Confirmatory factor analysis of Post-Occupancy Evaluation Model (POEM) for sustainable neighborhood development

R Yaman¹, ³, S Thadaniti¹, J Abdullah³, N Ahmad², N M Ishak³
¹The Environment, Development and Sustainability Program, Graduate School, Chulalongkorn University, Phayathai Road, Pathumwan, Bangkok, 10330, Thailand
²Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, Gombak, Selangor, Malaysia
³ Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

* rostamyaman1@yahoo.co.uk

Abstract. The sustainable urban development growth in the ASEAN region has accelerated tremendously. More demand on the sustainable development has led to bigger market driven certified green neighborhood and buildings. However, there is a lack of post-occupancy evaluation study conducted in assessing the end-users perspective on the certified sustainable neighborhood development. This paper aims to investigate the end-users point of view on sustainable dimension pillar (SDP) adaptation based on environment dimension, social dimension and economic dimension using Post-Occupancy Evaluation Model (POEM) framework. The research methodology employed stakeholders-Inclusion Approach survey questionnaires in order to obtained the sustainable dimensional adaptation score. The results show that there is sustainable dimension gap in POEM evaluation, hence, suggested the pre-occupancy criteria did not fulfill the SDP adaptation and pre-occupancy criteria and variables if differ from post-occupancy criteria and variables.

1. Introduction

The Malaysian construction and development sector has been over the years emerged and thrived in the direction of a more progressive sustainable urban agenda. The subject of sustainable neighbourhood or township benchmarking approach in the field of urban development in Malaysia is relatively new. Although GBI Township Assessment Criteria has been developed and implemented but there is no post-occupancy evaluation being conducted in assessing the performance, effectiveness and sustainability level on the certified development. There has been no study done to measure the greenness’ of the tools and the post certified township development. Even though there is study conducted on environment dimension, however fewer so are conducted on what really signifies socially or/and economically, and/or its application in the sustainable urban development context. Do sustainable neighborhood or township evaluation criteria and frameworks in common signify sustainable holistically? Therefore, proficiency and comprehension on urban sustainability benchmarking criteria could strengthen neighborhood sustainable indicators, effectiveness and sustainability level among the Malaysian sustainable urban development actors are vastly still low. Studies has indicated one of the main obstacles that hinder sustainable township/neighborhood development in ASEAN nations is the deficiency of knowledge in sustainable concerns subjects in relation to the involved building profession [1].
Past study done on sustainable building rating system potential in Malaysia also shows that Malaysia construction and development sector key stakeholders have insufficient understanding on sustainability development evaluation, benchmarking & indexing approach [2]. Due to this many green certified urban development project in Malaysia claim sustainability merely for label advertisement, marketing tools and higher premiums instead of fully addressing the sustainable pillars. Certified GBI township projects normally a high-end urban development projects, study has indicated that sustainable certification do improve leasing and selling rate of developed properties, but this outcome is further substantial for end-users who are more innately concerned with sustainability, or pushing their ‘green’ appearance [3]. Even though the noble foundation for sustainable township/neighborhood is to promote and applied sustainable development, but there is no study was undertaken to address and gauge this issues. Thus, this embarks the problem of the research: whether the existing GBI Township Assessment Criteria and certified urban development project fulfilled the post-occupancy performances, effectiveness and sustainability level according to dimensions Pillars of Sustainability.

2. Profile of the Respondents
The case study of this research is three GBI certified sustainable neighbourhood of Ken Rimba Development, Bandar Rimbayu Development and Sunway Resort City in Greater KL. In this Confirmatory Factor Analysis study, preliminary data analysis is conducted prior to it. Preliminary data analysis involves the total number of end-users/household respondents and the conduct test of reliability measurement in ensuring the consistency of the applicable data. The tabulation of Phase 3 survey respondents is as shown in Table 1. The detail composition of the respondents based on case studies are Ken Rimba 122 respondents, where 59 respondents are homeowners (15.60%), 52 respondents are tenants (13.75%) and 11 respondents are workers (2.91%). For Bandar Rimbayu case study, 71 respondents are homeowners (18.78%), 38 respondents are tenants (10.05%) and 16 respondents are workers (4.23%). The third or last case study is Sunway Resort City where 70 respondents are homeowners (18.51%), 39 respondents are tenants (10.31%) and 22 respondents are workers (5.82%). The description for such composition is that homeowners is the main type of users reside in the certified sustainable neighbourhood development. This is followed by tenants as the second type of users who occupied the chosen case studies and the balance is the workers. Since sustainable neighborhood development in the Klang Valley/Greater KL is a high-end property development, it is justifiable that most of the end-user respondents is the homeowners where they plan for permanent or long-term stay instead of tenants or workers.

