BUILDING ENVIRONMENTAL ASSESSMENT SCHEME FOR RESIDENTIAL BUILDING IN BRUNEI

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Building's construction activities, operation and demolition are increasingly recognised as a major source of environmental impact. One strategy for reducing such impacts is most widely known by the term Building Environmental Assessment (BEA). The research is an attempt to develop a new BEA scheme for residential buildings in Brunei which focussing on identifying BEA indicators that best suit for Brunei environment, social and economy. Studies show that Brunei residential sector needs urgent attention to transform its current consumption rate in more sustainable way. Recent launch of Brunei Green Building Council, mandatory energy efficiency guidelines and declaration of ambitious energy intensity reduction target, a new BEA scheme will help contribute sustainability target in residential sector. However the issues of developing a new BEA schemes using existing methods may face constraints in their effectiveness. In this regard, a consensus-forming technique - Delphi method – helps improve greater communication and gain consensus from experts in the construction industry through series of questionnaires. As a result, the final framework is produced comprises of 7 key categories and 37 applicable criteria that achieved high degree of consensus and importance.

Keywords: Brunei, building environmental assessment, Delphi Method, residential buildings

INTRODUCTION

One of the prominent sectors that contributed to high carbon dioxide (CO2) emission is construction industry. The World Business Council for Sustainable Development (WBCSD) proved that buildings are the largest energy consumers in the world economy, accounting for over one-third of final energy use and approximately 30% of global CO2 emissions (WBCSD, 2014). One strategy for reducing such impacts is by implementing Building Environmental Assessment (BEA) also known as Green Building Assessment. Green buildings can be defined as "healthy facilities designed and built in a resource-efficient manner, suing ecologically based principle" (Kibert 2012, 6).

However the issues of developing a new BEA schemes using existing methods may face constraints in their effectiveness. Studies suggest that adapting existing BEA schemes directly may suffer several constraints such as regional incompatibility (indicators and weightings), transparency and complexity (Cole, 1998; Chew and Das, 2008; Retzlaff, 2009). Nonetheless existing BEA can provide a general system as a

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foundation and an interface between different schemes (Gu *et al.,* 2006). As there is no BEA scheme for residential buildings in Brunei yet, the aim of this paper is not only to explore the required categories and criteria that best suit for Brunei socio-economic and environmental needs, but also to develop a BEA scheme for residential buildings in Brunei.

BRUNEI CONTEXTS

Brunei Darussalam is a small country located on the north-western coast of Borneo Island, facing the South China Sea, and with a land area of about 5765 square kilometres and an estimated population of around 410,000 and 68,208 households. In 2012, the Ministry of Development has launched a Green Building roadmap that will eventually lead to a National Green Building Certification Scheme (IBP Inc., 2015). The Ministry is urged to develop a scheme that is environmentally responsible and resource efficient in all stages of its development. The implementation is still in early stages and the Ministry is currently reviewing current maintenance practices and collecting data for the benchmarking of existing buildings (APEC, 2013). This initiative is in line with Brunei's aspiration working towards an ambitious goal of a 45 percent energy intensity reduction by 2035 on four major sectors including building sector (Prime Minister Office, 2014).

In particular, residential buildings should be paid critical attention to achieve this because residential buildings in Brunei consumed the highest energy and water consumption compared to other sectors: 48% of the electricity generated goes to residential, while commercial, government, the oil and gas industrial sector consumed 25%, 17% and 10% respectively (APEC, 2013). In 2011, domestic water consumption has reached 62,487 thousand cubic metre and commercial consumption is merely 4,294 thousand cubic metre. High CO2 emission is another matter to manage as Brunei is ranked fourth CO2 emissions from the consumption of energy in the world (APEC, 2013). Hence, the residential sector needs an urgent transformation that potentially make the contribution towards sustainability target.

RESEARCH DESIGN AND METHOD

This paper employs an exploratory mixed method approaches due to broad concept of sustainable development which covers a multi-dimensional aspects i.e. environmental, social and economic aspects. The main research strategy is conducting Delphi survey questionnaire involving construction experts. It is crucial to acquire stakeholders' involvement to help improve its effectiveness and relevance. Hence, Delphi method is adopted to improve communication and obtain the reliable consensus of opinion of experts through series of intensive questionnaires. Figure 1 shows the theoretical model showing the sequence of BEA scheme development.

