This paper has evaluated the hydro-geomorphology of the Niger Delta, in relation to its impact on cost of housing development, from the perspective of small scale speculative builders, who provide the bulk of housing in coastal areas. The primary geo-cost factors that drive the exorbitant cost of housing construction in the typical coastal island of Bonny are summarily captured in Table 3.

Table 3: Geo-Environmental Cost Factors in Housing Construction in the Niger Delta

Terrain Characteristics	Cost Factor
Subgrade Suitability and Possibilities of Improvement	Earth works, Availability of Laterites , Access to potential quarry sites, Haulage Distance, Cost of stabilisation alternatives, Alternative foundation types
Ground Water	Water table (Groundwater removal), Salinity (Specification requirements)
Transportation and Accessibility	Maritime transportation of Plant, Labour, Materials, Accessibility of track roads

Considering the huge resources relevant for housing construction, and the lack of checks, it is thus not surprising that the builders in Bonny, which is typical of other riverine areas, have resorted to cutting corners. While public policies such as reduced interest rate scheme for urban housing development are in place, riverine and coastal areas which are often rural, and require significantly higher funds for housing construction, lack any form of formal public policies to attract financial support. Housing in coastal areas are also largely unplanned, without zoning regulations, and sometimes built across storm water flow paths, which further increases flood risk. Regulatory frameworks which are sometimes enforced in the upland urban areas such as the minimum setback to the ocean, lagoon, river and creeks, and canals and drainages are largely ignored in riverine rural areas. Speculative developers in the riverine areas thus ultimately make decisions on where and how to build. This underscores the need to enforce technical checks as the only viable approach to ensuring structural integrity of housing in these flood prone areas. The researcher thus uses the study findings as a dual platform to establish the need for financial support and assistance on one hand, and legislation and enforcement on the other hand, to safeguard the lives of the building inhabitants, who in riverine areas are often low income earners, typical of the rural populace, with limited access to decent and affordable housing in good locations.

REFERENCES

Abam (2001). Regional hydrological research perspectives in the Niger Delta Hydrological Sciences Journal Volume 46, Issue 1, 2001.

Abam, T. K. S., Osadebe, C. C and Omange, G.N., (2005). Influence of geology on pavement performance: A case study of Shagamu-Benin City Road. Global Journal of Geological sciences, 3 (1), 17-24.

Aisuebeogun, A. (1995). The Port Harcourt region; land form characteristics of the environment. Journal of Geographic Thought. (1) 10 – 14.

Allen, J.R.I (1976). Late Quaternary Niger Delta and Adjacent areas. Sedimentary Environments and

Craig, R.F. (2006). Soil mechanics. E&FN, New York. pp 447.

Fatokun, O.1 and Bolarinwa, A.I. (2009). Problem Soils of Nigeria in Road Failure Investigation. Technical Dept. Nigeria Building and Road Research Institute, (NBRRI), 1988. Report No. 13, pp.30.

Nigerian Building and Road Research Institute, (NBRRI), 1998. Report No. 13, Pp.30

NDDC (2006) The Niger Delta Region, Land and People. The Niger Delta Regional Development Plan Chapter 1. Federal Republic of Nigeria.

Niger Delta Environmental Survey (NDES) (1997), Environmental and Socio Economic Characteristics.

Ngah, S. A. and Youdeowei, P.O. (2013) Salinity depths in coastal aquifers of Niger Delta, Southern Nigeria. Archives of Applied Science Research, 5 (2):222-233. Scholars Research Library.

Ngerebara, O.D., Abam T. K. S and Nelson K. (2014).Geotechnical soil characterization of Akanfa–Gbaran Road, Bayelsa State, Nigeria. International Journal of Scientific and Research Publications, Vol 4. No. 4. pp 2250-3153.

Nwankwoal, H.O and Oborie, E. (2014). Geo-technical Investigation and Characterization of Sub-soils in Yenagoa, Bayelsa State, Central Niger Delta, Nigeria. Civil and Environmental Research. Vol.6, No.7.pp 234-240.

Oguara, T.M. (2002). Sustainable Development of High Infrastructure in the Niger Delta Region. Nigerian Society of Engineers (NSE). pp 4-10.

OIatubara, C. O. (2007). "Fundamentals of housing." Housing development and management: A Book of Readings. pp. 70-106.

Otoko, G and Pedro, P. (2014) Cement Stabilization of Laterite and Chikoko Soils Using Waste Rubber Fibre. International journal of engineering sciences & research Technology. ISSN: 2277-9655. PP130- 136.

Otoko, G & Precious, R. (2014). Stabilization of Nigerian deltaic clay (chikoko) with groundnut shell ash. International Journal of Engineering and Technology Research Vol. 2, No. 6, June 2014, pp. 1 - 11, ISSN: 2327 – 0349.

Teme, S.C. (2002). Water: Its impact on Man in space and Time. An Inaugural lecture presented at the conference of the Rivers state University of Science and Technology. Port Harcourt.

Youdeowei P.O. and H.O. Nwankwala, (2013). “Suitability of soils as bearing media at a freshwater swamp terrain in the Niger Delta,” Journal. Geol. Min. Res. Vol. 5(3). pp. 58-64.

EXTERNAL COSTS AFFECTING SUSTAINABILITY OF TRANSPORT SYSTEMS

Inara Watson, London South Bank University

Railway transport, as part of the transportation system provides access and mobility for society and support to the growth of the economy. In the past years the role of rail transport has been steadily increasing, as congestion and environmental factors constrain the growth of car and air transport. Rail transport can offer efficient and an effective way to transport passengers and goods while using less energy, taking less land, and being a less environmentally polluting mode of transport. By developing high-speed rail, increasing in density of rail networks can reduce congestion and sufficiently increase mobility whilst providing speed, reliability, comfort and safety. It can tackle the climate change shift. Regarding sustainability, high-speed railway is the most efficient mode of transport. Using modelling techniques and comparative measures, this research investigates the sustainability and related factors of high-speed railways and compromises used to deliver sustainable solutions. This project compares and evaluates the sustainability of high-speed railways in Europe, USA and Asia including economic, environmental and social aspects. It identifies analyses and models the key influencing factors that affect sustainability. The expected outcomes of this research will contribute to the development and advances of more sustainable high-speed railway systems.

Keywords: comparative evaluation, high-speed railway, key influencing factors, sustainability.

INTRODUCTION

Transport is an important part of national and international economies. It provides access and mobility for society and supports the growth of the economy. To make transport systems sustainable there is a need to carefully balance the benefits that transport contributes to society and the negative impact caused by transport on the environment, climate change and health of people. These negative impacts of transport do not include the price that is paid by transport users. Users do not pay for air and noise pollution or climate change and they only partially pay for accidents through insurance and congestion through a decrease in productivity. Car driving or travel by airplane, or train brings benefits to those using the transport system, but non-users suffer from after effect caused by using the transport system.

In 2008, the total external costs for EU2 were between 5% and 6% of the total Gross Domestic Product (GDP). Average external costs for road transport (excluding congestion) are more than

four times higher than external costs for railways whilst for freight services it is more than six times higher (Rail Transport and Environment, 2015). High-speed railway is becoming an important mode of transport as it has the lowest external costs. It can offer efficient and an effective way to transport passengers and goods while using less energy, taking less land, and being less environmentally polluting mode of transport that can tackle the climate change shift.

However, when economists compared the profitability of rail transport, road transport and aviation these external costs have not been taken into account. This has been reported in many publications, by Maddison and Pearce, (1996), ECMT, (1998); Maibach and Schreuer, (2008); and UIC, (2015). An external cost is one of the major factors that affect the sustainability of transport modes, and in many cases it is much higher than the benefit of transportation. It is important to establish how it was generated and possible ways to reduce it.