| User/Neighborhood     | No. Of Respondents | Percentage (%) |
|----------------------|-------------------|----------------|
| Homeowners           | 59                | 15.60%         |
| Tenants              | 52                | 13.75%         |
| Workers              | 11                | 2.91%          |
| Ken Rimba            | 122               | 32.27%         |
| Homeowners           | 71                | 18.78%         |
| Tenants              | 38                | 10.05%         |
| Workers              | 16                | 4.23%          |
| Bandar Rimbayu       | 125               | 33.06%         |
| Homeowners           | 70                | 18.51%         |
| Tenants              | 39                | 10.31%         |
| Workers              | 22                | 5.82%          |
| Sunway Resort City   | 131               | 34.65%         |
| Total                | 378               | 100.00%        |
3. Theoretical Framework

The Framework of Research in this POEM for SND study using Stakeholders-Inclusion Approach – End-User/Household Survey comprises of one latent exogenous construct which is Post-Occupancy Evaluation Model for Sustainable Neighborhood Development (POEM for SND), and three dependent variable of Environment Dimension Pillar (EnP), Social Dimension Pillar (EnP), and Economic Dimension Pillar (EnP). The theoretical relationship between the constructs is modelled and shown in Figure 1.

As presented in Figure 1, the latent construct is Post-Occupancy Evaluation Model for Sustainable Neighborhood Development (POEM for SND). The three (3) observed variables in the study model are Environment Dimension Pillar (EnP), Social Dimension Pillar (EnP), and Economic Dimension Pillar (EnP). The first exogenous construct is Environment Dimension Pillar (EnP) which consists of six (6) endogenous variables. The second listed exogenous construct is Social Dimension Pillar (EnP), which contains of eight (8) endogenous variables. The last or third listed exogenous construct is Economic Dimension Pillar (EcP) which consists of seven (7) endogenous variables.

All endogenous variables is assessed by means of an interval scale which vary between from 1 (Very Low Sufficiency/Practice) to 5 (Very High Sufficiency/Practice) with the given end-user occupancy sustainable experience statement in POEM Assessment Criteria. The measurement of model for every exogenous construct in this study is adapted and simplified from previous POEM for SND Study (phase 1 & phase2). For this Stakeholders-Inclusion Approach – End-User/Household Survey model of POEM for SND, the study could assess the CFA measurement using one model for all constructs in order to achieve the relevant thresholds for validity and reliability (Awang, 2014; 2015; Awang et al., 2015; Kashif et al., 2015; 2016).

Hence, in this Stakeholders-Inclusion Approach – End-User/Household Survey model of POEM for SND study decided to conduct a single CFA procedure for all exogenous construct. According to Awang (2012; 2013; 2014; 2015) [4], Awang et al. (2015) [5] and Kashif et al. (2015; 2016) [6], the study prerequisites are to verify that all constructs in the theoretical model are discriminant of each other or it’s are not highly correlated particularly amongst the exogenous constructs prior to model the full structural model and implementation of Structural Equation Modelling. In the case where there are two or more exogenous constructs are highly correlated (correlation above than 0.85). Highly correlation will results of a significant problem called Multicollinearity or a phenomenon in which one
predictor variable in a multiple regression model can be linearly predicted from the others with a substantial degree of accuracy.

