The Sustainable Infrastructure Management Model (SIMM)

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Abstract: — **Sustainability is a topical issue regarding the contemporary socio-economic development generally. Given that, the interdisciplinary field of engineering, science and technological advancement among others rests on its applications for improved services delivery. As such, sustainable infrastructure management is not left out in this category by integrating the sustainability ideals. This paper presents the sustainable infrastructure management model as applied in testing the oil and gas facility platforms in Nigeria. The use of various engineering principles in the existing world engenders a sustainable development on infrastructure systems management. Building services engineers and the infrastructure systems experts are persistently demanded in the design and fixing of serviceable infrastructure networks all over the world. Hence, complex mechanical, electromechanical systems and subsystems are modelled as closed loop processes that interrelate recursively. So, it is of necessity to understand the multiphysics of these systems for a complete model conceptualisation and examination expansion. This developments and case study are also presented. Indeed, two fundamental areas where SIMM is vital are given in this report: building services operation and the strategic management decisions concerning infrastructure systems. Such applications would require accurate simulation and/or modelling platforms for inbuilt reliability and value engineering appraisal. Amongst the benefits of SIMM are the provision of an enabling environment for the sustainable management of infrastructure systems and the use of engineering sustainability approach for the present and future generations.**

Index terms— Engineering, facility, infrastructure systems, management, sustainability

I. INTRODUCTION

Infrastructure systems commonly are very complex in nature and require a broad based knowledge in engineering, technology and management methods for the overall success. Oil and gas platforms infrastructure systems are such systems that demands for suitable design, construction, operation (use) and maintenance for optimal services delivery. Often times, improper design and management ethics of the infrastructure network can cause a lot of problems to both infrastructure users as well as the environment.

Exceedingly, menaces likely to be attributed to infrastructure systems malfunction are diverse in dimensions and these include spillage, sewage pollution, wastage of energy and water resources among others in this list. As a result, this paradox does not promote the green growth and eco-efficiency perceptions regarding the infrastructure systems development and sustainability ethics. But, these indices are rather being described as the negative impacts resulting from the infrastructure network establishment. Obviously, the 21st century challenges in relation to sustainable infrastructure systems administration necessitate for sound educational awareness, innovative design and data analysis. It is also imperative to understand the multiphysics of these systems for a complete model conceptualisation and test for better services delivery towards sustainability success.

Sustainability concepts regarding the infrastructure systems management seek to address the overall interest of sustainable development. Indeed, the sustainability idea is this context perhaps best described the measure of the extent to which a particular endeavor is able to meet the goals of sustainable development. As such, the infrastructure systems management in the oil and gas sectors is not left out in the category of sustainable development activities. The quest for improved and sustainable infrastructure systems among other developmental economic strides culminate into the world summits aimed to scrutinize this anomaly. One of such fora is the World Commission on Environment and Development (WCED). The outcome of the (WCED, 1987) summit has made a very significant contribution to the well-being of man and the environmental resources use at large. This input is established through a better definition of the term sustainable development. As the development that meets the needs of the present devoid of compromising the ability of future generations to satisfy their own needs [1].

This simply implies that infrastructure system (utilities) or other networks in the oil and gas sectors which is not established on this platform of sustainable development is not sustainable. Notwithstanding, infrastructure systems can be designed and modelled for sustainability by integrating the new innovative and technological principles which could deliver improved and cost effective solutions. But, [2] however argued that sustainable infrastructure development generally is the process of moving activities to a pattern that can be sustained in perpetuity. It is an approach to environmental and development issues that seek to reconcile

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ISBN: 978-988-19252-4-4
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

human needs with the capacity of the planet to cope with the consequences of human activities. In this situation, the three dimensions or triple bottom line (TBL) of sustainable development focus on the economic, social and environmental values. This relationship of sustainability elements will promote suitable infrastructure and engineering development [3].

In other words, sustainable infrastructure systems then can be deemed as infrastructure in harmony with the continuation of social, economic and environmental sustainability. In view of the trio sustainability stand point, a more pragmatic effort is desired in the oil and gas sectors as well as other corporate organisations. Interestingly, a holistic approach is to establish the necessity in infrastructure growth and management of any system towards sound principles and decision making [3-5].