METHODOLOGY

The purpose of this research is to understand the components of external costs and their influence on sustainability of transport systems. The secondary data methodology has been used to prepare this paper. The preliminary literature review showed that this topic is relatively under-researched. There is a limited amount of information about the external costs of railways and on comparability of the performance of different railways around the world related to external costs. The outcome of this research indicated some limitation of the economy in pricing the full marginal costs of the travel, which in turn negatively affected the whole of society by increasing the congestion, air and noise pollution and contributed to climate change. By analysing the external costs of different modes of transportation and differences in external costs of selected high-speed railways in Europe, Asia and USA, the intention is to identify ways to reduce external costs of high-speed railways.

COMPONENTS OF EXTERNAL COSTS

"In public transport, at the level of the consumer, such private (or internal) costs include the costs of the trip ticket or the freight/shipping fare. All social costs that are not internal according this definition (i.e. that are not borne by the individual user or, depending on the system boundaries,

by user groups) are called external costs". (ECMT, 1998). The most important parts of external costs are: congestion, accident, noise, air pollution and climate change. In 2008, the total external costs in the EU27 (excluding Malta and Cyprus, but including Norway and Switzerland) were estimated at 510 billion Euro, excluding congestion (UIC, CER, Rail Transport and Environment, 2015). External costs of transport are growing rapidly because of increasing population and mobility. The largest part of external costs comes from road transport. In 2013 in the UK, there were 502 cars per 1000 people and the number of cars on the road is steadily growing (European Automobile Association, 2016). In 1971 it was 19 million and by 2007 it rose to 31 million, increasing on average by 3% every year (RAC Foundation, 2008). The steadily increasing amount of cars on roads is deteriorating the environment and actually decreasing the accessibility to community places.

This rapid increase in car ownership around the world has a few explanations; firstly, it is the huge lobby from the car industry to governments around the world that is promoting cars and building new roads. Secondly, the real cost of private cars in the past has actually fallen, but fares for public transport, buses and trains, steadily increased. With the continuation of current trends impact on the environment and the well-being of human beings cannot be predicted.

To reduce the negative impact of transport and to make more efficient use of the infrastructure there is a need to add external costs of transport to fares, so that this will improve the equity between users and non-users of transport and also equity between users of different modes of transportation. At the present time, users do not pay external costs back; it is paid by society as a whole. It is needed to adopt external costs and include them into prices that are charged for journeys. Transport systems hugely depend on fossil fuels, but there are huge differences in carbon dioxide emissions among the three main modes of transport; namely, railways, highways and airways. Adding external costs of air pollution to travel fares may produce a shift to more environmentally friendly modes of transportation. Shifting the medium distance travel by car and short flights to high-speed rail will sufficiently reduce the external costs that road and air travel produce. For example, a passenger train powered by electricity produces only 56 g of carbon dioxide per passenger-kilometre, short air flight 180 g and petrol cars 110 g per passenger-kilometre (TCPA, 2005). In the EU, noise-related external costs will be around 20 billion Euros by 2050. Accident related external costs will be around 60 billion Euros per annum by 2050.

External costs of congestion will be around 200 billion Euros per annum. Only external costs related to air pollution will decrease by approximately 60% by 2050 (Jehanno, 2011).

In the year 2000, in Europe external cost of road transportation was 84% compared to railways which were just under 2%. This clearly demonstrates that railway transportation has much less external costs compared to road vehicles or air transport which is 14 % (Jehanno, 2011). However, railways in Europe, Asia and USA have a big variety in their external costs. It depends on many factors and this will be described in more detail below. External costs depend not only on technical characteristics of the transport unit but also on the locations and time of day, but most importantly is the type of fuel that is being used by vehicles.

Congestion

Congestion is one of the major external costs of road transport. Although, the construction of new roads to relieve congestion might be in some cases validated, but it has been proved many times that building new roads will just create more traffic jams. The present cost-benefit appraisal process does not calculate the generated traffic, and fails to evaluate the environmental costs on the same basis as time savings by monetising them. The cost of congestion in Europe reaches approximately 1% of the total Gross Domestic Product (GDP) annually (EC Mobility and Transport, 2011).

Nevertheless, railways also get congested, but this external cost has not been evaluated up to now. For example, the Midland Main Line on 24th of October 2014 published a declaration that this sector of the Network Rail probably will be congested in one years' time. This will restrict the access to new companies to provide passenger or freight transportation and will restrict the expansion of the existing line.

The congestion also affected some high-speed lines, mostly those that are used by both passenger and freight trains. For example, German Federal Railways (DB) from the beginning decided to allow all categories of trains, including high speed trains and freight trains to use the conventional lines and high speed lines too, but only a few trains should run at a lower speed. This mix of traffic brought some disadvantages. One of them is reducing the capacity of the line and can also reduce the safety aspects of the railway. It was difficult to produce a timetable that

satisfied both, the passenger traffic and freight traffic, because of the significant speed differences. Most of the daylight time was allocated to passenger trains, but during the night the line needed to be maintained. This caused some serious delays for freight transport.

The railway systems have some spare capacity, however, 20% of Europe's main lines, which is about 16000 kilometres of track are classed as bottlenecks (European Commission, 2010). In a White Paper for Transport (2011), he European Commission put a goal to shift 50% of medium distance intercity passengers and freight journeys from road to rail and water-borne transport. To achieve this goal it is needed to substantially expand the railway network. To satisfy increasing demand for mobility worldwide, by 2050 there is a need to build around 335000 kilometres of railway track (Dulac, 2013). It was estimated to shift only 2% of traffic from road to rail in the UK there is a need to increase capacity of railways by 25% (Railway Technical Web Pages, 2016).

The development of the Global Navigation Satellite System for the railway industry and implementation of European Railway Transport Management System (ERMTS) will increase service frequency, and as a result will increase capacity of railway systems. Optimising the timetable, using more powerful locomotives, lengthening existing train services, increasing the speed of trains, upgrading infrastructure, electrification of existing lines, and building new lines, all of these can increase the capacity of railways.

Accident Costs

One of the largest parts of the total external costs belongs to accident costs and it is only one of the external costs that have steadily decreased in the past. Nearly 1.3 million people die in road crashes every year, and an additional 20-50 million are injured or disabled. Road accidents cost $518 billion globally, costing individual countries from 1-2% of their annual GDP. In the EU an average 86 people died per day on the roads in 2010, and totally more than 31000 a year. In the last two years in most European countries the number of deaths and injuries on the roads has decreased (ASIRT, 2016).

One of the reasons behind reducing the number of road accidents can be reducing the number of miles walking or cycling. From 1975 to 1994 the average number of miles cycled fell by 24%,

and the number of miles walked per person per year has fallen by 15% (Maddison and Pearce, 1996). Journeys by foot or bicycle are significantly lengthened because of waiting to cross roads with heavy traffic. People may avoid visiting certain places because the traffic was too heavy.

Fatalities rate per billion passenger-kilometres for passenger cars are 5.9, for buses and coaches and airlines are 0.4, but the high-speed rail is the safest mode of transportation with fatalities recorded close to zero (Baron, 2009). However, the fatality rates differ on different high-speed railways. The most outstanding record belongs to Shinkansen high-speed railway in Japan where no accidents have been registered that were followed by fatal injuries to passengers on board since the railway started operating in 1964 (JR-Central, Web Pages, 2016). Railways in the UK also have a very good safety record and it is one of the safest railways in Europe. Eight years in succession there have been no passenger or workforce fatalities in train accidents (European Railway Review, 2016).