### 3.1 Reliability Analysis

This POEM for SND study construct consists of three exogenous constructs named as Environment Dimension Pillar (EnP), Social Dimension Pillar (SoP) and Economic Dimension Pillar (EcP). EnP exogenous construct is measured using six (6) endogenous variables of POEM for SND evaluation criteria in the questionnaire which were Sufficient Designated Green Area (Q8.1), Sufficient Street or Park Lighting (Q8.2), Generate or Use Renewable Energy (Q8.3), Reduced or Recycle Water Practice (Q8.4), Bio-diversity Reserved Availability (Q8.5) and Infrastructure Services Efficiency (Q8.7). SoP exogenous construct is measured using eight (8) endogenous variables of POEM for SND evaluation criteria in the questionnaire which were Sufficient Communal Space (Q8.9), Population Density & Development Level (Q8.10), Universal Accessibility Availability (Q8.12), Security and Safety Experiences (Q8.13), Public Health Concerns (Q8.14), Recycling Facilities or Practices (Q8.15), Community Diversification (Q8.16) and Community Engagement & Management (Q8.17). Lastly, EcP exogenous construct is measured using seven (7) endogenous variables of POEM for SND evaluation criteria in the questionnaire which were Public Transport Reliability (Q8.19), Sufficient Pedestrian & Cycling Networks (Q8.20), Low Impact & Regional Materials (Q8.21), Promotion of Sustainable Construction (Q8.22), Construction Waste & Sedimentation (Q8.23), Sufficient Commercial Amenities (Q8.24) and Innovative Development (Q8.25).

Figure 2 below show the conceptual path model of POEM for SND CFA analysis.

![Figure 2. The exogenous constructs and measuring endogenous variables of POEM - SND](image)

This study employed the internal consistency approach in order to assess the reliability using Cronbach’s Alpha correlation-coefficient for evaluating internal consistency. It is by standard agreement that a Cronbach’s Alpha is 0.70 or higher, however, according to Hair (2010) in the exploratory research study Cronbach’s Alpha value can be lower up to 0.60.
Considering the importance POEM for SND evaluation criteria and its Sustainable Dimension Pillars (SDP) adaptation in relationship with post-occupied certified sustainable neighbourhood, a single latent construct (POEM for SND) has generated with these three sustainable dimension pillars influence factors as its endogenous variables. POEM for SND construct acted as the dependent variable. Each exogenous construct comprises of question items to which the respondents would opted their sustainable related experience based on a 5-scale point that suggest the extent to their conformity or disconformity with each given assertion. Table 2 details down the constructs, survey items and Cronbach’s Alpha indexes employed in this CFA of POEM for SND study. The findings suggested that the highest internal consistency is Social Dimension Pillar (SoP), followed by Economic Dimension Pillar (EcP) while the lowest is Environment Dimension Pillar (EnP).

**Table 2. Measurement of the Variables of the Hypothesized Model**

| Construct | Item | Survey questions | Mean  | SD    | Alph  |
|-----------|------|------------------|-------|-------|-------|
| EnP (Environment Dimension Pillar) | Q8.1 | Sufficient Designated Green Area | 3.751 | .0740 | 0.533 |
| | Q8.2 | Sufficient Street or Park Lighting | 3.791 | 0.736 | |
| | Q8.3 | Generate or Use Renewable Energy | 2.822 | 0.914 | |
| | Q8.4 | Reduced or Recycle Water Practice | 3.029 | 0.969 | |
| | Q8.5 | Bio-diversity Reserved Availability | 4.148 | 1.263 | |
| | Q8.7 | Infrastructure Services Efficiency | 3.624 | 0.575 | |
| SoP (Social Dimension Pillar) | Q8.9 | Sufficient Communal Space | 3.825 | 0.754 | 0.725 |
| | Q8.10 | Population Density & Development Level | 3.447 | 0.616 | |
| | Q8.12 | Universal Accessibility Availability | 3.164 | 0.671 | |
| | Q8.13 | Security and Safety Experiences | 3.695 | 0.651 | |
| | Q8.14 | Public Health Concerns | 3.510 | 0.695 | |
| | Q8.15 | Recycling Facilities or Practices | 3.343 | 0.957 | |
| | Q8.16 | Community Diversification | 3.484 | 0.703 | |
| | Q8.17 | Community Engagement & Management | 3.227 | 0.880 | |
| EcP (Economic Dimension Pillar) | Q8.19 | Public Transport Reliability | 3.187 | 0.678 | 0.613 |
| | Q8.20 | Sufficient Pedestrian & Cycling Networks | 2.735 | 1.417 | |
| | Q8.21 | Low Impact & Regional Materials | 3.425 | 0.652 | |
| | Q8.22 | Promotion of Sustainable Construction | 3.261 | 0.796 | |
| | Q8.23 | Construction Waste & Sedimentation | 2.079 | 1.717 | |
| | Q8.24 | Sufficient Commercial Amenities | 3.854 | 0.657 | |
| | Q8.25 | Innovative Development | 3.957 | 0.838 | |

