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ADVANCES IN BUILDING ENVIRONMENTAL SUSTAINABILITY ASSESSMENT TOOLS/METHODS AND THE NIGERIA CONTEXT: A REVIEW

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ABSRACT: *Improving the environmental performance of buildings is increasingly gaining global attention of researchers, policy makers/government agencies and the construction industry. This is because the construction industry as emerging sector is highly active in both developed and developing countries and responsible for the high level of carbon dioxide emissions and energy consumption especially in countries described as emerging economy. However, measuring the environmental performance or sustainability of buildings in developing countries like Nigeria, is relatively new and the practice of measuring sustainability is largely based on declarations that come from self-assessed developers and building material producers. The assessment methods, either environmental or performance-based are under constant evolution in order to surmount their various limitations. However, two main assessment approaches can be identified or distinguished: qualitative assessment methods and quantitative assessment methods. The field of environmental assessment methods/tools for buildings is vast, the aim of this paper is to clarify that field by analysing the terminologies and categorising existing tools in the context of the Nigerian building industry.*

KEY WORDS: Building environmental assessment tool, Sustainability, Qualitative and Quantitative assessment methods

INTRODUCTION

Generally, sustainability is a term that describes the interactions and important relationships among environmental, social and economic parameters. With regards to the building industry, sustainability ensures that a building is environmentally friendly, economically feasible and provides healthy / quality indoor environment to its users (Tsimplokoukou & Paolo, 2014). On the other hand, sustainable building construction refers to series of construction techniques adopted for implementing construction project that promote environmental preservation, increased use of recycled materials, actions that are beneficial to the society, and profitable aspects for the company (Shena et.al 2010). Improving the environmental performance of building is increasingly gaining global attention of researchers, policy makers and the construction industry. This is because of the highly active nature of the construction industry in developed and developing countries and is responsible for the high level of carbon dioxide emissions and energy consumption (Tang & Wu, 2014). In Nigeria for instance, Buildings and construction activities are the second fastest growing sector in the Nigerian economy – second only to the telecommunication industry (NPC, 2012).
The need to achieve environmental sustainability is rooted in the realization that the benefits of development have be distributed unequally and there have more negative impacts on the environment (Harris, 2003).This is evident in fast growing cities like Abakaliki–Nigeria. As a result of the urbanization many traditional societies have been devastated by heavy construction

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activities/deforestation, disruption of water ways. This negative trend was also highlighted by (Mead, 2008) that "we are living beyond our means. As a people we have developed a life – style that is draining the earth of its priceless and irreplaceable resources without regard for the future of our children and people all over the world" (Mead, 2008).

Construction project can be considered sustainable when all the three dimensions of sustainability – environmental, economic, and social – are taken into consideration. These dimensions of sustainability can actually be interwoven and influence each other, while the inter relationship of a building with its surroundings creates various effects such as global warming. Tsimplokoukou & Paolo (2014), added that with reference to the building sector, preservation of the cultural heritage, natural conservation, use of eco-friendly building materials, energy saving and more quality indoor conditions are the main objectives of environmental sustainability. However, to realize these objectives and enhance sustainable architectural practice and building construction, holistic approaches must be adopted and building sustainability assessment method will contribute energy in promoting a more sustainable built environment (Mateus & Braganca, 2011).

Appraisal of Existing building environmental assessment methods

Measuring sustainability in buildings is a complex task. Considerable research work has gone into developing approach or systems to measure building's environmental performance over its life (Ding, 2008). These systems or methods have been developed as an instrument for assessing how successful any development is with regards to balancing energy, environment and ecology, considering both the social and technological aspects of the building project (Clement-Croome, 2004).Building environmental performance assessment has emerged as one of the major issues in sustainable design and construction (Holmess & Hudson, 2000).

However, measuring the environmental performance or sustainability of buildings in developing countries like Nigeria, is relatively new and the practice of measuring sustainability is largely based on declarations that come from self-assessed developers and building material producers (Giwa & Peng, 2012). Most of the building sustainability assessment tools cover the building level and are based on some form of life – cycle assessment database (Seo, Tucker, Ambrose, Mitchell, & Wang, 2006). According to Ding (2008), these tools are basically in two categories; Assessment Tools and Rating tools. Assessment tools provide quantitative performance indicators for design alternatives, while rating tools determine the performance level of a building in stars. The main purpose of environmental building assessment method is to provide a holistic environmental characteristics of a building (Cole, 1999). This is done by using a common and verifiable set of criteria and targets for building owners and designers to attain higher environmental standard.
Ding (2008) added that, environmental building assessment method enhances the environmental awareness of building practices. Thereby setting out the needed direction for the building sector to move towards environmental protection and archiving environmental sustainability goals. Especially in countries like Nigeria that are experiencing rapid urbanization due to massive housing development from both the informal and formal sector of the building industry. The majority of environmental building assessment methods are developed for local use and do not allow for national or regional variations. These variations include; difference in climatic conditions income level, building materials and construction techniques, building stocks, and application of historic valve (Kohler, 1999) and differences in transportation mode or building material haulage.