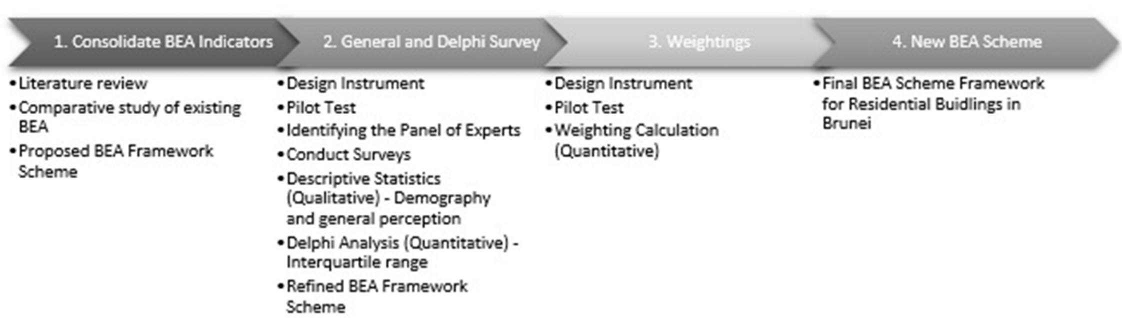

Figure 1: Theoretical model for Brunei BEA scheme development

The different BEA assessments including BREEAM (BRE Environmental Assessment Method), GMS (Green Mark Scheme) and GBI(Green Building Index) are reviewed and their indicators are compared to set common indicators, typically as a starting point for developing a new assessment scheme (Cole *et al.,* 2005). The proposed assessment will then be used to develop research instrument (pilot study and survey). Through series of questionnaires, the instrument will eventually produce a refined BEA framework for Brunei in Figure 2.