**3.2 Full Measurement of CFA**

In this study, a full measurement path model is acquired by using the Confirmatory Factor Analysis (CFA) method on the applied endogenous variables scales. The measurement path of the model is determined to investigate the level of the observed endogenous variables measure and the exogenous latent constructs. It indicates how the observable endogenous variables capture the hypothetical exogenous latent constructs intended in this study. Confirmatory Factor Analysis (CFA) is applied to assess all the construct via the overall measurement of path model as shown in Figure 3. Prior to full model measurement, the exogenous constructs (dependent variables) and their endogenous variables
independent variables) were selected corresponding to its underlying study theories. The factors denote exogenous constructs, and the supporting study questions denote their endogenous variables. Table 3 specifies the detail breakdown of CFA measurement of the listed constructs and variables. In executing the full CFA model measurement, firstly, the appropriateness of fit for every measure was assessed in order to equate how adequate the model describes the data rationally. In this Phase 3 study, Chi-square ($\chi^2$), RMSEA (Root Mean Square Error of Approximation) TLI (Tucker Lewis Index) and CFI (Comparative Fit Index) are applied to decide whether the model is acceptable. Secondly, the estimated path model outcomes are assessed to identify transgressing estimates. This is referring to the results signs and the statistical significance of overall study estimated parameters, which are the regression weights, the standardized regression weights and the probability value (P-value). For this study IBM SPSS Amos 22 was used, the full CFA measurement path model was designed and executed efficaciously which has produced the affirmative outcomes as presented in the Figure 3.

![Figure 3. Results of Confirmatory Factor Analysis (CFA) procedure](image)

**Table 3. Parameter Estimates of Full Measurement Model**

| Construct & Variables | Unstd (a) | Std (b) | S.E. | C.R. | P   |
|-----------------------|----------|--------|------|------|-----|
| Q8.7                  | .1000    | .545   |      |      | *** |
| Q8.5                  | -.714    | -.354  | .127 | -.563| *** |
| Q8.4                  | 1.292    | .421   | .197 | 6.563| *** |
| Q8.3                  | 1.310    | .453   | .190 | 6.881| *** |
| Q8.2                  | 1.520    | .646   | .172 | 8.823| *** |
| Q8.1                  | 1.218    | .515   | .160 | 7.635| *** |
| Q8.17                 | 1.000    | .721   |      |      |     |
| Q8.16                 | .424     | .383   | .060 | 7.014| *** |
| Q8.15                 | 1.018    | .677   | .084 | 12.141| *** |
| Q8.14                 | .622     | .567   | .061 | 10.233| *** |
4. Main Results and Discussions

The overall measurement of parameter estimates are shown in Table 3. The P-values of all specific parameter estimates are highly significant where the value is at 0.001 (***), level amongst the construct except for Q8.10---SoP and Q8.23---EcP are statistically significant where the P-values are ≥ 0.001 but ≤ 0.05 (refer to Table 6.4). The affirmative co-efficient sign with highly significant P-value (***), and statistically significant P-value ≤ 0.05 means all hypothesized paths within the CFA model indicates a highly significant relationship, therefore, all hypotheses are supported. The Confirmatory Factor Analysis (CFA) model generated the overall data (relative Chi-square = 1.890; RMSEA = 0.049; GFI = 0.930; TLI = 0.904) which fulfilled their significant outscores. The values of AGFI (0.899) and NFI (0.859) are acceptable for a satisfactory model although these are slightly less than the suggested condition level of 0.90 (Hair, 2010). Thus, the model justifies that the data were ideally well represented as most of the indices yield a fit values of standardized loading estimates.