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According to International Energy Agency (IEA) project, Annex31 (IEA, 2012) environmental assessment tools can further be categorized into five classes. They are; (i) Energy modelling software (ii) Environmental life cycle assessment (iii) Environmental assessment frameworks and rating systems, (iv) Environmental guidelines or checklist and (V) Environmental product declaration catalogues, reference information certificate and labels.

Understanding building environmental assessment system terminologies

Building sustainability and sustainable building assessment system are terms often used interchangeably depending on the author. Shari (2011) observed that there are three terminologies mostly used to describe building assessment system. These terminologies are; Building environment assessment system, Sustainable building assessment and Building sustainability assessment (Shari, 2016). In most cases the first is used to describe green building while the other two are often uses in the context of sustainable building. The next questions will be – what is the difference between sustainable building and green building; and are all green building sustainable? A building is said to be green when it is designed and built to reduce the footprint it leaves on the natural environment and on the health of its occupants. This can be achieved by focusing on energy efficiency, renewable energy sources, natural ventilation systems, minimizing the use of materials with high level of volatile organic compounds (VOCs) and creating healthy indoor environment (Martty, 2016). Cole (1999) was however on the opinion that green building is a term that describe building design strategies that reduce the environment and ecological damages associated with buildings. On the other hand, sustainable building goes beyond health or environmental issues. For a building to be sustainable, it must embrace the three pillars of sustainability; economic dimension, social dimension and environmental dimension.

Green building must not necessarily be designed to all the standards of a sustainable building but the design must focus on energy efficiency, resource depletion, impacts on the environment and protection of human health (Lutzkendorf & Lorenz, 2006).

Qualitative Assessment Methods Vs Qualitative Assessment Methods

The development of building environmental sustainability assessment methods and respective tool is a huge challenge for researchers and architects in practice. The challenge ranges from managing the flows of information to accessing the knowledge between the various levels of indicator systems (Braganca, Mateus, & Koukkari, 2010). The assessment methods, either environmental or performance -based are under constant evolution in order to surmount their various limitations. However, two main assessment approaches can be identified or distinguished: qualitative assessment methods and quantitative assessment methods (Reijnders & Roekel, 1999 and Forsberg & Malmberg, 2004).

Qualitative Environmental Assessment Methods

The qualitative assessment method are generally based on the auditing of buildings, followed by rating or scoring of assessed criteria, which results in an overall rating or score for the building performance (Forsberg & Malmberg, 2004). Cole (1998) opined that Qualitative assessment methods are based on the relative environmental performance of a building when compared with other buildings or design alternatives. The scores or rating could be based on quantitative data, e.g. energy use, common sense or experiences (Blom, 2006). Nevertheless, international consensus

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does exists on the development, applications, and use of such data (Kohler, 1999) (Cole, 2005) (Kohler, 1999). The advantages of qualitative assessments methods are:

i) It is less complex, thus requires less time and expertise in performing the assessment.

ii) It takes into account indicators that are difficult to quantify e.g. land use.

On the other hand, the disadvantages includes;

I) In most cases, the validity result of qualitative assessment are easily challenged scientifically. This is because some aspect of the assessment are based on non-validated assumptions and the weighting of scores to obtain a single number result is subjective (Blom, 2006).

ii) It is often difficult to establish a benchmark, due to many design variables

iii) Blom (2006), added that it is almost impossible to rank all technological possibilities for scoring purposes. The leaning that scoring is based on available data.

iv) Qualitative assessment method does not take into consideration all environmental issues relating to building. That means environmental problems considered are limited, thereby making the level of detail in the assessment result relatively low.