Sustainable infrastructure systems management has brought about several deliberations in both private and public sectors in recent times and the challenging impact are so vast. The impact arising from infrastructure implementation is currently gathering more momentum in the international, national and world politics and turn into a central matter for the experts around the world. But, all these brainstorming sessions focused on sustainable development concept which requires a more holistic consideration widely than before on lives and of the infrastructure network [6,7].

Rio de Janeiro (Rio + 20) summit 2012 held in Brazil and the previous earth conferences still debate on the basic infrastructure- water resource, drinking water, wastewater and storm water. The summit also deliberated upon the sustainable infrastructure (energy) which is needed for strengthening the economic ties but with a major challenge arising from protecting the ecosystems and achieving equity. Sustainable energy (utility) initiative is aimed to ensure universal access to modern energy services, improve efficiency and increase use of renewable sources and are poised towards achieving the sustainable infrastructure success [8, 9].

Oil and gas sectors are not left out as most of their platforms which house these systems are even situated on the ocean, subsea and the river banks. As a consequence, they are prone to be inadvertently involved with some form of environmental hazards (greenhouse gas) GHG emission due to poor design and management associated with infrastructure systems. Debatably, [10] puts forward that sustainable management of the associated resources in infrastructure systems stimulate quality services (welfare) which can be improved upon and expanded for socio-economic transformation. However, the mindset towards sustainable infrastructure growth should foster the resulting gains and competitiveness in production perception, thereby, driving the economic gains and ultimate welfare. Infrastructure systems development commonly have very significant impact on sustainability, then promoting environmentally sustainable and eco-efficient infrastructure is an important objective for the economic expansion of any nation [10,11].

On the whole, oil and gas organisations are faced with a lot of tasks in meeting their investment and profit margin targets through boosting the production capacity. But, the necessity to provide for eco-efficient and sustainable infrastructure systems within the built environment cannot be overstressed in the prevailing economic circumstances. Indeed, a more pragmatic effort is desired in keeping the economic, social and environmental values pace in the pursuit of attaining the sustainability success [12]. As infrastructure systems without such elements will negatively impact on the well-being of the present and future generations at large.

II. METHODOLOGY OF STUDY

A two-stage methodology was employed for this study. These were the literature survey and measured field data obtained from the two oil and gas production platforms (Fig. 1) within the company in Akwa Ibom State, Nigeria. The study site in Fig. 1 is located on a coastal region along the South-South geo-political zone in Nigeria. Related literature review as used in this study was aimed at recognising the lapses and the best management practices.

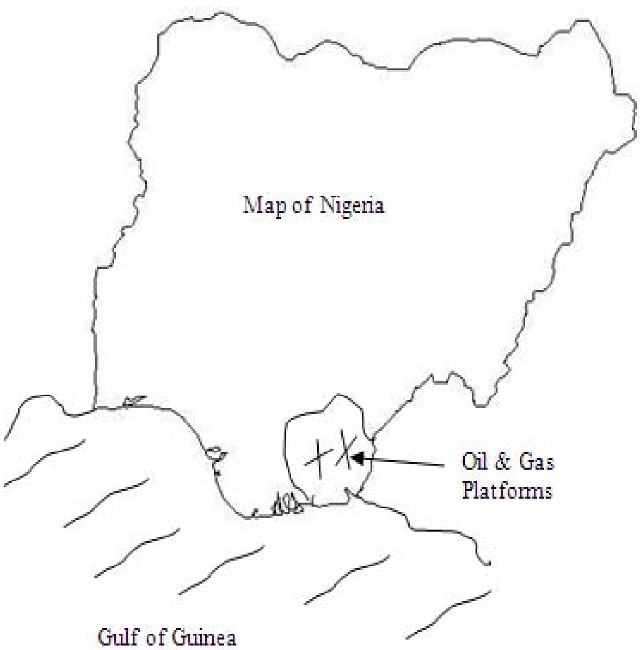

Fig. 1: The site map and location of the study.

This study utilises the methodologies according to the following authors in [13, 14]. Pilot study was earlier conducted followed by the structured survey administration. In essence, efforts in the survey were also directed towards the building services infrastructure systems in this organisation.