4.1 Environment Dimension Pillar (EnP)

EnP has six variables as indicated in Table 3. These variables consisted of information regarding environment dimension pillar post-occupancy evaluation criteria, which concerns on Sufficient Designated Green Area (Q8.1), Sufficient Street or Park Lighting (Q8.2), Generate or Use Renewable Energy (Q8.3), Reduced or Recycle Water Practice (Q8.4), Bio-diversity Reserved Availability (Q8.5) and Infrastructure Services Efficiency (Q8.7). The P-values for all specific parameter estimates of Climate, Energy & Water Construct are statistically high significant value at 0.001 (***), level, signifying that the paths model created from the construct to all six (6) variables are accepted. The standardized regression weights of the construct and variables are range in-between -0.354 to 0.646. The relationship between construct to EnP (Environment Dimension Pillar) indicated less significant value as indicated by Hair (2010), where the regression weights generated are below than 0.7. Furthermore one of the construct indicated negative value at -0.354 (Q8.5) against EnP.

It is distinctly indicated that Environment Dimension Pillar is less significant and moderately sufficient or experienced by the end-users/households of the selected case studies of certified sustainable neighborhood in the Klang Valley/Greater KL. Nevertheless, the correlation concerning construct to Q8.1 (Sufficient Designated Green Area), Q8.2 (Sufficient Street or Park Lighting), Q8.3 (Generate or Use Renewable Energy), Q8.4 (Reduced or Recycle Water Practice), and Q8.7 (Infrastructure Services Efficiency) standardized regression weight (0.421 – 0.646) denoted less significant but closed to the considerable level indicated by Hair (2010). However for Q8.5 (Biodiversity Reserved Availability), the correlation concerning construct is negative value (-0.354)

| Q8.13 | SoP | .577 | .563 | .057 | 10.144 | *** |
| Q8.12 | SoP | .193 | .191 | .060 | 3.239 | .001 |
| Q8.10 | SoP | .112 | .116 | .053 | 2.110 | .035 |
| Q8.9  | SoP | .740 | .623 | .066 | 11.283 | *** |
| Q8.25 | EcP | 1.000 | .711 | .384 | *** |
| Q8.24 | EcP | .246 | .222 | .064 | 3.844 | *** |
| Q8.23 | EcP | -.250 | -.174 | .082 | -3.044 | .002 |
| Q8.22 | EcP | -.491 | -.367 | .077 | -6.372 | *** |
| Q8.21 | EcP | .749 | .684 | .066 | 11.325 | *** |
| Q8.20 | EcP | -.464 | -.390 | .069 | -6.745 | *** |
| Q8.19 | EcP | .218 | .191 | .065 | 3.332 | *** |

Note:
(a) Estimated unstandardized regression co-efficient
(b) Standardized regression co-efficient
(c) Standard error of estimated unstandardized co-efficient.
(d) Probability of a t value equal to or greater than actual t value in a two-tailed test for significance of coefficient under the null hypothesis that the true value is zero. The symbol *** indicates that the null hypothesis is rejected at the .001 level of significance.
indicated that this provision is not available or experiences by the end-users/household of the selected certified case studies.

4.2 Social Dimension Pillar (SoP)
SoP construct has eight (8) variables as presented in Table 3. These variables consisted of information regarding social dimension pillar post-occupancy evaluation criteria, which regards to fulfil sustainable community related criteria of Sufficient Communal Space (Q8.9), Population Density & Development Level (Q8.10), Universal Accessibility Availability (Q8.12), Security and Safety Experiences (Q8.13), Public Health Concerns (Q8.14), Recycling Facilities or Practices (Q8.15), Community Diversification (Q8.16) and Community Engagement & Management (Q8.17). The P-values of all specific individual parameter estimates for EEC Construct are highly significant at 0.001 (*** value) and statistically significant at ≥ 0.001 but ≤ 0.05 (refer to Table 4), representing that all eight (8) variables of the construct paths are accepted. The regression weights of the construct between the variables are range from 0.116 to 0.721 which is less than significant level except for Q8.17 (Community Engagement & Management) variables is significant where the generated values higher than 0.7.

