ENHANCEMENT OF USERS' REQUIREMENT ASSESSMENT FOR SUSTAINABILITY OF EXISTING PUBLIC OFFICE BUILDINGS USING LEAN THINKING APPROACH

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Abstract

The improvement of existing buildings had been argued to be a major approach in attaining sustainability in the built environment, especially in developing countries. However, literature review shows that users' requirement is the basis of accomplishing sustainable improvement, but hardly achieved in purported improved buildings. The paper approached the sustainable improvement diagnosis technique of public office buildings through the enhancement of users' requirement assessment using the lean thinking concept. The research adopted the quantitative method, using diagnostic Post Occupancy Evaluation as data acquiring tool from a massive office complex in Nigeria, a developing country. Survey questionnaires related to the triple bottom line of sustainable development were distributed to all the 971 civil servants in the study area, from which 339 useable questionnaires were retrieved. The analyses were done using Analysis of Moments Structures (AMOS) regressions, while the findings established that muda is inherent in public office buildings, with highly significant inverse causal effects of -0.661 and -0.760 on job productivity and design features respectively; and strong effect sizes of 44% and 58% in explaining both their variances respectively. The study revealed that users are more concerned about facilities put in place within public office buildings, compared with spatial plan or structure. Urgent improvement is therefore required more in facilities for sustainability. The study concludes that lean thinking can enhance the assessment of users' requirement in existing public office building improvement diagnosis in Nigeria, a developing country. However, the approach can only be used as a supplement and not a replacement of the diagnosis technique, since the end-users are not able to provide the technical details of professional expertise and equipment needed in a typical improvement diagnosis technique.

Keywords: *User requirement, lean thinking, 'muda', sustainable improvement, public office buildings*

1. INTRODUCTION

The improvement of old buildings from existing built assets for sustainability is termed sustainable improvement (Mansfield, 2011), and it is an offshoot of Sustainable Development (SD), which was defined as the ability to meet the needs of the present users without compromising the ability of future generations to meet their needs (WCED, 1987). Jylha and Junnila (2014) noted that facility management in recent years had shifted to an end-user-driven mindset in which focus is on supporting end-users. This suggests a change in improvement philosophy, while knowledge of user requirement would enable proper decisions for improvement of office buildings (Israelson and Hansson, 2009). Schipper and Swets (2010) also suggested that a creative solution from intensive research is required to determine and address users' requirement. Studies have shown that purported sustainably improved buildings' performance have not adequately reflected end-users' requirement (Hansson, 2010). The main objective of this study therefore is examine whether the lean thinking approach can enhance the assessment of users' requirement in sustainable improvement diagnosis technique for public office buildings.

This paper evaluates sustainability of existing public office buildings through the improvement as against maintenance of their standards. In maintenance, the original standard at construction is restored, while in improvement, the original standard is upgraded. Hence when maintenance is carried out on a non-sustainable building, it can at best reinstates it to its original non-sustainable standard as depicted in Figure 1. The paper adopts the definition of improvement as a work carried out on existing buildings in an attempt to upgrade them to sustainable standards whilst retaining their current use (Marir and Watson, 1995), which is a condition superior to an earlier one.

