GREEN BUILDINGS IN CAMPUS: AN ASSESSMENT OF GREEN POTENTIAL FOR EXISTING CONVENTIONAL BUILDINGS

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Abstract

Refurbishing conventional buildings into green buildings can increase campus sustainability alongside building new sustainable buildings. However, refurbishing all campus' buildings is impractical, uneconomical and involves thorough planning and prioritisation. Unlike other concepts of assessment, assessing the green potential of a conventional building is rarely discussed in past literature. Therefore, this paper presents the development of a conceptual framework for prioritising buildings that can be refurbished by assessing their green potentials. Through this paper, this concept will be discussed in depth by reviewing relevant literature on existing assessment tools. The review focuses on identifying methods and indicators that can be adopted for the assessment of green potential. The study discovers that while literature on green potential assessment is limited, the frameworks of other types of assessments concerning green buildings are still viable. It is found that the most suitable indicators can be derived from commercial green building rating tools with some modifications to produce evidence that can be collected and measured. This paper anticipates that apart from filling the gap in knowledge, these findings will assist the government, campus administrators and managers to strategize their efforts towards achieving campus sustainability.

Keywords: *sustainable campus, green potential, green building assessment, rating tool development, assessment indicators*

Introduction

As a centre for knowledge, the university holds a crucial position in disseminating and promoting sustainability (Cusick 2009; Lukman & Glavic 2007; Rappaport & Creighton 2007, p. 14; Rusinko 2010). M'Gonigle and Starke (2006, p. xv), in their book, stated their frustration that although sustainability is preached in faculties, there still exist an ominous gap where the universities allow its environment to degrade in order to make way for physical development. In view of this, it is imperative to narrow the gap between what universities preach and what universities do M'Gonigle and Starke (2006, p. xv). Universities need to be sustainable in every attribute; economic, social and environment.

A large pool of literature regards university campuses as a 'small city' for their area, population size and their resources (Hoe 2011, p. 11; Mat et al. 2009). The combined population of 500,000 in Malaysia public universities alone qualify the universities as a state growth conurbation population where the largest university reaches 40,000 and qualifies as a major settlement centre (Department of Town and Country Planning 2012). A recent report by Ministry of Energy, Green Technology and Water (2011) shows that public universities are the biggest electricity consumer in comparison with other public buildings. The average consumption of 21,758,470 KWh per university is equivalent to the consumption of 2,112 residential homes (US Environmental Protection Agency 2013). These alarming figures signal that it is time to expedite and intensify efforts towards sustainable campuses.

One of the approaches towards campus sustainability is through green refurbishment. Not a new concept, green refurbishment has been proposed nearly two decades ago (Keeping & Shiers 1996), stemmed from the idea that existing conventional buildings can be refurbished into green buildings or made sustainable by integrating more environmentally conscious qualities into them. During the late 1880's, demolishing and rebuilding old buildings were a rampant practice in the UK (Power 2010). However, since studies reveal that green refurbishment produces less carbon footprint in comparison with demolishing and rebuilding (Burton & Kesidou 2005; Chileshe, Khatib & Farah 2013; Durmus-Pedini & Ashuri 2010; Juan, Gao & Wang 2010; Ma et al. 2012), green refurbishment has gained popularity in the built environment (Power 2010; Thomsen & van der Flier 2009). Commonly, green refurbishments are implemented on small and single projects such as office floors or residential homes (ACF 2009; Wall & Shea 2013). While these modest efforts are plausible, green refurbishment of building stocks such as the university campus provides a more promising impact.

In the context of a university, green refurbishment is increasingly accepted to improve campus sustainability (Zakaria et al. 2012). It is preferred over constructing new green buildings with the understanding that the benefits from the new green building will be subdued and outnumbered by the mass of pre-existing conventional buildings (Durmus-Pedini & Ashuri 2010). In a conventional building stock, there are other factors that induce a refurbishment project such as change of usage or capacity, building deterioration and to increase property value (Umar et al. 2013).