Not all high-speed railways have good safety records. Recently there have been a few accidents, and one of them was in February 2016 in Bavaria, Germany. Two commuter trains traveling at a speed of around 100 km/h collided on a stretch of single-track that killed 11 people (ITV News, 2016). One of the deadliest train crashes in German modern history was in 1998 when 101 people were killed and 88 more injured (The European Railway Webring, 1998). In the last few years the increasing amount of accidents on high speed lines (Spain, China, and France) makes people cautious about the level of safety on high speed trains. At the present moment airlines in Germany have a higher safety record than high-speed rail.

High-speed rail in the USA also has some safety issues; one of them is that the route between Boston and Washington DC is not grade-separated. New build high-speed rail for safety reasons must avoid having level-crossings. There is some correlation between punctuality and accident rates, between speed and accident rates, and also correlation between accident rates and type of high-speed rail, but these matters are beyond the scope of this paper. Nevertheless, the external costs of accidents caused by road transport are incomparably higher than external costs of accidents on railways.

Improving the punctuality of railways will improve the safety too and, so many accidents are caused by trains that are travelling late. The safety records can be improved by improving rolling stock. Avoiding the use of the level crossings is another way to improve the safety records of

railways. Integration of Global Navigation Satellite System with an Automatic Train Protection (ATP) system will also improve the safety. Safety of passengers and staff for railways is the most important issue and there are many more ways to improve the safety records.

Climate Changes

An International Panel on Climate Change predicted the global temperature will increase from 1º to 6º Celsius from current levels by 2100 (IPPC Climate Change, 2007).This will depend on future greenhouse gas emissions, and to prevent this change in temperature there is a need for immediate action to be taken.

All emissions can be divided to global air pollution, such as carbon dioxide, and local air pollution. Approximately 25% of the UK's carbon dioxide emissions are contributed by the transport sector. Road transport accounts for more than 80% of total transport emissions. It was estimated that climate change costs is approximately 1% of world GDP, but by increasing to 2.5° Celsius in temperature it would reduce global GDP by approximately another 1.5% (Maddison, Pearce 1996).

The transport industry is the second largest carbon dioxide producer with 27% after the energy industry with 34%. However, railways contributed just 1.6% of total carbon dioxide emissions produced by the transport industry. 95% of the total amount of transport around the world depends on fossil fuels which are a finite resource (UIC, 2008). Shifting traffic to high-speed rail can sufficiently reduce this dependence.

Fuel prices should be based on the environmental damage each fuel causes; and price differentials should reflect the environmental advantages of one fuel over another. At the moment users of the road network and airline network pay only a part of fuel costs and as a result of this, part of the external costs of road and air transports has grown out of control.

Railway contribution to the total carbon dioxide emissions is only 1.6%, but contribution of carbon dioxide by different railways differs considerably. This depends on the energy resources that railways use and also on the ways that electricity for railways is generated. If electricity for high-speed railways is generated from solid fuels or oil it will have a higher environmental impact on climate change and higher external costs.

External costs of climate change for high-speed rail in Germany is much higher than in France. In Germany about 54 % of their electricity is generated from solid fuels compared to France with only 4.5% of electricity generated from solid fuels. In France 85.8% of their electricity is generated by nuclear power stations. For this reason high-speed railways in France have lower external costs related to climate change, but they have other environmental problems related to storage of waste from nuclear power stations (European Commission, 2010).

Japan generates only 1% of electricity by nuclear power stations and around 30% from solid fuels and 43% from gas (US EIA, 2015). USA generates around 13% of electricity from renewable energy resources (US EIA, 2016). High-speed rail in Sweden uses only renewable energy resources such as hydro power and solar power.

Approximately 80% of the railways in Europe and 100% of high-speed rail is powered by electricity, this means that high-speed rail do not contribute to greenhouse emissions. Railways are the most carbon efficient compared to aeroplanes or cars. High-speed train produces 17g carbon dioxide per passenger kilometre compared to a private car with 115g carbon dioxide or to an aeroplane with 153 g carbon dioxide per passenger kilometre (European Commission, 2010). However, there is a need for more detailed analyses of secondary carbon dioxide pollution from high-speed rail to fully estimate external costs of climate change related to high-speed railway.

There are many ways to make railways more energy efficient, some of them are: make trains lighter, reduce the axle load, and upgrade the infrastructure. Implementing the regenerative braking system on passenger trains can give up to 20% reduction in energy use.

“Eco Mode” is a computer based Train Control System that helps to reduce energy by reducing the engine idling in stations. Improving driving techniques of train drivers can also save on fuel (Kampman, *et al.*, 2009). Railways in Europe by 2050 have an ambitious target to have zero carbon dioxide emissions.

Noise Pollution

Noise levels are continually increasing and in the majority these increases have been drawn by the increasing amount of transport on roads, expansion of airports and railway networks and the

increasing of urbanization. This disrupts sleep, negatively affects health and reduces property prices, and therefore in overall the quality of life is reduced.

Noise is one of the most important environmental emissions for people who are living next to roads, railways or airports. The financial cost of noise and vibration is significant. It was estimated that noise and vibration pollution varies from 0.06% to 1.98% of the country's GDP (The Royal Society, 1995).

Approximately 90 million people in Europe at day time and almost 50 million at night time is affected by noise from road traffic. It is significantly more than 12 million people affected at day time and around 8 million at night time by noise from railways (Jehanno, Palmer, James, 2011). Railway traffic has the lowest percentage of noise pollution compared to air or road. However, not all high-speed railways have the same level of external costs caused by noise pollution.

ICE3, the high-speed train in Germany, has the lowest noise level compared to TGV in France, Shinkansen in Japan or Amtrak trains in the USA. Only TR07, Maglev train of Germany, has a lower noise level than ICE3 (Lynch, 1998). External cost of noise pollution from high-speed rail depends not only on technical issues, but also it depends heavily on the density of population living next to high-speed rail lines. For this reason external cost of ICE3 in Germany, is higher than external costs of TGV in France, as Germany has a higher density of population and more people are affected by noise from high-speed rail. The public were very concerned about increasing noise pollution from transport, and this was one of the reasons for Shinkansen, high-speed rail in Japan decided not to increase the speed of high-speed trains to a higher speed (Statistics Times, Web Pages, 2016).

There are many ways to decrease the noise emission produced by railways. One of them is to build the high-speed line in the cut-and-cover tunnels. For example, 40% of HS2 length will be covered by tunnels (Department for Transport, 2013). Building a noise barrier is another way of substantially reducing the noise pollution. Improving the rolling stock design, and track design can also reduce the noise pollution from railways.

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

The external costs substantially affect sustainability of transport systems and the road transport is responsible for the majority of it. Generally, the road user pays through taxation only about one-

third of the marginal external costs and as a result the external costs of transport and particularly road transport, have grown out of control. The rest of external costs relies on the society in the form of congestion, climate change and health problems.

Sustainable road systems mean that each road user must pay the full marginal cost of the journey. The current problem with the transport system is that journeys undertaken by individuals have not been fully paid. There is an urgent need to tackle this problem, but road lobbyists prefer to rely upon technological solutions rather than a direct reduction of demand.

Clearly, transport significantly influences growth of the economy and the level of advancement of transport systems indicates the level of countries development. However "social benefits from additional activity generated by transport activities will not compensate for the cost it represents to society which will hamper the development of other activities." (Jehanno, *al.*, 2011)

The sustainable transport system means that each transport user pays the full marginal cost of his or her journey. This will increase the demand for public transport and decrease the number of journeys taken by private motor vehicles. Pricing the environmental pollution of transport modes will encourage the consumer to choose the transport mode that is not only the best value for money, but it is also the most environmentally friendly mode. It will encourage use of the infrastructure more efficiently, reduce the negative effect from transport and improve the equality among transport modes. It will help the shifting of traffic from roads and airlines to more sustainable modes of transportation. In turn it will bring sufficient reduction in environmental externalities that overall will make all transport systems more sustainable. There are many ways to make transport systems more sustainable and this can be made possible through a technological improvement or reducing transport demand, or through a combination of both.