Cole (2005) added that the criteria used in qualitative tools tend to be open to wider interpretation by assessors and hence require the commitment of an unbiased third party to be successful. The most commonly known qualitative assessment tools are; Envest, Breeam, Leed, Green Building Tool (SBT), Green Star, Hong Kong Building Environmental Assessment Method (Hk Beam) and Sustainable Building Assessment Tool (SBAT)

LEED

Leadership in Energy and Environmental Design (LEED) was developed and piloted in the United States in 1998 as a consensus – bases building rating system adopting the existing building technology (Fowler & Rauch , 2006). LEED is one of the most widely accepted green building rating system in the US and presently efforts are being made to integrate LCA in the LEED assessment system (Trusty, 2006) . LEED consists of nine a suite of nine rating systems for the design. Construction and operation of buildings. According to Schmidt (2012). The basic LEED rating system has a maximum of 100 points or credits for a building and the rating system is organized into five (5) environmental categories each with a maximum of possible points: sustainable sites (26 possible points), water efficiency (10 possible points), Energy and atmosphere (35 possible points), Materials and Resources (14 possible points), indoor Environmental Quality (15 possible points). Points between credits are assigned based on the potential environmental impacts and human benefits of each credit with regards to a set of impact categories (Schmidt, 2012). LEED uses the U. S. Environmental Protection Agency (USEPA) TRACI environmental impact categories as the basis for weighting each credit (USEPA, 2006). .

BREEAM

Bream-Building Research Establishment Environmental Assessment Method was first published by the Building Research Establishment in 1990. Bream is the world's longest established method of assessing, and rating, with the aim of reducing the negative effect of construction and development on the environment (Watts & Norman, 2011). It can be used in various ways across different professing ranging from clients, developers and design team and building/property managers (BREEAM, 2010) .

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The BREEAM assessment procedure evaluates procurement, design, construction and operation of a development against targets that are based on performance benchmarks. According to Breeam (2010), it measures sustainable value in a series of categories, ranging from energy to ecology fig… And each of these categories addresses most influential factors, including low impact design and carbon emission reduction; design durability and resilience; adaption to climate change; and ecological value and biodiversity protection. Each of these categories are assigned development score points-called credits-for achieving targets and their final total determines their rating. The categories are sub-divided into range of issues which advances the use of new benchmarks, aims and target. (Breeam 2017). When a target is reached credits are awarded.

SBAT

The sustainable building assessment tool (SBAT) has been developed as a means of supporting the implementation of more sustainable practices in the building and construction industry in developing countries (Gibberd, 2001). The tool proposes that there are fifteen (15) main areas in buildings that need to be assessed in order to form a clear picture of the extent to which a building project agrees with sustainability concept. According to Gibberd (2001) and (2002), the tool measures sustainability performance in the built environment against the following criteria:

A). Social

- SO1: Occupant Comfort
- SO2: Inclusive Environments
- SO3: Access to Facilities
- SO4: Participation and control
- SO5: Education, Health and Safety

B). Economic

- EC1: Local economy
- EC2: Efficiency
- EC3: Adaptability
- EC4: Ongoing costs
- EC5: Capital costs

C) Environmental

- EN1: water
- EN2: Energy
- EN3: Waste
- EN4: Site
- EN5: materials and components

Performance in each of these areas is measured out of five (5) and it is presented on a radar diagram, see example below. This approach helps performance in the different area to be understood as quick as possible and the balance of the process between social, economic and environmental performance to be ascertained moreover, SBAT does not only assess the performance of buildings with regards to sustainability but also assess the extent of the building contribution to supporting and developing more sustainable system around it (Gibberd, 2002).

Quantitative Environmental Assessment Methods

Quantitative assessment methods are often referred to as life cycle assessment tools. These methods are based on and inventory of material and energy flows during the life cycle of product