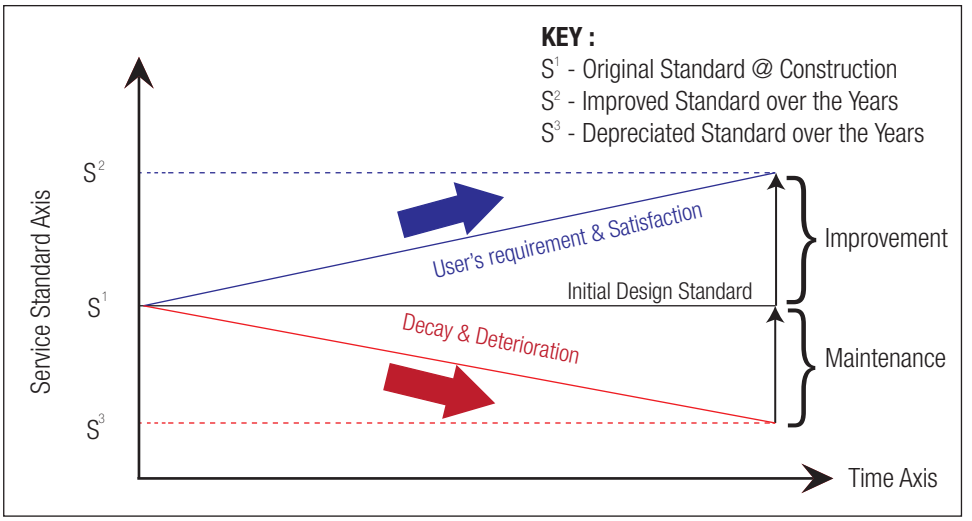

Figure 1: Building maintenance and improvement (Adeyemi, 2010)

2. LITERATURE REVIEW

2.1 Users' requirement and job productivity

Karna defines users' satisfaction as when the quality of a service meets or exceed expectations; otherwise, they are not satisfied. From this perception, an important attribute of users' requirement that could serve as a measure of performance is the reference to the user as a key determinant of quality (Rotimi, 2013). Therefore, improvement of quality needs to be directed towards ensuring that facilities fulfill the requirements and specifications assigned from users' perspective (Seo, 2007). The most important factor as a benchmark for a building improvement to meet sustainability objectives is the level of users' requirement incorporated in it (Birkeland, 2012). Black observed that world class systems incorporate intense end-user focus in which the end-user is an indispensable part of the process. Black gave an example of Boeing (aircraft manufacturer) who involves users' views in its production process in what is termed as aggressive listening (to end-users). Therefore, the built environment also needs to focus on end-users' satisfaction in order to generate world class facilities. Haynes argues that a sustainably improved office can have direct impact in increasing job productivity and it is a crucial factor in job satisfaction, staff recruitment and retention.

Eilam and Shamir (2005) reported that office building improvement provides opportunity for self-expression and self-enhancement, in which users are expected to support the change when it is perceived as agreeable with their self-concept. On the other hand, when the improvement is not concordant with users' self-concept, it will result in stress and lack of motivation and other forms of resistance. It can then be expected that this resistance will lead to poor ratings of the environment, low occupants' satisfaction and possibly reduced job productivity. Therefore, it can be assumed that users' requirement inclusion in the improvement design process as suggested by Speckelmeyer as well as the consideration and continuity of successfully adapted environmental features lead to successful environments in offices. A leading argument for economic sustainability is the belief that sustainable buildings are healthier and lead to job satisfaction, less employee absenteeism and higher levels of productivity thereby boosting the overall profitability of business occupiers (Wilkinson et. al., 2011) .

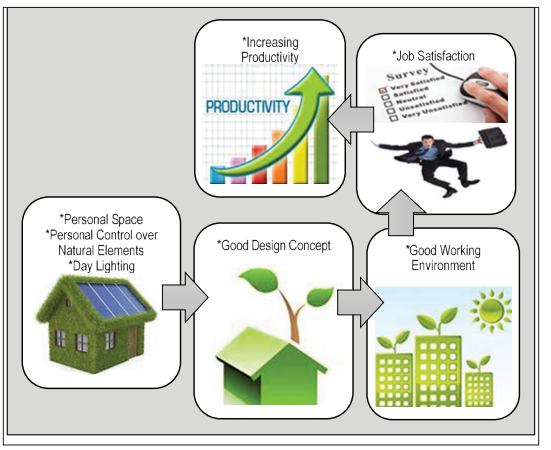

Figure 2: Users' satisfaction and job productivity (Adeyemi, 2016).

Figure 2 depicts literature impression of the relationship between users' requirement (which includes personal space, control over natural elements, etc.) satisfaction and job productivity in the office environment. Comfort is the absence of unpleasant sensations, which has positive effect on human well-being (Speckelmeyer, 1993), and is seen as a key determinant of users' requirement, since the building should not be perceived as an object separated from its users, thus end-users, their perception of the environment and their participation during the initial planning and design phases should play an important role in the process of sustainable improvement (Sinou and Kyvelou, 2006) and Rey also noted that the question of users' requirement plays a prominent role during the design stage of an improvement project. In order to achieve sustainability objectives, a coherent strategy and action plan is needed to address end-users' expectations and needs in existing buildings (Shika et.al., 2012).