Many countries around the world are planning to build high-speed rail and it is important to look at ways to make them more sustainable. Comparing and evaluating existing roads and looking at the key influencing factors of sustainable railway systems indicate the way to have more sustainable high-speed railways. One of the ways to have more sustainable transport systems is to reduce the external cost of them. In some cases it can be more profitable to look at alternative ways to improve the transport mobility. It can be upgrading the conventional rail, using tilting

trains or looking for a new way of transportation. For example, the latest way of transportation, "Hyperloop" can replace all other medium to long distance transportation modes.

Regarding further research to look at ways to decrease external costs of railways it would be beneficial to study in more details the following:

- Evaluation of congestion on railways;
- Correlation between punctuality and accident rate, correlation between speed and accident rate and correlation between accident rate and type of high-speed rail;
- Nature of secondary carbon dioxide pollution from high-speed rail;
- Advantages of Green Growth approach for railways; and advantages of integrating the sustainable mobility products with in railways.

REFERENCES

Association for Safe International Road Travel, (2002-2016), Annual global crash statistics, available at: http://asirt.org/iniatives/informing-road-users/road-safety-ffacts/rooad-crash-stats, (Accessed 30th April 2016)

Baron, T. (2009), High speed rail contribution to sustainable mobility, available at: https//www.docplayer.fr/3506286-high-speed-rail-contribution, (Accessed 7th April 2016)

Central Japan Railway Company, (2016), Safety, available at:

http://english,jr-central.co.jp/about/safety.html, (Accessed 6th July 2016)

Department of Transport, (2013), HS2engine for growth impacts of tunnels in the UK, available at: http://hs2.org.uk/sites/default/files/inserts/impacts%20of%20tunnels%20UK.pdf, (Accessed 6th May 2016)

Dulac, J. (2013), Global land transportation requirements, available at: https//www.iea.org/publications/freepublications/publication/global-land-transport-infrastructure-requirements.html, (Accessed 6th 2016)

EC Mobility & Transport, (13th April 2011), All Facts and Figures, Roadmap to a single European transport area, available at: http://ec.europa.eu/transport/strategies/facts-and-figures/all-themes/index_en.htm, (Accessed 30th April 2016)

European Automobile Association, (2014), Passenger car fleet per capita, ACEA, available at:

http://www.acea.be/statistics/tag/category/passenger-car-fleet-per-capita, (Accessed 6th May 2016)

European Commission, (2010), High Speed Rail Europe, A sustainable link between citizens, available at: http://ec.europa.eu/transport/themes/infrastructure/studies/doc/2010_high_spped_rail_en.pdf, (Accessed 6th May 2016)

European Conference of Ministers of Transport, (1998), Efficient transport for Europe, Paris, OECD Publications, pp 23-34, 45-71

European Railway Review, (Issue2, 2016), UK remains one of the safest railways in Europe, p8

The European Railway Webring, (June 1998), Danger ahead! Historic railway disasters, special report, Eschede, Germany: available at:

http://www.danger-ahead.railfan.net/features/eschede.htm, (Accessed 6th May 2016)

IPPC Climate Change, (2007), Working Group1, The Physical science basis, available at:

http://www.ipcc.ch/publications_and_data/ar4/wg1/en/, (Accessed 30th April 2016)

ITV News, (9th February 2016), German train crash: The latest in a history of rail accidents, available at:

http://itv.com/news/2016-02-09/a-history-of-german-train-disasters/, (Accessed 6th May 2016)

Jehanno, A., Palmer, D., and James, C., (2011), High Speed Rail and Sustainability, available at:

http://www.old.uic.org/download.php/publication/531E.pdf, (Accessed 30th April 2016)

Kapman, B., Rijkee,X., Pidmore, A., Hulskotte, J., (2009), EU Transport GHG routes to 2050, pdf, available at:

http://www.eutransportghg2050.eu/cms/assets/EU-Transport-GHG-2050-Paper-4-Operational-Options-30-10-09.pdf, (Accessed 6th May 2016)

Leibling, D., (2008), RAC Foundation, available at:

http://www.racfoundation.org/assets/rac_foundation/content/downloadables/car%20ownership%20in%20great%20britain%20-%20leibling%20-%20171008%20-%20report.pdf, (Accessed 6th July 2016)

Lynch, T., (1998), High Speed Rail in the U.S.: super trains for the millennium, Amsterdam, Netherlands: Gordon and Breach Science Publishers, p.84

Maddison, D., Pearce, D., (1996), The true cost of road transport, Blueprint5, London: Earthscan, pp11-18, 51-61, 84-89, 132-190

Railway Technical Web Pages, (2016), Railway statistics for Britain, available at:

http://www.railway-techniczal.com/statistics.shtm, (Accessed 6th May 2016)

Statistic Times, (2015), Population density, available at:

http://www.statistictimes.com/population/countries-by-population-density.php, (Accessed 6th July 2016)

TCPA Policy Statement, (2015), Planning for an accessible and sustainable Transport 2005, available at:

http://www.tcpa.org.uk/data/files/transport/pdf, (Accessed 5th May 2016)

The Royal Society, (1995), The railways, challenges to science and technology, London, pp 11-33

UIC, CER, (June 2008), Rail transport and environment, facts and figures, pdf, available at:

http://www.siteresources.worlbank.org/EXTRAILWAYS/resources/515244, (Accessed 30th April 2016)

UIC, CER, (September 2015), Rail transport and environment, facts and figures, available at:

Paris: UIC, CER, booklet, pp39-42

US Energy Administration, (September 2015), Japan intends to restart some nuclear plants in 2015, available at:

http://www.eia.gov/todayinenergy/detail.cfm?id=19951, (Accessed 30th April 2016)

US Energy Administration, (2016), International Analysis, Japan, available at: http://www.eia.gov/beta/international/analysis.cfm?iso=JPN, (Accessed 6th July 2016)

White Paper for Transport, (2011), available at: http://ec.europa.eu/transport/themes/strategies/2011_white_paper_en.htm, (Accessed 6th July 2016)

IMPROVING SAFETY PERFORMANCE IN CONSTRUCTION USING SAFETY CLIMATE FACTORS

Tariq Umar- A'Sharqiyah University, Oman

Data from a number of industrialized countries show that construction workers are 3 to 4 times more likely than other workers to die from accidents at work. In the developing world, the risks associated with construction work may be 3 to 6 times greater. Construction is one of the world's biggest industrial sectors, including the building, civil engineering, demolition and maintenance industries, and in Oman it accounts approximately 10% of the total GDP. Statistic indicates that a total of 723000 residents including 91% foreigners were working in 100000 construction organizations in 2014 and have the second largest rate of occupational injuries after manufacturing industry with an estimated cost of 3.7 M US$ per year. Construction workers are exposed to a wide variety of hazards on the job, including dusts and vapours, asbestos, awkward working positions, heavy loads, adverse weather conditions, work at heights, noise, vibration from tools, and therefore closer to occupational accidents. In recent years the awareness of the importance for safety performance of organizational, managerial and social factors, has increased. Safety climate is an aspect of organizational climate, offers a route for safety management, complementing the often predominant engineering approach. While the composition of workforce and cost of accidents are discussed here, this paper further present the research in progress on using safety climate factors for improvement of safety performance in construction organizations. Eight key factors which influence safety climate are identified by a thorough review of published literatures including twelve safety climate questionnaires having 55 different factors. The process on how to measure these factors among workforce of a construction project is discussed. The result of safety climate factors will help construction organization to improve their safety performance using different ideas and by making short mid and long term plans to achieve the required level of maturity for each safety climate factor.