4.3 Economic Dimension Pillar (EcP)
EcP has seven variables as shown in the Table 3. These variables consisted of information regarding economic dimension pillar post-occupancy evaluation criteria, which concerns on Public Transport Reliability (Q8.19), Sufficient Pedestrian & Cycling Networks (Q8.20), Low Impact & Regional Materials (Q8.21), Promotion of Sustainable Construction (Q8.22), Construction Waste & Sedimentation (Q8.23), Sufficient Commercial Amenities (Q8.24) and Innovative Development (Q8.25). The P-values of all specific individual parameter estimates for EcP Construct are highly significant at 0.001 (*** value) and statistically significant at 0.002 value (Q8.23). The hypothesized model paths shows significant correlation, thus hypotheses of variables are all supported. For all variables of EcP Construct, the relationship co-efficient are yielding from -0.390 to 0.711 in standardized regression weight, which on standard are less significant except for Q8.25 (0.711) where the value is above significant level. All these variables generated the loading estimates below 0.7 value which are less ideal regression weight (Hair, 2010). Three variables yielded negative standardized regression weight value (Q8.20 at -0.390; Q8.22 at -0.367; and Q8.23 at -0.174). The balance three (3) variables yielded positive standardized regression weight value but below suggested acceptance level of above 0.7 value (Q8.19 at 0.191; Q8.21 at 0.684; Q8.24 at 0.222).

5. Conclusions
The CFA analysis and findings above reflect end-users opinion on SDP adaptation in certified sustainable neighborhood/township development in Greater KL. Summary of main findings of this study indicated overall theoretical model for POEM is significance where the P-value is at .0001 for all evaluation criteria. The conclusion of the study suggested there is SDP gap in SND development upon occupancy even though the pre-occupancy did adapted SDP. The full measurement CFA of this study indicated that the highest adapted SDP dimensions is Social Dimension (SoP), followed by Environmental Dimension (EnP) and finally Economic Dimension (EcP). It is also suggested that the pre-occupancy assessment criteria and post-occupancy assessment criteria theory and variables are differs. Hence, the study concluded that the existing GBI Township Assessment Criteria and certified urban development project did not fully fulfilled the post-occupancy performances, effectiveness and sustainability level according to dimensions Pillars of Sustainability.

Acknowledgments
The authors would like to thank EDS of Chulalongkorn University for providing a platform in conducting this study and the UiTM for supporting this research and all informants who provided inputs in this study through workshops, surveys, and interviews.
References

[1] Yahya WK and Hashim NH 2011 International Conference on IEEE. The role of public awareness and government regulations in stimulating sustainable consumption of Malaysian consumers. Business, Engineering and Industrial Applications (ICBEIA)

[2] Shari, Z., et al. 2008 International Journal on Sustainable Tropical Design Research & Practice. The Potential of sustainable building rating System in the Malaysian building industry ALAM CIPTA 3 3

[3] Sullivan, L. J., et al 2014 Neighbourhood sustainability frameworks-a literature review

[4] Awang, Z. 2012 A handbook on SEM. Structural Equation Modeling.

[5] Awang, Z 2015 SEM made simple: A gentle approach to learning Structural Equation Modeling. MPWS Rich Publication.

[6] Awang Z, Afthanorhan WMAW, & Asri MAM 2015 Modern Applied Science. Parametric and non parametric approach in structural equation modeling (SEM): The application of bootstrapping 9 58.

[7] Delaney DJ, Bernstein M, Farrow M and Stein LAR 2017 Alcoholism-Clinical And Experimental Research : The Brief Situational Confidence Questionnaire: Validating The Measure With An Incarcerated Adolescent Sample Using Structural Equation Modeling 41 pp. 87A (USA: WILEY)