It is worthwhile to indicate that a total of 50 copies of the survey were produced and mailed to the maintenance/ operations managers within this company. The study recorded only 23 copies of the survey as feedbacks from this organisation. Thus, the response rate for the responded survey was 46%. However, this response rate came high above the normal rate of 20 – 30% for most posted and hand-administered survey in the field studies [14].

III. THE SIMM

In this analysis, a SIMM alongside probability functions were developed for testing the oil and gas infrastructure systems. As a result, the SIMM appraises the social, economic and environmental values (as sets of system goals) for the sustainability values (S_{uv}) accomplishment. This measured sustainability indices (SI) ranges of $0 \leq S_{uv} \leq 1$ by applying the probability (P) theory model into sustainability. Besides, a trapezoidal function and the statistical software package (SPSS 19.0 version) were integrated into the study and to model the infrastructure systems performance (IP).

The IP examination however considered the area (A) under a curve as contained in Eqn. 1. Also, the SPSS application in this analysis was capable of establishing the reliability index of the measured field data as supplied by this company.

$$A = 1/2(a + a - x)h \quad (1)$$

Where; x, a, and h signify the originating point, length and height of the trapezoid respectively.

The SIMM model as applied in evaluating this case study is very promising and the results are consistent. More details regarding the study are demonstrated in the results and discussion section.

IV. RESULTS AND DISCUSSION

The research results and discussion are as indicated. Fig. 2 shows the examined oil and gas platforms (facilities) A and B. From the infrastructure systems probability study, the SI for platforms A, yield = $0 \leq 0.45 \leq 1$ and B = $0 \leq 0.47 \leq 1$.

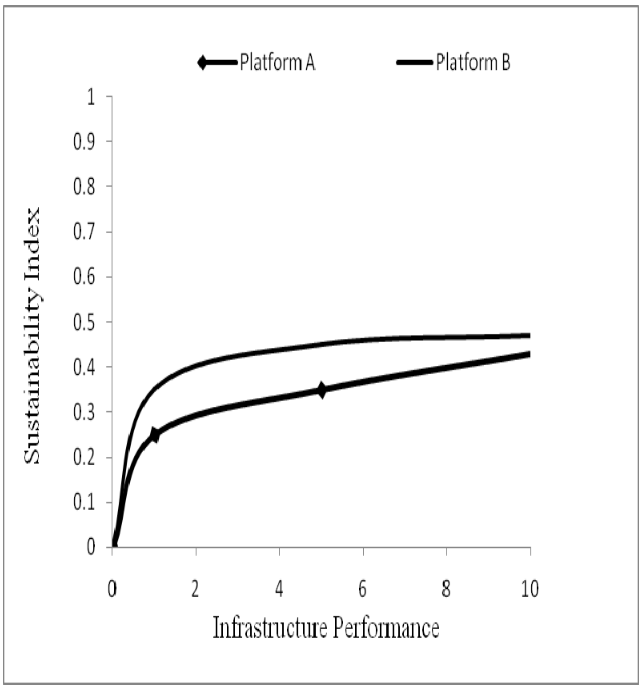

Fig. 2: The SIMM.

In Fig. 2, the relationship between SI and IP are verified. On this basis, for the area under a curve in Platforms A and B, the outcomes are presented.

IP for Platform A = 4.05
IP for Platform B = 4.23

Consequently, from the system analysis it could be inferred that the IP in Platform B is more effective comparably to Platform A in terms of services delivery. Therefore, the interpretation of this result suggests that Platform B is more sustainability conscious relatively, Fig. 2. These results are however quite reliable considering the infrastructure systems of interest in this investigation.

Notwithstanding, the study overall interest through the application of the SIMM for the area under a curve is poised at achieving improved quality of services in Fig. 2.
Taking into account that SI and IP are represented by y and x axes respectively, then, for the area of performance A, will produce:

$$A = xy \quad (2)$$

$$y = f(x) \quad (3)$$

$$SI = f(IP) \quad (4)$$

$$A = \int_a^b \mathrm{SI}\, d(\mathrm{IP}) \quad (5)$$

$$A = \int_a^b f(IP)\, d(\mathrm{IP}) \quad (6)$$

Therefore, the infrastructure systems performance model in Eqn. (6) is suitable for the area under a curve in both scenarios. Also, based on these findings, strategic planning, mapping and management decisions regarding the systems performance could be drawn from this SIMM scheme.