Green refurbishment is also favourable as it creates opportunities to incorporate sustainability strategies together with other types of building improvements (Mickaityte et al. 2008; Santamouris & Dascalaki 2002). This way, the benefit reaped from a green refurbishment is twofold.

While the benefits of green refurbishment is evident, implementing it on the entire campus' building stock instantaneously is impractical and uneconomic (Olanrewaju 2011). University campuses are often composed of clusters of conventional buildings. The mass of buildings to undertake, financial inadequacy and space constraint, are among various factors that hamper the implementation of simultaneous green refurbishment throughout university campuses. This exercise requires thorough planning and prioritisation.

Refurbishment projects should be implemented in phases and should be prioritised according to each building's potential on becoming a green building, or, its 'green potential' (Ben Avraham & Capeluto 2011). This planning strategy is similar to planners' strategy of zoning deteriorated buildings in an urban context. The strategy is realistic and it ensures successful employment of green refurbishment throughout the campus. Prioritising green potential in existing buildings necessitates the development of a green potential assessment method for the entire university campus building stock.

Unlike other concepts of assessment, green potential assessment is rarely discussed in past literature. Therefore, this paper presents the development of a conceptual framework for prioritising buildings that will be refurbished by assessing their green potentials. This study also discusses the concept in depth by reviewing relevant assessment tools available in the literature.

Assessing Green Potential in Existing Buildings

Even though green refurbishment has been studied since two decades ago, the assessment of green potential, on the other hand, was only recently explored by scholars. Ben Avraham and Capeluto (2011) initiated this assessment concept by developing a green potential assessment tool for office buildings in Israel. Ben Avraham and Capeluto (2011) defined green potential as the capacity to refurbish a conventional building into a green building (green refurbishment) through architectural interventions.

Several others have explored the potential for green refurbishment that responds to green certification criteria (Itani, Ghaddar & Ghali 2011; Rysanek & Choudhary 2013; Zakaria et al. 2012). The green certification criteria typically consist of a set of related indicators. However, these past research only suggest strategies to convert conventional buildings into green buildings. While the strategies are effective in employing green refurbishment for buildings in isolation, the researchers did not discuss the application of green refurbishment for campuses with large building stocks.

Green potential assessment is an important milestones in the process towards sustainable campus. Figure 1 illustrates that green potential assessment is employed prior to any other stages for green refurbishment. Assessing the green potential of each building in a building stock assists decision makers in prioritising buildings to be refurbished. The assessment will rank buildings with the highest to the lowest green potential. The building with the highest green potential signifies that less effort is needed to convert it into a green building compared with the building with the lowest green potential.

Similar to other forms of assessments, to assess green potential requires a specific tool of measurement. The tool should fulfil the criteria of an assessment tool which are; it should be measureable and systematic. Its true intention is to assess the green potential of each building and subsequently compare the buildings against each other. To achieve this, a rating system is needed. Ding (2008) describes that rating systems ascertain the performance level of a building through grades or stars, while assessment tools provide detailed measurable indicators of the building's actual performance. Accordingly, the final outcome of this study is a green potential rating tool (GPRT) with the objective to 'grade' each building in comparison with other buildings in its built environment. So far, to the authors' knowledge, no such tool has been developed yet in the South East Asian region.