Keywords: Construction safety, safety climate factors, safety performance, construction organization

INTRODUCTION

Statistics published by International Labour Organization (2015) indicated that at least 108,000 workers are killed on construction site every year, a figure which represents about 30 per cent of all occupational fatal injuries. Data from a number of industrialized countries show that construction workers are 3 to 4 times more likely than other workers to die from accidents at work. In the developing world, the risks associated with construction work may be 3 to 6 times

greater. Many more workers suffer and die from occupational diseases arising from past exposure to dangerous substances, such as asbestos. Construction is one of the world's biggest industrial sectors, including the building, civil engineering, demolition and maintenance industries. It accounts for a large proportion of GDP for many countries for example, 10 percent in the U.K., 17 percent in Japan, and 10 percent in Oman. Statistics published in the daily Times of Oman dated June 09, 2014, a total of 723,000 residents were working in construction industry.

In most developing countries, construction is among the fastest growing areas of the labour market, continuing to provide a traditional entry point for labourers. It is, however, one of the most dangerous industries. Construction workers build, repair, maintain, renovate and demolish houses, office buildings, factories, hospitals, roads, bridges, tunnels, stadiums, docks, airports and more. During the course of their work they are exposed to a wide variety of hazards on the job, including dusts and vapours, asbestos, awkward working positions, heavy loads, adverse weather conditions, work at heights, noise, and vibration from tools, many others. The causes of accidents and ill-health in the sector are well known and almost all are preventable. A report published in daily Times of Oman dated February 28, 2015 states that there is no official statistics of how many company workers get hurt in the course of their duties but according to the individual Health and Safety Environment's (HSE) records of top 10 contractors, more than 3,700 of them needed medical treatment in 2014. The injured workers who get hospitalized made up nearly 10 per cent of the total workers on this list. Sadly, about 18 per cent of them died either at the sites or in hospitals in 2015. In comparison to the previous year, 246 more workers got injured in 2014 but for obvious reason, company directors do not want this part of the record to be made public.

In construction organizations most of the workers are foreigner (92% of total work force) and as such they are not insured under the government authority. As per law of the country, construction organizations required to seek private insurance for their workers however as the risk associated with construction workers is high their insurance premium is comparatively more. Construction organizations further bear high cost at the time recruitment and pay for repatriation, compensation and replacement in case of accidents involving injuries and death. There is high potential for construction organizations to reduce the cost associated with accidents either direct or indirect by improving safety culture through safety climate.

In recent years the awareness of the importance for safety performance of organizational, managerial and social factors, has increased. Safety climate is a subset of organizational climate, offers a route for safety management, complementing the often predominant engineering approach. An understanding of the safety climate dimensions can be useful in improving the safety performance of an organization. In addition, safety climate investigations are more sensitive (e.g. multi-faceted) and proactive bases for developing safety, rather than reactive (after the fact) information from accident rates and accident and incident reports (Seo et al., 2004). Over the past century focus concerning factors influencing safety and safety improvements within industries has changed and expanded. Hale and Hovden (1998) describe three ages of safety: the technical age (1920's), the human factor age (1970's) and the management system age (1980's). The third wave or age of safety expanded the focus to include safety culture, and the concept of safety culture was first truly introduced and defined after the Chernobyl accident in 1986 (INSAG, 1992). Safety culture and safety climate are concepts that today attract much attention across a broad number of industries and sectors (Clarke, 2000). One of the reasons for this is that a rich safety culture and a mature safety climate are some of the most important factors in achieving a safe workplace. In order to improve the level of safety culture and safety climate it is important to: a) determine the current level of safety culture and safety climate, b) decide what level of safety culture and safety climate is needed, attainable and wanted, and c) to create a plan to achieve the safety culture and safety climate that is wanted (AIChE, 2012).

Safety climate may be defined as shared perceptions among the members of a social unit, of policies, procedures and practices related to safety in the organization. Safety climate investigations are more sensitive (e.g. multi-faceted) and proactive bases for developing safety, rather than reactive (after the fact) information from accident rates and accident and incident reports Safety climate is defined as workgroup members' shared perceptions of management and workgroup safety related policies, procedures and practices. Researchers and practitioners have identified safety culture and safety climate as key to reducing injuries, illnesses and fatalities on construction worksites. Many construction contractors are trying to improve these indicators as a way to move closer to a goal of achieving zero injury worksites. This paper presents the initial research of how different safety climate could be used by construction organizations to improve their safety performance.

WORK FORCE IN CONSTRUCTION INDUSTRY OF OMAN

Oman construction industry in highly populated by foreign worker composing 92% of the total workforce. The construction workforce in Oman is male dominated while the female form only 1.4 % of the total. Most of the workforce is employed by grade I and grade II construction organization as shown in table 1. The majority foreigner workforce (75%) is either skilled or semi-skilled and they originate from Asian and African countries without any formal education. The 38 % of the total expatriate population living in Oman are having education level of primary or below (NCSI, 2015). Construction is one of the industry normally employee such workers. In fact construction is the only industry where educational level does not matter; if one does not find work anywhere, he or she can get in construction where the only requirement is they can do the required work? The composition of expatriate worker in different construction organizations registered in Oman by their role is shown in Figure 1.

Construction Organizations			
Type of Workforce	**Grade One and Above**	**Grade two and below**	**Total**
Omani Male	43979	1475	45454
Omani Female	8100	1199	9299
Expatriate Male	386486	295999	682485
Expatriate Female	1302	53	1355
Total	439867	298726	738593
Grand Total	738593		

Table 1: Distribution of Workforce in Construction Organizations (2015) – (OSC, 2016)

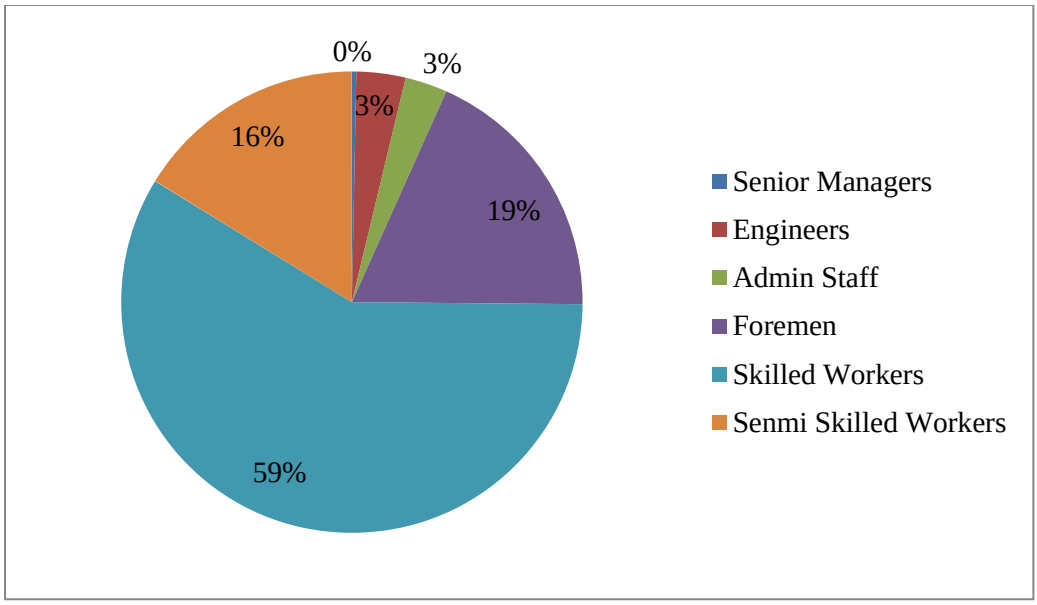


Figure 1- Distribution of Expatriate in Construction Organizations of Oman (2015) – (OSC, 2016)