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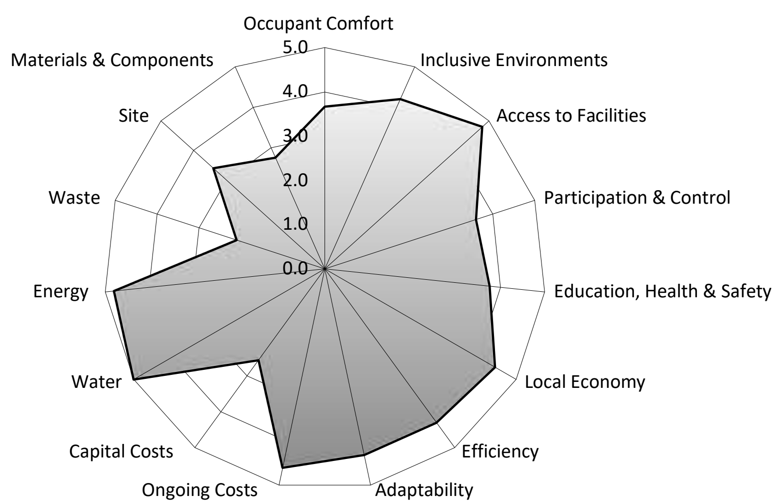
(Blom, 2006). Blom (2006) further stated that assessment methods operate at two levels; the level of the material and energy flows and the level of individual substance flows. It is important to note that methods operating on the level of material and energy flow are based on the noting that smaller flows are better. While tools operating on the second level contains an impact assessment of the flows of substances from and to the environment, Sebake (2014) added that quantitative assessment tools also include qualitative criteria; but care must be taken and precision given to the description of the qualitative criteria in order to reduce the level of misinterpretation.
Nevertheless the presentation of the performance results differentiates between quantitative criteria and the scores that is obtained from qualitative assessment methods (Cole, 2005).

The disadvantages of quantitative assessment methods include;

i) The method is very complex, thus requires huge amount of money, time and expertise to carry out an assessment.

PROJECT ASSESSMENT

Project title:	Date:
Location:	Undertaken by:
Building type (specify):	Company / organisation:
Internal area (m2):	Telephone:
Number of users:	Fax:
Completion date:	Email:



Social	4.0	Economic	4.0	Environmental	3.6
		Overall	3.9		

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Fig.1 Sustainable Building Assessment Tool (SBAT) (Gibberd, 2005)

ii) The gaps between developed and developing countries with respect to current knowledge on environmental sustainability assessment mechanisms coupled with lack of sufficient data often result to uncertainty in the assessment and outcomes (Sebake, 2014).
iii) When compare with qualitative assessment methods. The result of quantitative assessment is be difficult to interpret. Interpreter, multiplier and Equations are often employed to make sustainability measurement less subjective but readable (Waer & Sibley, 2005). The advantages of quantitative assessment are;
I) In quantitative assessment approach, it is possible to figure out the process with the highest environmental burden so that specific measures can be employed to mitigate the environmental burden attributed to buildings.
II) The possibility to ascertain and use the contribution of a product or particular component to the entire dimension of environmental burden.
Some Examples of quantitative LCA based tools for building includes: Envest, Athena, SimaPro, Gabi etc.

ENVEST

Envest is a web-based tool developed by BRE. It is designed to simplify the process of designing environmentally friendly buildings (Bayer et.al 2010). Envest allows both environmental and financial tradeoff to be made explicit in the design process, thereby allowing the user to optimize the concept of best value according to their priorities (envest v 2. Bre. Co. uk/account ysp).The tool allows large design firms to store and share information in controlled way. Developed to be used during early design stage and with the possibility of in – house benchmarking and design compares. Environmental data may be presented as a range of 12 impact categories from climate change to toxicity, as well as a simple Ecopoint score, for ease of communication, especially when compared with costs. Two versions of the tools are available: Envest 2 estimator and Envest 2 calculator. See table.

ATHENA IMPACT ESTIMATOR

Athena impact estimator (IE) allows users to evaluate whole building s assemblies based on internationally recognized life cycle assessment methodology (ATHENA,Impact Estimator 4.1, 2010). It provides a full inventory of natural resource, energy, water use, emissions, and land use for complete building or for individual assemblies (Bayer, et.al 2010). The type of building assemblies covered by Athena includes; foundation, walls, floors, root, columns and beam. The primary aim of the tool is to point out the consequences of different material mixes and design options, while considering trade-offs among the various environmental effects. See table

ATHENA ECO-CALCULATOR.

Athena Eco-Calculator is a spread sheet – based life cycle assessment tool developed by Athena institute in conjunction with the university of Minnesota and Morrison Hershfield Consulting Engineers (Bayers et al 2010). According to Athena. Eco-Calculator (2010), the tool is an Excel-based tool that provides instant life cycle Assessment results for over 400 common building assemblies. However, the results are based on detailed assessments completed with the Athena. Impact estimator for buildings.

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SimaPro

Developed by pre- consultants this software is product design oriented (Bayer et al 2010). SimaPro is a full – service LCA tool and one of the two most uses quantitative environmental sustainability assessment tools globally (Hollerud & Bowyer, 2017). The data library provided by SimaPro is a combination of; Eco invent, USLCI, ELCD and Agric-footprint. Datasets are very comprehensive and offers extensive lists of inputs and outputs. Hollerud et.al (2017) added that the outputs can be divided into three categories; emission to air, emission to water and emission to soil. And that breaking the outputs into categories enhances the understanding of the consequences of that particular outputs on the environment. The ability to trace the origin of any result makes SimaPro very unique. There are three versions of SimaPro available depending on the type or the purpose of the assessment.