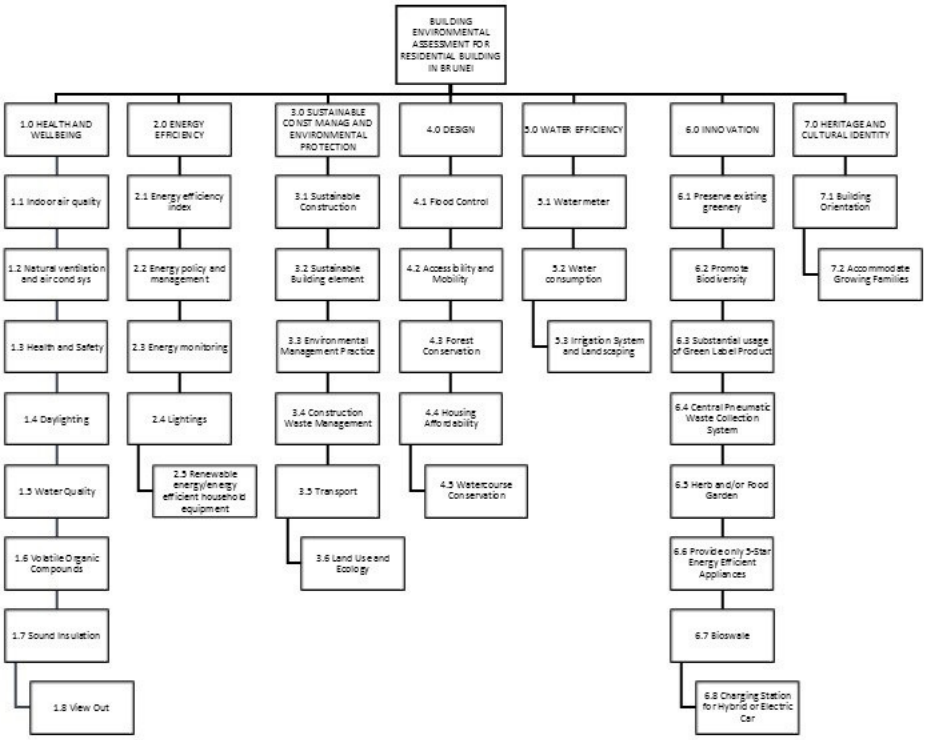

Figure 2: Framework of new BEA Scheme for Residential Building in Brunei

Delphi Survey

The Delphi method was developed by Dalkey and Helmer for the US Defence Industry at the RAND Corporation in the 1950s. Its objective is to obtain the most reliable consensus of opinion of a group of panels through series of intensive questionnaires interspersed with controlled opinion feedback (Dalkey and Helmer, 1963). It is a systematic, iterative procedure for "structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem" (Linstone and Turoff, 2002, 3) and it is desirable as it does not require the experts to meet physically, which could be impractical for international experts (Okoli and Pawlowski, 2004).

Many researchers found its ranking is the most appropriate for multi-dimensional aspects that requires greater communication in the development and customisation of BEA scheme. Delphi study in this research covers three rounds of questionnaire: (1) the discovery of issues, (2) determining the most important issues, and (3) ranking the issues.

Panel Selection and Size

The three rounds of questionnaire are sent out to panellist comprise of architects, engineers, managers, contractor, surveyors and academics from both government and private sectors. Ludwig (1997) found that the majority of Delphi studies have used between 15-20 respondents, and avoid large numbers of respondents which may lead to difficulty in the summarising process. However the panel should be sufficiently large to allow the patterns of responses to be clearly seen (Okoli and Pawlowski, 2004) and provide increase in the reliability of group responses (Fusfeld and Foster, 1971). Essentially, the main objective should be to select panellists with the capability, knowledge, professional qualifications and relevant experience in the field under investigation. Therefore, this research adopts expert sampling to ensure the proposed outcome is reliable. The target sample consists of key stakeholders includes:

Academic specialises in the area of construction, environment and sustainability
Decision-maker, policy-maker or practitioner in the field of building construction
Accredited professional in one of the leading sustainable assessment systems
Practical experience and sufficient knowledge in construction, environment and sustainability
Experts with level of influence and the main driver in the construction industry
Willingness to participate

Data Collection

Round 1: this round intended to gather as many input as possible to seek increase in accuracy and representative statistics of opinions by careful selection of sample. General or introductory questions are asked before the actual Delphi questionnaire section started. The questions make sure that, the participants are aware the typical category and criteria in BEA schemes. Participants are asked to rate the initial set of indicators using 5-point Likert scale and are encouraged to provide additional indicators that they believe are important and vice-versa, and to comment on their rationale for omitting or adding and rating additional indicators. The data are analysed and identify area of agreement or disagreement by calculating their central tendency including inter-quartile range (IQR): the indicators with IQR less than or equal to 1.0 – based on 5-point Likert scale – are deemed high consensus and hence, were omitted in round 2 (Faherty, 1979; Raskin, 1994; Rayens and Hahn, 2000; Heiko, 2012). The additional indicators are brought forward in Round 2 for rating.

Round 2: this questionnaire round is developed based on the information collected from round 1. Respondents are asked to rate all additional indicators identified in the round 1and repeat the analysis to identify degree of agreement or disagreement.

Round 3: the Delphi respondents finalise their decision on each item. To assist in their consideration, participants are provided summary of analysis or final outcome of the study in the previous round and are asked to revise their judgments or to specify the reasons for remaining outside the consensus, if any.

RESULTS AND DATA ANALYSIS

In the Round 1, a total of 207 were invited to participate and 102 (49%) responded, 89 are good for use and 69 respondents are willing to participate in the consecutive rounds while both Round 2 and 3 received 28 responses (41%). It is important to provide demographics characteristics so that it can be judged the relevance and reliability of the respondents (Schmidt, 1997). The size of the response is indicated in both percentage (%) and raw numeric terms. Table 1 shows that the participants are dominated mainly by engineer which contribute 57% which is 51 out of 89 participants. However, good number of participations 15, 9 and 8 are also obtained from quantity surveyors, architects and academics respectively. A total of 7 senior officers, directors, managers and company owners are amongst the respondents. The respondents' working experience in construction industry is a defining index of their knowledge about construction project in general as well as in residential project in particular. More than 67% respondents have over 6 years' experience in construction industry, while 33% have at least 5 years or less. Their views with experience obtained through the survey can be regarded as important and reliable data.