PROJECTS IN OMAN

The largest project in Oman which is in pre-execution phase is Oman Rail (Oman National Railway), with a total length of 2,135 kilometres (km), and has a budgeted value of US$15.6 billion. It will be executed in nine segments and will be completed by 2022. It is divided into several segments linking Oman's borders with the UAE to Muscat, as part of the GCC Railway Network. It will also link to the southern parts of the country including port of Al Duqm, port of Salalah and the Yemen border. The railway line will be doubled track, non-electrified and it is designed to serve mixed freight and passenger. The map of proposed Oman rail network is shown in figure 2. The next two largest projects which were expecting to be awarded in 2015-2016 financial year are having the values of US$1.7 billion and US$1.3 billion. The first project is of Oman Oil Refinery and Petroleum Industries Company, "Liwa Steam Cracker and Polyethylene Project" for enhancing both fuel and plastics production. The second project is of Special Economic Zone Authority at Duqm, "Liquid Terminal Project" which is designed to handle the increase in liquid volumes associated with a large scale refinery and petrochemicals hub envisioned at the Special Economic Zone.

By looking at ongoing and planned projects in different sectors in Oman including those which are expected to be awarded in financial year 2015-2016, the construction sector projects stand out as the largest one, amounting to US$ 43160 Million (Deloitte, 2015). The value of ongoing and planned projects including projects in construction sectors for financial year 2015-2016 in Oman are shown in Figure 3.

Figure 2-Oman Rail Network (Oman Rail, n.d)

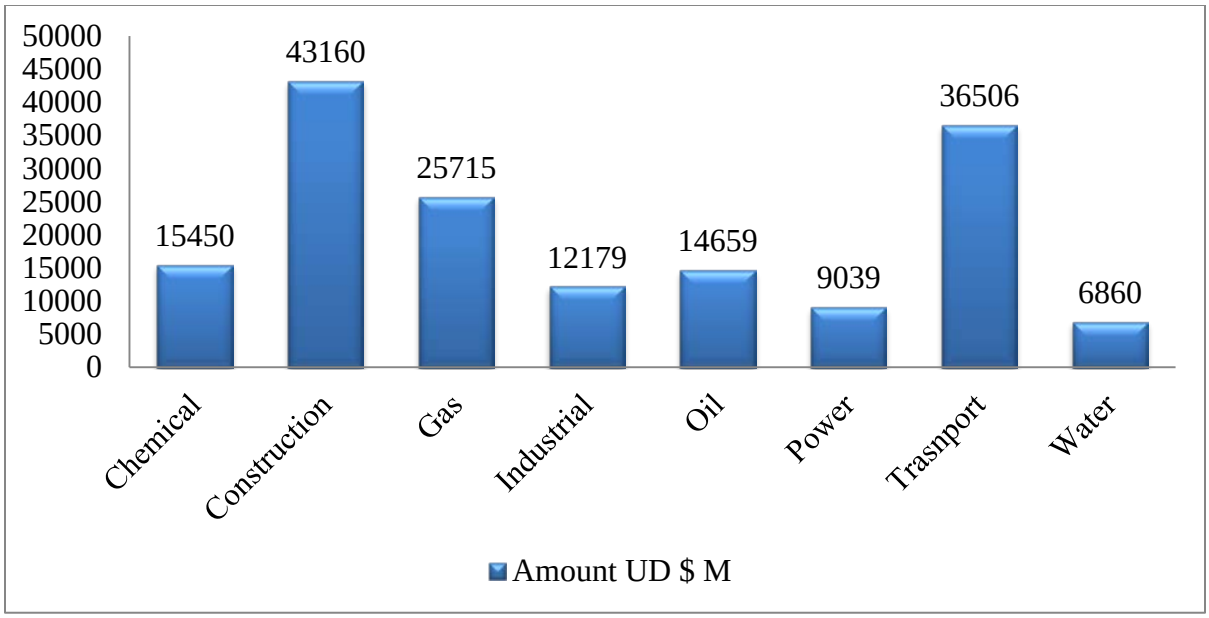


Figure -Values of Ongoing and Planned Projects in Different Sectors of Oman (Deloitte, 2015)

COST OF ACCIDENTS IN CONSTRUCTION

In terms of safety performance the construction industry in Oman is not advanced as the UK and USA, therefore it is anticipated that the cost associated with this industry could be comparatively more. An internet based search covering six months (May 2015 to November 2015) of one daily newspaper shows that nine construction workers were killed and twenty five were injured in Oman at different construction sites. These were major accidents in construction sites located in cities therefore they published in newspaper, there could be accidents happened in construction sites which were not reported because it may happened in a remote area or the accidents were minor involving less casualties and injuries. Although, in Oman the true cost of accident associated with construction industry need to be carefully calculated, however in this article, a rough cost of construction accident in Oman is calculated considering two criteria i.e. number of total workers and cost of Projects.

Cost of accidents based number of workers

The public Authority of Social insurance in Oman registered Omani nationals' annual report for 2014 shows that 401 cases of work related injuries were disbursed which cost a total amount of

US$ 1055600 (PASI, 2014). The number of active insurees in the Social Insurance System was 197510 in 2014; which means on average the cost of accident was US$ 5.35 / insure/ year. This can be applied to the total number of workers (700000) in construction industry of Oman to get rough cost of accident in construction which comes to US$ 3.74 Million per year.

Cost of accidents based on project cost

Cost of accident in USA was determined as 6.5% of the total value of completed work and in UK it is approximately 8.5% of the tender value (The Business Roundtable, 1995, Anderson, 1997). The cost of accident associated with construction in Oman is determined based on the average of these two values which is 7.5 %. (6.5%+8.5% = 7.5%). In Oman the construction projects in 2015, were amounting to a value of US$ 43160 Million and 7.5% of the amount is US$ 3237 Million which is cost of accident in construction. Cost of accident associated with construction and other projects determine based on this principle are shown in figure 4.