The paper therefore suggests the enhancement of users' requirement assessment from end-users' perspective, since only them can best define their requirements (Jylha and Junnila, 2014). The paper equally promotes the role of the facilities manager in providing users' requirement details for sustainable improvement purpose, since they relate more with end-users (i.e. occupants) than other professionals in the built environment (Adeyemi, 2010).

2.2 Lean thinking concept

Lean thinking has the underlying philosophy that by identifying and eliminating 'muda' (i.e. Japanese word for waste), standard (hence performance) can be improved to meet users' requirement, and at reduced cost (Kempton, 2006). According to Averill, lean thinking is an improvement model that emphasizes on the ultimate elimination (or continuous minimization) of 'muda' and non-value-added activities in delivering high quality products to end-users at the lowest possible cost. It has its origin in the philosophy of achieving improvements in most economical ways with special focus on reducing 'muda' from end-users perspective (Womack and Jones, 2005). The concept of 'muda' became one of the most important concepts in quality improvement activities primarily originated by Taiichi Ohno's famous production philosophy from Toyota in the early 1950s. Ohno realized on his visit to Ford Motors in USA that there was too much muda everywhere, which he classified into 7 drivers, namely: Defect/Error, Inventory, Waiting/Delay, Motion, Transportation, Over-processing and Overproduction; this system later metamorphosed into what is now branded as lean thinking by Womack, Jones and Roos. Womack and Jones later added the 8th driver - Human talent, and introduced lean thinking principles as applicable beyond manufacturing environment into any field.

According to Nicholas and Soni, the two overarching philosophy of lean thinking for sustainability are elimination of 'muda' and continuous improvement (or kaizen in Japanese). Wang defined kaizen as a system of continuous improvement in quality, technology, and safety, while opined it as the effort for perfection which is never reached but creates the urge to make improvements, since there is no end to muda elimination. Kaizen works by utilizing everyone's knowledge to identify and implement improvements quickly and without significant cost (Askin and Goldberg, 2007).

Nicholas and Soni suggested that the concept of lean thinking applies to a vast range of operations and processes in widely differing industries, offices, health care, etc. with only

"tweaking of details". Thus, varying industries have since adopted the concept including the construction industry from where terms such as lean design and lean construction emerged. The substantial argument is that the concept had delivered large improvements in manufacturing, in particular the motor vehicle industry, and where already applied in construction. Lean thinking concept was initially used to measure only waste but Sharp and Jones extended the application to include the measurement inefficiency, which was adopted for this paper.

2.3 The variables

Schipper and Swets (2010) opined that 'muda' is universal and constant, appearing in every sector but that the definitions of the 'muda' drivers should be adapted to describe the situation to which it is applied. Schipper and Swets (2010) argued that as any new situation is approached for the application of lean thinking, the definitions of the drivers can be customized to fit the specific circumstances. Thus, the 'muda' drivers were adapted to suit office building (i.e. scope of the study) as depicted in Table 1, and used as independent variables. This was done through "tweaking of details". DeVellis (2012) noted that theory plays a vital role in the conceptualization of measurement variables.

Table 1: Concept of 'muda' adapted for office building

S/N	Muda drivers	Modified description
1	Waiting/Delay (WAT)	Delay, due to inadequate provisions for access to carry out maintenance activities, etc.
2	Overproduction (OPN)	Large accommodation space, too many corridors, etc. not appreciated by users.
3	Inventory (INV)	Storage facilities; and building materials kept for maintenance that are not necessary or have short life spans.
4	Motion (MOT)	Wasted human motion as related to workplace: ergonomic design negatively affecting productivity, quality & safety e.g. walking, reaching and twisting.
5	Over-processing (OPS)	Adding Design Features not needed by users, e.g. bath tubs in general convenience; irregular office shapes that reduces functional space; etc.
6	Transportation (TRN)	Distant location between complimentary offices and other ancillary rooms causing unnecessary movements for users.
7	Defect/Error (DEF)	Situation where one or more elements of a building do not perform their intended function; and failure in the function, performance, statutory or users' requirement of a building that manifests itself within the structure, fabric services or other facilities of the building.
8	Human talent (HMT)	Non-inclusion of end-users' input in design or improvement policy formulations. How could people be better involved in kaizen?