Delphi study results were analysed using descriptive statistics, including the mean ranking and the interquartile range. As a result, additional criteria and new major categories have been developed to produce final BEA framework for Brunei in Figure 2 which illustrates the framework comprising of 7 key categories and 37 applicable criteria that cover aspects of sustainability including environment, economic and social. Results in Table 2 show that overall IQR average of 0.31 and overall mean ranking scores 4.01 which indicate high degree of consensus in all the categories and criteria.

Table 1: Demography of participants

Expert Sample									
Designation*	Eng	QS	Arc	Aca	SO	FM	EO		
No	51	13	8	7	6	3	1		
%	57	15	9	8	7	3	1		
Working Experience									
Years	2-5	6-10	11-15	16-20	21-25	>25			
No	29	31	12	9	4	4			
%	33	35	13	10	5	4			
Qualifications									
Type**	O lev	Diploma	HND	Degree	Masters	PG	PHD	RIBA	MICE
	1	1	24	24	27	2	3	5	1
%	1	1	27	27	31	2	4	6	1
Note:	* Eng – Engineers Arch – Architects QS – Quantity Surveyor, Project Manager Acad – Academics SO – Senior Officers, Managers, Owners FM – Facility Manager EO – Environmental Officers				** HND – Higher National Diploma PG – Post Graduate PHD – Doctorate Philosophy RIBA – Member of Royal institute of British Architect MICE – Member of Institution of Civil Engineer				

Health and wellbeing

Health and wellbeing ranked as the most important categories by the panellist with mean ranking of 4.41 and IQR of 0.23. Indoor air quality and, natural ventilation and air-conditioning system are considered more important due to extreme heat and humidity in Brunei's equatorial climate and thus, contributing clean air, thermal comfort and well-being of the occupants. Moreover, the additional criteria – health and safety – is deemed to be an important issue due to increase in awareness and its enforcement in the Brunei construction industry.

Energy efficiency

The result shows how the panellists recognise the importance of efficient use of energy in common areas, limiting energy usage. Positive attitudes towards implementing energy efficient building increase readiness to monitor energy consumption by installing energy monitoring system in residential buildings. In this regard, energy policy and management play an important role to identify feasible policy, energy targets and its annual review.

Sustainable construction management and environment protection

They are six criteria listed in this category with score higher than 3.86 mean ranking. Two key criteria in this category - sustainable construction and sustainable building element -received as top indicators. The former adopting sustainable design and use of sustainable and recycled materials (off-site or on-site). While the later recognise and encourage the use of construction materials with a low environmental impact over the full life cycle of the building. Furthermore environmental management practice also regarded as important as this encourage adoption of environmental friendly practice in construction such as performance incentive, educate building user, quality control, provision of composting and recycling facilities and etc.

Design

Design category comprises of five criteria where flood control dominated the mean ranking due to issue of flood occurring in some parts of the districts in Brunei. Despite its seasonal phenomena, persistent heavy rainfall can cause inconvenience to residents and substantial expenditure to government as floods may lead to landslides and damage to properties and infrastructure. Promoting accessibility and mobility for the aged and the disabled are recognised as important and should set mandatory minimum standards for easing and guiding building use. Other criteria achieved almost similar level of importance.

Water efficiency

All criteria are rated high level of important with mean ranking above 4.0 where water meter ranked as top priority. This is to ensure water consumption can be monitored and managed and therefore encourage reductions in water consumption.

Water consumption gained significant attention as this encourage the building user to minimise the consumption of potable water in sanitary applications. Provision of suitable systems that utilise rainwater or recycled water for landscape irrigation are also regarded equally important.