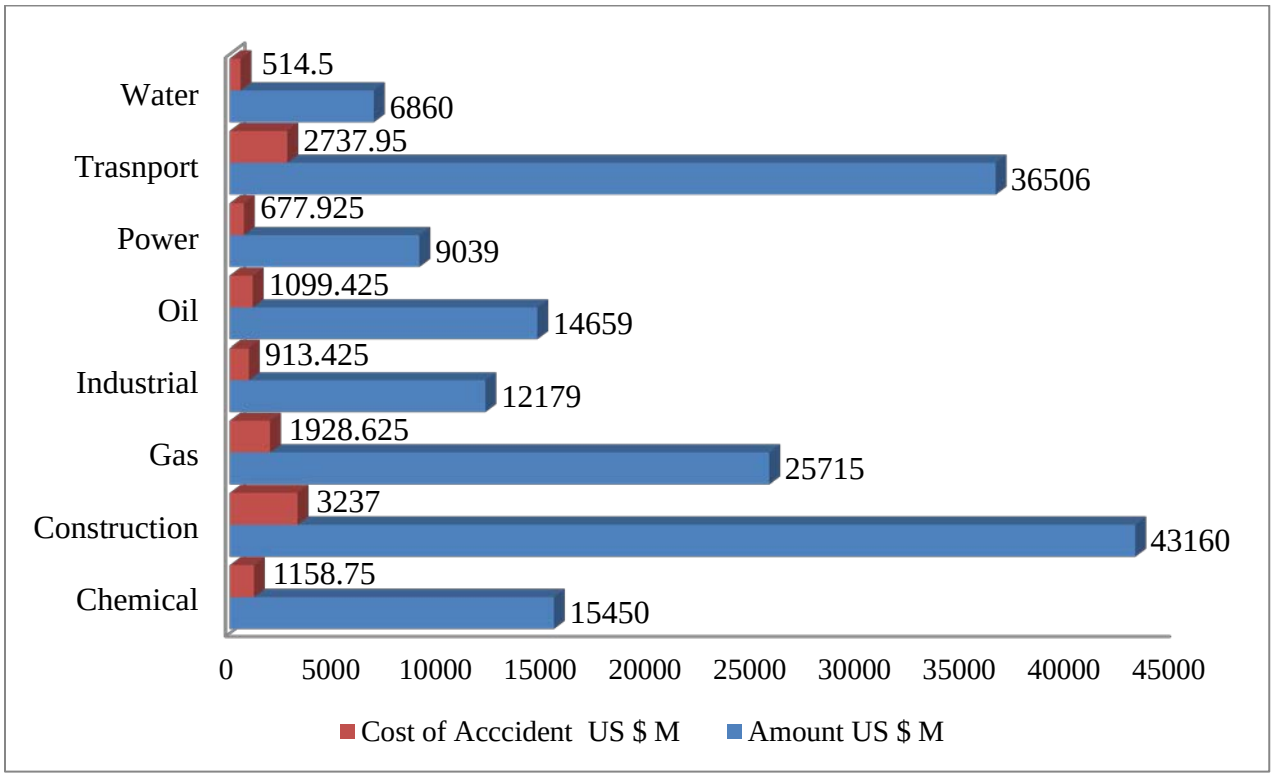


Figure 4-Projects Values in Different Sectors for Year 2015-2016 and Cost of Accident in Oman.

DEFINING SAFETY CLIAMTE

Although the meaning and definition of the term safety culture remains a subject of deliberation and debate, it is generally accepted that safety culture has an impact on safety performance. Recent UK research concluded that factors that contribute negative and positive safety cultures in construction includes; organizational factors, individual factors, team factors, job design factors, management factors and supervisory factors (Wamuziri, 2013). It should however be noted that safety climate and safety culture are distinct but related concepts.

The safety climate on a specific construction project refers to managements' and workers' shared perceptions of the adequacy of the safety and health programs and the consistency between the organization's espoused safety policies/procedures and the actual conditions at the jobsite. It is the combination of safety climates from multiple organizations including the project owner, construction manager/general contractor, and subcontractors and it may be influenced by local conditions such as project delivery, scheduling, planning methods and existing norms amongst involved trades (CPWR, 2014).

SAFETY CLIMATE FACTORS

An internet search using the key words "safety climate factors" and "safety climate assessment tool" has been conducted to find different safety climate factors used by different researchers. The selected search period was from 1980 to 2011. A total of twelve safety climate assessment tools obtained by this search have been complied with full details as shown in appendix I. Briefly, the number of assessment tools found through internet search was one in each year 1980, 1991, 1997, 2000, 2004, 2005, 2006, 2008 and 2010; while there were three tools found in 2011. The leading safety climate factors (55 factors) used in these assessment tools are further mapped with each other and arranged as under;

1. Demonstrating Management Commitment
2. Aligning and Integrating Safety as a Value
3. Ensuring Accountability at all Levels
4. Improving Supervisory Leadership
5. Empowering and Involving Workers
6. Improving Communication
7. Training at all Levels

8. Encouraging Owner/Client Involvement

USING SAFETY CLIMATE FOR IMPROVEMENT OF SAFETY PERFORMANCE

Safety climate of a construction project or construction organization can be assessed by means of quantitative, psychometric questionnaire surveys, so-called 'safety climate scales', measuring the shared perceptions/opinions of a group of workers on certain safety-related dimensions or factors. The outcome of such safety climate scales are regarded as a predictor or indicator of safety performance. The Nordic safety climate questionnaire (NOSAQ-50), developed by a group of researchers at National Research Centre for the Working Environment at Denmark (Kines *et al.,* 2011), consists of 50 questions across seven safety climate dimensions and uses a scale of 1-4 (strongly agreed – strongly disagreed). This questionnaire is available in over 25 languages, and results from around the world are currently being collected in an international database in order to allow for benchmarking and further development. The Centre for Construction Research and Training (CPWR,2014) suggests the assessment of leading safety climate factors on a scoring scale of 1-5 (strongly agreed – strongly disagreed). These safety climate factors can be measured among different categories of staff working in construction organization or in a project undertaken by the construction organization. The results will reflect the safety climate of organization or safety climate of the specific project. After the assessment of safety climate factors, construction organizations will be able to identify and prioritize the weak area for improvement. Safety climate leading factors can be reviewed on a five level scoring scale to assess what level of safety culture for that factor is achieved by construction organization. Maturity level for all the factors can be classified as uniformed, reactive, complaint, proactive and exemplary. Construction organizations can make short term (1-2 months), mid-term (6-12 months) and long term (1-2 years) plans if the required level for the factors is not adopted by using different ideas. The process of safety climate from assessment towards a mature level is shown in figure 5.

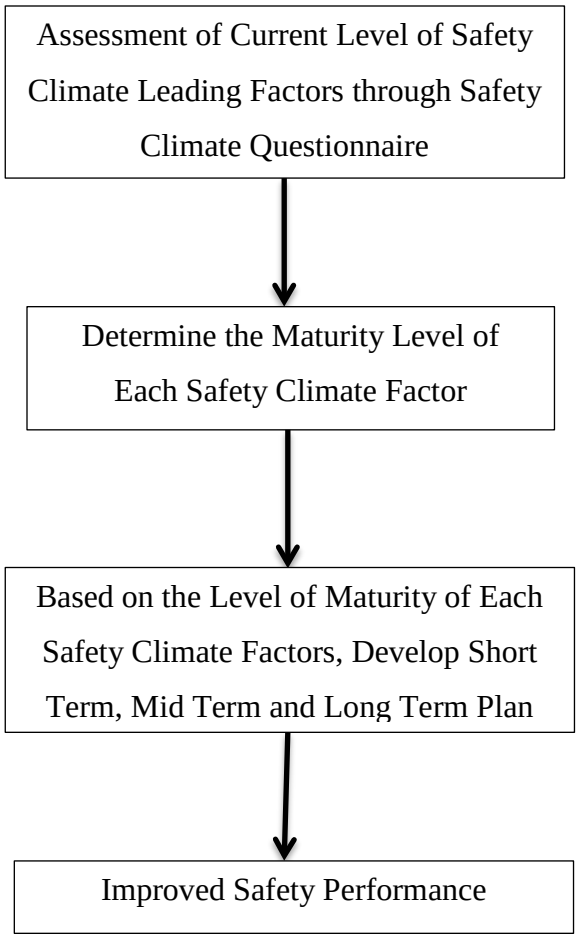


Figure 5-Process of Using Safety Climate to Improve Safety Performance

CONCLUSION

Infrastructure projects in Oman are at the peak now. Construction organization in Oman has a huge potential and requirement to reduce the cost of accidents especially in current scenario as the price of oil has significantly lower and project funding are affected. The Rich safety culture and mature safety climate are important factors which can help in improving the safety performance of construction organization. The method of assessment of safety climate factors is explained in this article. Such assessment can help the construction organization to make plans for achieving the required level of safety climate maturity. Safety climate is one of the concepts which can improve safety performance; however, safety climate alone is not the key that can ensure that accidents will not take place on construction sites. The construction organization size

could be one of the factors which can restrict the adopting this concept of improving safety performance; therefore the effectiveness of using safety climate factors in different size of construction organizations needs to be evaluated. The major issue with small construction organizations could be their financial status and capability to adopt the safety climate approach for improvement of safety performance.