The paper also adapted the job productivity framework of Haynes', which suggests that the job productivity of the office occupier is influenced by comfort, office layout and distraction as shown in Table 2, while the study also adapted Arge's design features classifications as depicted in Table 3. The design features were adopted because they concisely captured all the building elements (Adeyemi, 2016). Both the job productivity and design feature variables were used as dependent variables in this study.

Table 2: Job productivity variables (Haynes, 2007)

S/No.	Variables	Items
1	Comfort (CFT)	Temperature (TEMP); natural lighting (DAYL); decor (OVRF); cleanliness (HYGN); security (SCTY).
2	Office layout (OFL)	Storage facilities (STRR); office shape (OFSH) and office size (OFSZ); office ergonomics (OFEG); circulation routes (PSSG).
3	Interaction (INT)	Social interaction (SINT); work interaction (WINT); aesthetically pleasing (AEST) i.e. modern attractiveness with regular upkeep; refreshment areas (RFSH); creative environment (CREN).
4	Distraction (DST)	Noise/concentration (NOIS); toilet sanitary condition (TOIS); downtime (DNTM); health due to IAQ (HLTH); electricity (ELEC).

Table 3: Design feature variables (Arge, 2005) in sustainable improvement

S/No.	Variables	Items
1	Spatial Plan (SPL)	Offices design (OFFD) and layout (OFLT); ancillary rooms' design (ARMD) and layout (ARML); and overall building design (BLGD).
2	Structure (STR)	Walls (WALL); floors (FLOR); windows (WIND); doors (DORR); ceiling (CEIL).
3	Facilities (FAC)	Water (WATR); electricity (ELTR); ICT facilities (ICTF); security (SECU); and other facilities such as Parking lot, fire-fighting equipment, safety measures, storage facilities, cooling devices, etc. (OFAC).

3. METHODOLOGY

The study examined the enhancement of users' requirement in sustainable improvement diagnosis technique of existing public office buildings using the lean thinking approach from users' perspective. The Federal Secretariat office complex, Bauchi, a massive public building in Nigeria was chosen for the study because of the urgent need for improvement in developing countries while the civil servants in the complex were the respondents as end-users. Eisenhardt (1989) argues that a study area tends to be more appropriate to confirm or challenge a theory or address a rare or unusual situation. Public office buildings in Nigeria were selected because they are a constant subject of discussion by eminent Nigerians and scholars alike both in the country and in publications and on the internet.

The subject property was selected because of the researcher's in-depth local knowledge of it (Yin, 2013) and for the followings reasons stated below:

(a) It was designed and constructed in 1989, when sustainability was not a consideration (Miller, and Buys, 2008);
(b) It has not undergone any major improvement work since its construction;
(c) It is a massive structure accommodating 26 different government parastatals with combined civil servants of 971, reflecting the *federal character* and *quota system* of the nation (Strzelecka, 2008);
(d) The building is still operational and not abandoned; and
(e) Easy access to the building for collection of data (Yin, 2013)

The Post-Occupancy Evaluation (POE) tool was adopted for acquiring data from occupants, and related to the sustainable development (SD) triple bottom line (TBL) components of the environment, economy and society (Zheng et.al., 2014). The paper focuses on the building superstructure i.e. that part of the building which is above the ground and serves the purpose of the building's intended use.

The study design adopted the quantitative method while the study technique involved the use of survey and direct observation approaches. The method involved the use of SPSS, AMOS, narrations and discussions to analyze data. The βeta coefficient, which indicates the unique contributions, causal effects and factor loadings of the variables; the R^2 or effect size, which explains the variances of the constructs; and the P-value, which indicates practical significance, were used as standards of measurement (Adams and Lawrence, 2015), to determine the significance of the 'lean thinking' approach with respect to the objective of the study.

The questionnaire was distributed to all 971 civil servants at the study area, while a total of 339 useable questionnaires were retrieved for analysis. This figure represents a response rate of 35%, which is above the required minimum of 29% for the subject population size (Bartlett et. al., 2001). The diagnostic POE tool adopted for the study was used to acquire data from occupants (as respondents) regarding the observed variables in Tables 1, 2 and 3 to determine muda and its effect on perceived job productivity and design features from end-users' perspective through questionnaires for enhance users' requirement in sustainable improvement diagnosis of public office buildings.