GaBi

GaBi is full-service life cycle assessment based tool and one of the most widely used assessment tools in the world. Offering over 5,000 processes reported from wide variety of industries (GaBi Software, 2017). This assessment tool has the capabilities to assist in greenhouse gas accounting, life cycle engineering, design for environment, substance flow analysis , strategies risk management and total cost accounting . It also allow the user to develop the product system for analysis because the product system is user-defined and not fixed (RMIT-Royal Inst. of Technology, 2007).

LCA in Sustainable Architecture (LISA)

LISA is a LCA decision tool developed for architects and professionals in the building industry to assist in green design. The inputs required are; Bill of materials and quantities, work schedule, fuel consumption by construction equipment and utilization schedules. The output can be graphical or tabular format flowing the environment impact of each stage in terms of resource energy use in GJ, greenhouse emissions in metric tons of equivalent Co2, 3PM, NAIVOC, water, $No_2$and So_2(Bayer et al 2010). LISA is designed to; Help identify key environmental issues in construction, give designers an easy to use tool for evaluating the environmental aspects of building design; to enable designers and to make informed choices based on whole of life environmental considerations (LISA, 2010).

Environmental Sustainability Assessment and the Nigeria Context

Globally, there are series of building evaluation tools that focus on different aspect of sustainable development and are designed for different types of projects. There are over 382 registered building software tools being used for evaluation of building energy efficiency, renewable energy and building sustainability (Nguyen, 2011). Nguyen (2011) added that despite the number of registered evaluation software, only few systems are widely acknowledged and have set a recognizable standard for sustainable development.

However, assessment of environmental sustainability of buildings in Africa is relatively new especially within fast developing economics like Nigeria where the practices or procedure for assessing sustainability issues are base or results declared by product manufactures (Giwa & Peng, 2012) as earlier mentioned. A study by Adegbile (2012) shows that most of the building assessment carried out in Nigeria, used more of qualitative assessment method. And Nigeria as a

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country has no locally- based building environmental sustainability assessment tool or application procedure (Adegbile, 2012 and Tamaraukwuro et.al 2017). The Green Building of Nigeria (GBCN) has been developed and was a prospective member of World Green Building Council, (WGBC) as at Jan. 2014, and is yet to produce an environmental rating tool that could be used for office, residential, public and education building projects in Nigeria (GBCSA, 2014). South Africa is the only Africa country with an established Green building council and locally – based assessment tools.

Interestingly, there are few LEED certified buildings in Nigeria. They are: Heritage Place Ikoyi-Lagos; Nestoil Ultra-Modern Office Victoria Island Lagos; the Nox building – Abuja (LEED BD + C: new construction Vs-LEED 2009); P&G Nigeria MDO warehouse (LEED BD + C new construction Vs-LEED 2009); AFDB Nigeria field office Abuja (LEED BD + C new construction Vs-LEED 2009); Asdads Building No: 4, Bourdilon street – Lagos (GBCSA, 2014). Breeam, CASBEE, GREEN Star and other assessment tools have not been used to certify any buildings in Nigeria (Tamaraukwuro et.al, 2017).

CONCLUSION

Existing literature has shown that building environmental assessment tool or methods are designed for their specific locality (Cole, 1999). And therefore not suitable to all regions or countries. There are factors that directly or indirectly affect the outcome of any sustainability assessment such as: land use paten, geographical characteristic, climate condition, resource consumption, renewable energy/ technological no how, sources of raw materials and government policies. LEED and BREEAM have been suggested for use in Nigeria by some researchers such as Adegbile(2012) .However, according Tamaraukwuro et.al(2017), LEED and BREEAM uses energy and the renewable energy commissioning systems. These systems only favor developed countries due to their high level in technological breakthrough. Moreover, both tools are designed for compact system which is not common in Nigeria and the concept is geared toward the urban rich.

Therefore it is imperative that more research and studies be carried out with the aim of developing an assessment framework that will be based on data relevant to local conditions. Hence, the review suggests that the effectiveness of rating tools or any assessment methods depends significantly on their ability to address the contextual impact categories or environmental issues of the region/locality.

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