REFERENCES

AIChE (American Institute of Chemical Engineers), (2012), n.d., Safety Culture: "What is at stake" <www.aiche.org/ccps/topics/elements-process-safety/commitment-process-safety/process-safetyculture/building-safety-culture-tool-kit/what-is-at-stake>

Anderson, J (1997), The problems with construction. The Safety and Health Practitioner, May, 29 - 30.

Hale A. R. and Hovden, J. (1998), Management and Culture: the third age of safety. A review of approaches to organizational aspects of safety, health and environment. Occupational Injury: Risk, Prevention And Intervention 1998, 129-227.

Clarke, S. (2000), Safety culture: underspecified and overrated? International Journal of Management Reviews, 2, 65-90.

CPWR (2014), The Center for construction research and training repot ‘’Strengthening Jobsite Safety Climate’’ 2014.

Deloitte (2015), Deloitte GCC Powers of Construction 2015 Construction – The economic barometer for the region.

https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/real-estate/deloitte-uk-gcc-powers-of-construction-2015.pdf

(Accessed on April 27, 2016)

INSAG (International Nuclear Safety Advisory Group), (1992), INSAG-7 The Chernobyl Accident: Updating of INSAG-1, Safety Series No. 75-INSAG-7.

NCSI (2015) National Center for Statistics and Information, Oman Statistical Year Book Issued No. 43.

Oman Rail (n.d), Project, http://www.omanrail.om/brochure.html, (Assessed on April 27, 2016).

OSC (2016), Oman Society of Contractors (2016), Annual General Meeting Report, 12 January; 2016.

PASI 2014, Public authority of Social Insurance (PASI) Oman, 21st annual report 2014.

Kines, P., Lappalainen, J., Mikkelsen, K. L., Pousette, A., Tharaldsen, J., Tómasson, K. & Törner, M. (2011), Nordic Safety Climate Questionnaire (NOSACQ-50): A new tool for measuring occupational safety climate. Int. J. Industrial Ergonomics, 41, 634-646.

Wamuziri, S. (2013), Factors that Influence Safety Culture in Construction, Proceedings of the Institution of Civil Engineers: Management, Procurement and Law. 166, 219-231.

Seo, D.C., Torabi, M.R., Blair, E.H., Ellis, N.T. (2004), A cross-validation of safety climate scale using confirmatory factor analytic approach. Journal of Safety Research 35 (4), 427-445.

The Business Roundtable (1995), Improving Construction Safety Performance Report A - 3. New York: The Business Roundtable.

APPENDIX I				
S.No.	Name of tool or survey Author Source	Used in Construction?	Number of Questions	Number and Name of Included Dimensions/ Factors
01	Institute of Work & Health 2011 Benchmarking Organizational Leading Indicators for the Prevention and Management of Injuries and Illnesses: Final Report. http://www.iwh.on.ca/benchmarking-organizational-leading-indicators	Utilities	8	-Not divided into factors -Leading indicator tool developed for Ontario workplaces
02	Dedobbeleer & Beland 1991 A safety climate measure for construction sites. Journal of Safety Research 22(2): 97-103 http://www.sciencedirect.com/science/article/pii/002243759190017P	Yes	9	2 -Management commitment -Worker involvement
03	DeArmond et al. 2011 Individual safety performance in the construction industry: Development and validation of two short scales. Accident Analysis and Prevention 43 (948–954) http://www.sciencedirect.com/science/article/pii/S0001457510003647	yes	10	2 -Safety compliance -Safety participation
04	Zohar & Luria, 2005 A Multilevel Model of Safety Climate: Cross-Level Relationships Between Organization and Group-Level Climates. Journal of Applied Psychology 2005, Vol. 90, No. 4, 616–628 http://psycnet.apa.org/journals/apl/90/4/616.html	yes	16	6 3 Organizational Level -Active practices (monitoring, enforcing) -Proactive practices (promoting learning, development) -Declarative practices (declaring, informing) 3 Group Level -Active practices (Monitoring, controlling) -Proactive practices (Instructing, Guiding) -Declarative practices (Declaring, Informing)

05	Parker et al, 2006 A framework for understanding the development of organizational safety culture. Safety Science 44 (2006) 551 562 http://www.sciencedirect.com/science/article/pii/S0925753505001219	No (oil industry)	18	Uses 5 descriptions (text-based rubrics) reflecting level of organizational safety culture maturity Descriptions divided into two categories: - Concrete organizational aspects -Abstract organizational concepts
06	Seo et al. 2004 A cross-validation of safety climate scale using confirmatory factor analytic approach. Journal of Safety Research 35 (2004) 427– 445 http://www.sciencedirect.com/science/article/pii/S0022437504000817	No	30	5 - Management commitment to safety - Supervisor safety support - Coworker safety support - Employee participation in safety-related decision making and activities -Competence level of employees with regard to safety
07	Pousette et al. 2008 Safety climate cross-validation, strength and prediction of safety behavior. Safety Science 46 (2008) 398–404 http://www.sciencedirect.com/science/article/pii/S0925753507000926	Yes Swedish tunnel workers	33	4 -Management safety priority - Safety management - Safety communication -Workgroup safety involvement
08	Neal, Griffin & Hart 2000 The impact of organizational climate on safety climate and individual behavior. Safety Science, 34, 99-109, 2000 http://www.sciencedirect.com/science/article/pii/S0925753500000084	Yes but not published	35	8 - Management values - Communication - Training -Physical Work Environment - Safety Systems - Knowledge - Motivation

				- Behavior
09	Zohar, 1980 Safety Climate in Industrial Organizations: Theoretical and Applied Implications Journal of Applied Psychology 1980, Vol. 65, No. 1, 96-102 http://psycnet.apa.org/journals/apl/65/1/96.pdf	Yes	40	8 -Management attitude toward safety - Work pace and safety - Effects of safe conduct on promotion - Effect of safe conduct on social status - Perceived risks -Perceived importance of safety training - Perceived status of safety officer - Perceived status of safety committee
10	UK HSE Safety Climate Tool 1997 http://www.lboro.ac.uk/departments/sbe/downloads/pmdc/safety-climate-assessment-toolkit.pdf	Yes (2012 London Olympics)	43	8 -Organizational commitment - Health and Safety oriented behavior - Health and Safety Trust - Usability of Procedures - Engagement in health and safety - Peer group attitude -Resources of health and safety -Accidents and near miss reporting
11	Gittleman et al. CPWR survey, 2010 [Case Study] City Center and Cosmopolitan Construction Projects, Las Vegas, Nevada: Lessons learned from the use of multiple sources and mixed methods in a safety needs assessment. Journal of Safety Research Volume 41, Issue 3, June 2010, Pages 263–281 http://www.sciencedirect.com/science/article/pii	Yes (Las Vegas City Center Project)	44	Not divided into factors Survey includes separate questions for general contractor and subcontractors

	/S0022437510000447			
12	Nordic occupational safety climate questionnaire Kines, et al. http://www.arbejdsmiljoforskning.dk/en/publikationer/spoergeskemaer/nosacq-50	yes	50	7 -Management safety priority, commitment, and competence -Management safety empowerment - Management safety justice -Workers' safety commitment -Workers' safety priority and risk non-acceptance -Safety communication, learning, and trust in co-workers safety competence -Trust in the efficacy of safety systems Currently translated into 25 languages.