In a related development, the SPSS software was also applied to further assess the results in Table 1 for the reliability of the system.

Table 1: The SI Results

Platform	SI Result
A	0.45
B	0.47

More so, the reliability (α) outcome was determined for the case study through the application of the model shown in Eqn. (7).

$$\alpha = \frac{k}{k-1}\left(\frac{\sum_{i}^{k}=1\sigma^2 Y_i}{\sigma^2 x}\right) \quad (7)$$

The parameters in Eqn. (7) are defined as follows; where α is the Cronbach Alpha, k is the number of levels associated with the infrastructure variables in this condition. Also, σ^2 represents the variance in the data population and x indicating each variable in the Platforms A and B. On the other hand, Y_i in the study signifies the probability of achieving sustainable infrastructure services delivery within the examined platforms.

In this study also, the reliability index result (α = 0.81) of the infrastructure systems services delivery was achieved. This is very encouraging despite the fact that their SI results are not strong enough. This finding is explained through the values of the coefficient in the measured parameters with (α =

ISBN: 978-988-19252-4-4
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

0.81). The reliability result also demonstrates a direct and strong degree of regression among the appraised variables. Since, a cubic function was applied in determining the regression of the facilities performance.

The interpretation of this result suggests that ever since the case study involves oil and gas exploration, there is that tendency for the infrastructure systems to generate some environmental damage. This obviously is a commonplace regarding oil and gas facilities in Nigeria where the issue of oil spillage, gas flaring among others frequently occurred. These indices have advanced a lot of havoc to both man and eco-systems alike. Health and safety in this context are becoming threatened requiring more pragmatic approaches in eco-efficient design and management of the infrastructure systems. This outcome therefore drives home the need for the infrastructure systems engineers, (professionals) and other promoters of sustainability ethics to be proactive minded in formulating policies. Such strategies will be capable of mitigating the infrastructure systems crisis management.

Evidently, this result should form the basis for appraising oil and gas facilities not only within Nigeria but, globally as it could provide useful information in addressing similar situations.

IV. CONCLUSION

The study re-assesses the infrastructure systems within the oil and gas sectors in Nigeria. In this analysis, the findings disclose differences in both platforms with the investigated information. The research has presented and examined the aim of investigation, background literature, methodology and results on the infrastructure systems in this case study. However, the research has benefited a lot from the related literature exploration which provided comprehensive facts regarding the systems performance in this background. This development provided a guide into achieving the results as presented. A SIMM alongside probability functions were as well developed for testing the oil and gas infrastructure systems.

Also, a trapezoidal function and SPSS 19.0 version were integrated into the study and to model the infrastructure systems performance (IP). These methods were tailored in pursuit of establishing the value engineering (VE) of the infrastructure systems. This system approach however guaranteed for the infrastructure performance. Given that, the VE is a scientific technique for analysing infrastructure services delivery and to determine whether the overall quality of performance (services delivery) is achieved at the lowest cost. In this study also, the sustainability indices results are shown in Table 1. However, both platforms A and B were tested and their IP's results are 4.05 and 4.23 respectively. Reliability analysis as well yields ($\alpha = 0.81$) for the case study signifying a strong degree of regression among the evaluated variables.

Findings from this case study reveals that the model propounded in Eqn. (6) is capable to deliver in the strategic planning, mapping information and management decisions making regarding the systems performance generally.

The investigation noted that infrastructure systems without sustainability success can have more negative consequences on the service delivery. In this case, a more holistic effort towards sustainability awareness is desired. This is with a view to addressing profitable growth builds on the trio (economic, social and environmental) pillars of sustainability for sustainable development.

ACKNOWLEDGMENT

The authors hereby acknowledge the support of the Akwa Ibom State University of Technology (AKUTECH), Nigeria for their continued sponsorship. Members of staff (operation and maintenance) managers, engineers and technicians in this organisation are lauded for their cooperation.

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