The study adopted Hassanain (2008) evaluation options to measure 'muda' using a 5-point Likert scale with options ranged from "strongly dissatisfied", "dissatisfied", "marginal", "satisfied" to "strongly satisfied"; each option was allotted a score from 1 to 5 respectively. In addition, Haynes evaluation options were adopted to measure the job productivity variables using a 5-point Likert

scale evaluation options ranging from "very negative", "negative", "marginal", "positive" to "very positive", while each option was allotted a score from 1 to 5 respectively to answer the question - *"In your opinion, what effect do the following elements have on your Perceived Job Productivity in your office environment?"*.

Furthermore the evaluation options Haynes (2007) was adopted for measuring the design feature variables based on a 5-point Likert scale of "very poor", "poor", "marginal", "good" or "very good", with each option allotted a score from 1 to 5 respectively. AMOS regression was subsequently conducted to estimate the causal effects of 'muda' (independent variable) on job productivity and design features (dependent variables), as well as the relationship between job productivity and design features. All estimates were given in standardized coefficients (i.e. estimates for each of the different variables were converted to the same scale by AMOS for ease of comparison).

4. RESULTS AND DISCUSSION

4.1 Establishment and ranking of muda

The AMOS regression analysis depicted in Table 4 reveals the unique contributions of the 'muda' variables from the strongest to the least based on their respective βeta coefficient estimates and effect sizes (R^2), which were used to rank the 'muda' drivers in order of prominence. The result confirms that 'muda' is inherent in public office buildings and substantiates the claims of Nicholas and Soni, Schipper and Swets (2010) and Samuel et. al., (2015), who opined that 'muda' is universal, appearing in every situation and can be determined through the customization of the definitions of the drivers to fit the specific circumstances after a careful analysis of the nature of the new environment, and adopted to describe the situation to which it is applied. The result also shows significant practical applications (i.e. the usefulness of the research findings in real life) through their P-values of <0.05 (Awang, 2015).

Table 4: Ranking of *muda* drivers based on βeta coefficient

Muda Driver	βeta Coef	R^2	P-value	Result	Ranking
Inventory (INV)	0.848	0.72	***	Significant	1
Defect (DEF)	0.796	0.63	***	Significant	2
Over processing (OPS)	0.782	0.61	***	Significant	3
Over production (OPN)	0.770	0.59	.004	Significant	4
Motion (MOT)	0.669	0.45	***	Significant	5
Transportation (TRN)	0.636	0.40	***	Significant	6
Human Talent (HMT)	0.523	0.27	***	Significant	7
Waiting (WAT)	0.472	0.22	.025	Significant	8

*** indicates highly significant at <0.001 (Awang, 2015)

4.2 Causal effects of 'muda'

The βeta coefficients of -0.661 and -0.760 depicted in Figure 3 shows the inverse causal effects of 'muda' on perceived job productivity and design features respectively, indicating that as 'muda' increases by 1 unit, it will inversely affect job productivity and design features by -0.661 and -0.760 units respectively.

The keys to the coding in the tables and proposed structural model are found in Tables 1, 2 and 3). The 'muda' effect size of 44% and 58% also explained the variances for perceived job productivity and design features respectively from users' perspective, which are very strong (Awang, 2015). The result also showed highly significant p-value and thus confirming their practical significance to everyday life, with P-value of <0.05 (Samuel et. al., 2015) as depicted in Table 5. These are consistent with Veitch et al.; Warr (2011) and De Been and Beijer (2014), who reported that satisfaction with the physical working environment are directly related to job productivity.