Innovation

This category comprises of eight criteria where two of which are deemed very important while the other six criteria achieved similar level of important. However, the list of criteria is non-exhaustive as any other innovation related to BEA can also be included. This category encourages the designer to use of other green features which are innovative and have positive environmental impact. The most important criteria is preserve existing greenery and this enhances the quality of living environment, reduce surface runoff to drainage system and minimise impacts on fresh water and ground water systems during building use. While promote biodiversity ranked second in this category. It maintains the ecology of local areas, minimise disruption to natural habitat and promote the biodiversity of the site, attracting birds and the like.

Heritage and cultural identity

Similar with innovation, this category regarded as low to moderate important however both categories achieve high degree of consensus. Residential buildings in Brunei are greatly influenced by cultural considerations. The orientation of buildings should consider the direction of Qibla and ensure separate spaces for male and female to perform their religious obligations.

The orientation should also consider the location of external doors to provide privacy to the occupants for instance, external doors should not give direct access to domestic quarter. Accommodate growing families is also included in this new category. This emphasises the importance of the relationship between family members.

Table 2: Mean ranking and IQR

CATEGORIES	MEAN RANKING	IQR
1.0 Health and wellbeing	4.411	0.227
2.0 Energy efficiency	4.411	0.240
3.0 Sustainable construction management and environmental protection	4.289	0.233
4.0 Design	4.239	0.236
5.0 Water efficiency	4.178	0.226
6.0 Innovation	3.780	0.264
7.0 Heritage and cultural identity	3.276	0.305
1.0 HEALTH AND WELLBEING	MEAN RANKING	IQR
1.1 Indoor air quality	4.483	0.223
1.2 Natural ventilation	4.427	0.226
1.3 Health and Safety	4.414	0.453
1.4 Daylighting	4.303	0.232
1.5 Water Quality	4.103	0.244
1.6 Volatile Organic Compounds	3.920	0.510
1.7 Sound Insulation	3.910	0.511
1.8 View Out	3.773	0.530
2.0 ENERGY EFFICIENCY	MEAN RANKING	IQR
2.1 Energy efficiency index	4.157	0.241
2.2 Energy policy and management	4.125	0.246
2.3 Energy monitoring	4.067	0.242
2.4 Lightings	3.932	0.318
2.5 Renewable energy/energy efficient household equipment	3.932	0.473
3.0 SUSTAINABLE CONSTRUCTION MANAGEMENT AND ENVIRONMENT PROTECTION	MEAN RANKING	IQR
3.1 Sustainable construction	4.393	0.228
3.2 Sustainable building element	4.393	0.235
3.3 Environmental management practice	4.281	0.234
3.4 Construction Waste management	4.000	0.250
3.5 Transport	3.865	0.259
3.6 Land Use and Ecology	3.862	0.518
4.0 DESIGN	MEAN RANKING	IQR
4.1 Flood Control	4.172	0.240
4.2 Accessibility and Mobility	4.069	0.246
4.3 Forest Conservation	3.893	0.514
4.4 Housing Affordability	3.724	0.537
4.5 Watercourse Conservation	3.690	0.542
5.0 WATER EFFICIENCY	MEAN RANKING	IQR
5.1 Water meter	4.466	0.246
5.2 Water consumption	4.169	0.224
5.3 Irrigation System and Landscaping	4.000	0.500
6.0 INNOVATION	MEAN RANKING	IQR
6.1 Preserve existing greenery	4.258	0.235
6.2 Promote Biodiversity	4.079	0.245
6.3 Substantial usage of Green Label Product	3.865	0.259
6.4 Central Pneumatic Waste Collection System	3.764	0.266
6.5 Herb and/or Food Garden	3.685	0.271
6.6 Provide only 5-Star Energy Efficient Appliances	3.685	0.271
6.7 Bioswale	3.596	0.278
6.8 Charging Station for Hybrid or Electric Car	3.443	0.290
7.0 HERITAGE AND CULTURAL IDENTITY	MEAN RANKING	IQR
7.1 Building Orientation	3.621	0.276
7.3 Accommodate Growing Families	3.483	0.287

Family members are expected to make serious and sustained efforts to live together and plan their role in society. Therefore, extended families were common in traditional Muslim societies where respect and care for elder people is essential within the family border.