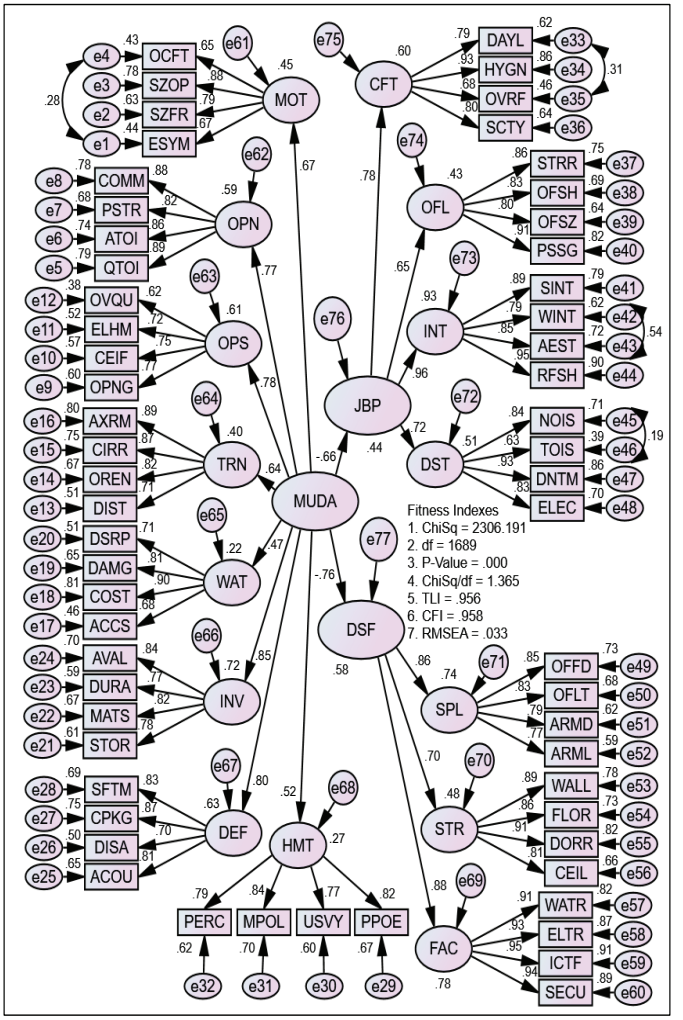

Figure 3: Proposed structural model

Table 5: Regression weights of proposed structural model

Path			Beta Estimate	S.E.	C.R.	P-Value	Result
JBP		MUDA	-.661	.162	5.944	***	Significant
DSF		MUDA	-.760	.265	6.397	***	Significant

*** indicates highly significant at <0.001 (Awang, 2015)

4.3 Design feature to eliminate 'muda'

The summary of respondents' perception of design features in the preliminary analysis (Table 6) revealed that spatial plan and structure were deemed "Good" with mean scores of ≥ 3.00, while facilities was deemed "Poor" with a mean score of < 3 (Haynes, 2008).

Table 6: Respondents' perception of design features

S/No.	Construct	Mean	Users' Perception	Ranking
1	Spatial Plan (SPL)	3.04	Good	1
2	Structure (STR)	3.00	Good	2
3	Facilities (FAC)	2.59	Poor	3

Furthermore the respondents suggested that urgent improvement is needed in public office building *facilities* (i.e. services and utilities provided), as compared to *spatial plan* (i.e. design and layout) and *structure* (i.e. building elements and finishing); 77% of the opinions were on need for *facilities*, while *spatial plan* and *structure* had 10% and 13% respectively (Figure 4). This suggests that the occupants are not as bothered about the design and layout (*spatial plan*) or building elements and finishes (*structure*), compared with services and utilities (*facilities*) put in place in public office buildings in order to eliminate or minimize perceived *muda*. Thus, more urgent improvement is required in *facilities* (i.e. services and utilities), which is consistent with Spring (2004), who opined that architects are often criticized for giving preference to aesthetic values rather than functional, thus creating 'muda' in the built environment.

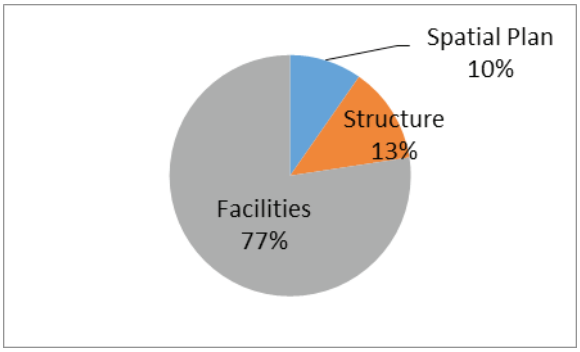

Figure 4: Users' requirement by design features

4.4 Relationship between design features and job productivity

Figure 5 showed a direct and moderate correlation of 0.48 (Awang, 2015) between design features and job productivity. This correlation implies that as design features are improved (particularly *facilities*), job productivity will equally improve, thus enhancing public office buildings performance and leading to increase in job productivity simultaneously.