DISCUSSION

The results show that total number of indicators (excluding innovation category) for BREEAM, GMS and GBI are 34, 21, 37 respectively while Brunei BEA has 29 indicators which is good for a new scheme. Large number of indicators are best avoided to avoid issues of regional incompatibility, complexity and transparency as mentioned earlier. Undoubtedly the findings indicate that existing BEA schemes for residential building shared many similarities in terms of indicators, however the number of indicators and the level of importance - based on weighting or credit allocation - reveal important differences.

For instance, category for 'Health and Wellbeing' ranked as the most important category in this paper whereas BREEAM ranked it 3rd out of 9, GMS ranked it 5th out of 5 and GBI ranked it 3rd out of 6 categories. It is justifiable to recognise Health and wellbeing as the most important in Brunei. Vulnerability assessments show that the country has medium to high climate change exposure, mainly due to higher temperatures leading to potential heat-related stress and haze pollution arising from forest fires (Ministry of Development Brunei, 2015).

The issues related to 'Health and Wellbeing' are main concern to the Brunei government as part of its mandate is to ensure the highest quality of life. This made Brunei one of the most advanced standards of living in Asia and hence, 'Health and Wellbeing' is among the best in the developing world and it has already achieved almost all of the targets outlined in the Millennium Development Goals (Prime Minister Office, 2014). Moreover, study on world green building trends suggests that 'Health and Wellbeing' is the top social reasons for improved health and productivity (McGraw Hill Construction, 2013).

'Cultural Identity and Heritage' category regarded as unique addition in this assessment scheme. BREEAM, GMS and GBI do not take this category into consideration in their scheme despite Malaysia shared similar cultural importance. Residential buildings in Brunei are greatly influenced by cultural considerations. Privacy from outsiders and between male and female are important aspects when designing a residential buildings. His Majesty constantly emphasise that any development should not compromise the religious and cultural traditions that Bruneians hold dear (Suzana, 2009; Salleh, 2009; Duraman and Tharumarajah, 2010).

This is in line with His Majesty intention for Bruneian to embrace Malay Islamic Monarchy (MIB) philosophy that proclaimed in 1st January 1984 – the very moment Brunei Darussalam assumed its independent and sovereign status. MIB is an integration of three elements: Malay language, culture and Malay customs, the teaching of Islamic laws and values and the monarchy system which must be esteemed and practiced by all. Design should also consider future family expansion to nurture culture of living together. Report shows that many Bruneians prefer and continue to have extended family system resulting in demand for bigger house (Ministry of Development, 2013).

Additional indicators such as flood control, health and safety, forest conservation, accessibility and mobility, housing affordability and water quality gained substantial attention as depicted in Table 2.

These indicators – excluding flood control – are excluded by the BREEAM, GMS and GBI schemes which may jeopardise the effectiveness of a new scheme and contradict the fundamental of BEA development. 'Energy Efficiency' remains the top priority in

BREEAM, GMS and GBI including for Brunei BEA. McGraw Hill Construction (2013) asserts that energy savings are by far the most critical environmental reason to build green. It scores same level of importance with Health and wellbeing with only slight different in degree of consensus.

In 2015, Brunei has published the guideline on energy efficiency and conservation for non-residential buildings and made it mandatory for government building. This initiative made significant awareness amongst participants in this industry and recognised its importance. Moreover, evidence shows Brunei is ranked fourth CO2 emissions from the consumption of energy in the world which dominated by residential sectors.

CONCLUSIONS AND THE WAY FORWARD

This research has presented the process of identifying the important categories and criteria to be incorporated into the Brunei BEA framework. Although they are similarities with BREEAM, GMS and GBI, many new indicators incorporated to suit with Brunei context. The findings revealed that all categories and criteria achieved high degree of consensus and importance. Further work includes another questionnaire aims to quantify the weighting of every indicator as mean to evaluate level of building performance and certification. Validation of the new framework will be sought through interviews from experts who have been involved in BEA policy, design and implementation. This includes expert from members of Green Building Council Brunei, a team of Green Building Initiatives in Ministry of Development Brunei and experts from Housing Department.

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