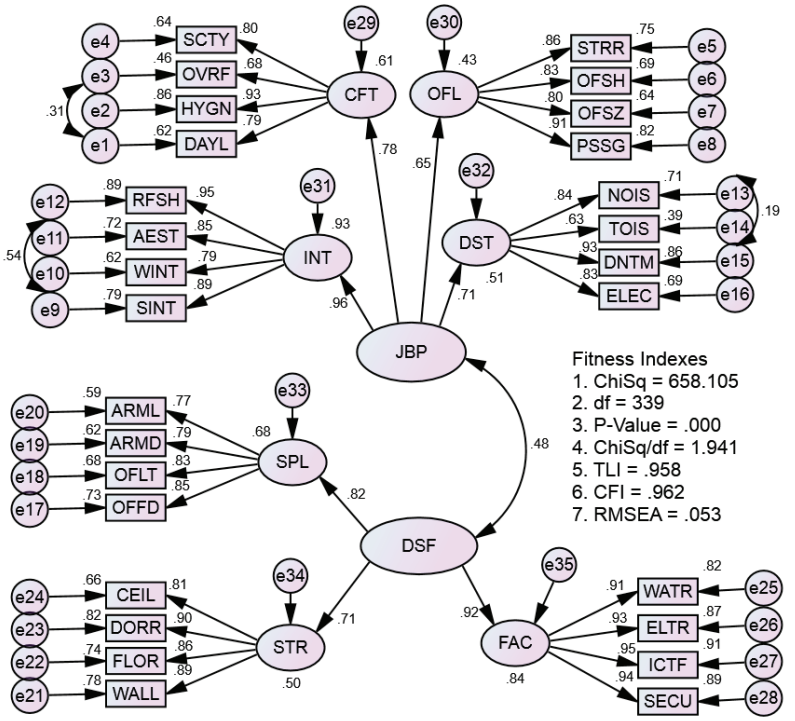

Figure 5: Correlation of job productivity and design features

Table 7: Regression weight of relationship between job productivity and design features

Path				**β**eta Coef	S.E.	C.R.	P-Value	Result
JBP		DSF		.484	.029	6.062	***	Significant

*** indicates highly significant at <0.001 (Awang, 2015)

Table 7 shows a highly significant P-value, suggesting that the result has practical significance to real life. This is consistent with Haynes (2007), Shika *et al.* (2012) and Birkeland (2012), who reported that a good office design had direct impact in increasing productivity and is a crucial factor in job satisfaction. Eilam & Shamir (2005) also reported that workers would be more satisfied with a recently improved work environment, hence increased productivity. This is also in agreement with Gohardani and Bjork, (2012) who opined that 'muda' and productivity are very important factors to consider in the pursuit of cost efficiency

5. CONCLUSION

The paper has shown that *lean thinking* can enhance users' requirement assessment in the sustainable improvement diagnosis technique of existing public office buildings, since it could provide additional information directly from the occupants with respect to 'muda' (i.e. waste and inefficiencies). However, the paper suggests that *lean thinking* cannot replace or substitute the typical diagnosis technique such as Tool for Office Building Upgrading Solutions (TOBUS) (Caccavelli & Gugerli, 2002). since it works only with inputs from the end-users who may not be able to provide technical and professional details required for other assessments, in particular for energy reduction, Green House Gases emissions and building elements condition, which may require sophisticated equipment to analyze. The paper promotes the multi-stakeholder and bottom-up policy formulation approaches to SD, in which end-users are involved as stakeholders.

Perceived 'muda' has significant influence on both perceived job productivity and design features which makes *lean thinking* an important consideration for enhanced assessment of users' requirement in the bid for sustainable improvement of public office buildings along the local TBL setting of environment, economic and social factors required for successful SD. The paper has shown that in meeting the needs of the people as defined in SD, the design feature of *Facilities* is a major user requirement, which can minimize (or eventually eliminate) 'muda' inherent in public office buildings, and guard against in future design of public office buildings. There is no doubt that there are a number of other factors and barriers that affect our ability to make existing buildings more sustainable. However, until the major issue of 'muda' is also addressed from end-users' perspective, the pace of SD in developing countries may remain slow.

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