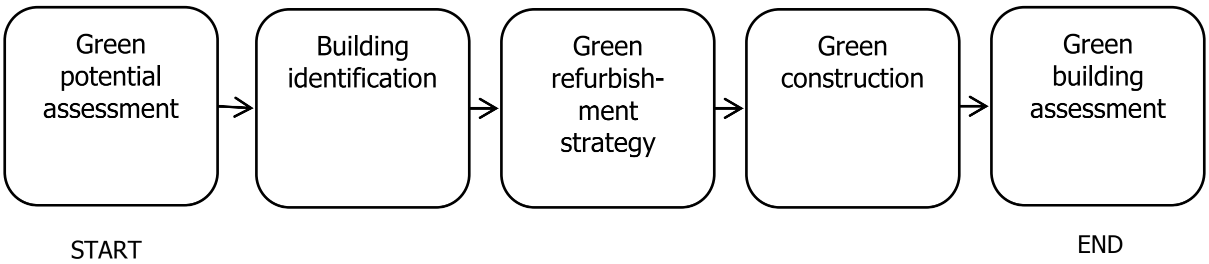

Figure 1: Green refurbishment milestone

Methodology

Assessment is defined as a diagnostic process that measures a subject's performance using instruments and procedures (John 2011). The assessment tool provides evidences for the building performance management that assists decision making for building operations (Bourdic & Salat 2012). The development of an assessment tool should be managed step by step to avoid losing focus (Davis & Morrow 2004). While an assessment tool should be designed exclusively to achieve its objective, generally, the tool should outline a systematic procedure and instrument by producing evidence and can be validated, is reliable, flexible and fair (John 2011).

Although ample literature is available on developing building assessment tools, the authors resolved that the development of the GPRT should observe the fundamentals of an assessment tool. Design and Development of Assessment Tools Guideline by The Department of Education Employment and Workplace Relations (2012) provided four elementary stages for developing an assessment tool (Figure 2). Although the guideline was prepared to develop assessment tool for workers' performance, its fundamental stages are applicable to any type of assessment tool. Each stage was followed through chronologically in order to develop the GPRT systematically.

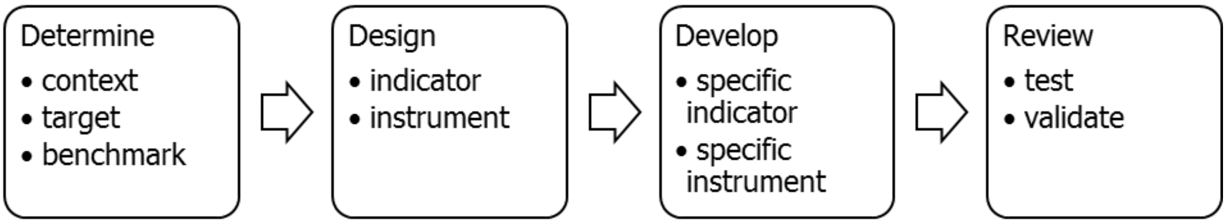

Figure 2: Four stages to develop an assessment tool

Figure 3 identifies the context and target for the assessment. In the context of sustainable campus, conventional buildings were identified as targets to be assessed against selected and modified green building standards, which are set as benchmark.

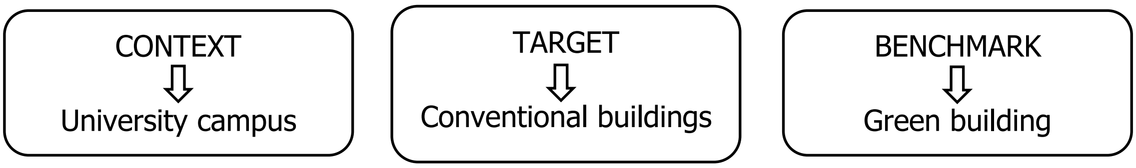

Figure 3: Subjects of Green Potential Rating Tool (GPRT)

The study took advantage of the availability of numerous literature on building assessment tools and made reference to the indicators and instruments suitable for collecting evidence for the assessment. The indicators defined in dominant building assessment tools were reviewed and the most prevalent indicators were shortlisted. Due to lack of literature specifically on green potential assessment, green building rating tools (GBRT) were deemed most suitable for adoption and modification for the GPRT. The availability of literature yielded the model of the GPRT as shown in Figure 4. Upon reviewing, the study selected the most relevant indicators to assess green potential in conventional university buildings and designed the best instruments to collect evidence.

Like any assessment tool, validation is important to confirm that the tool has assessed the targets appropriately and the instruments used have addressed all the evidence accurately. Validation also tests the applicability of the tool for the intended context. However, the present paper will not discuss the final stage of the GPRT development as it involves testing the finalised GPRT on case studies and collection of evidence.

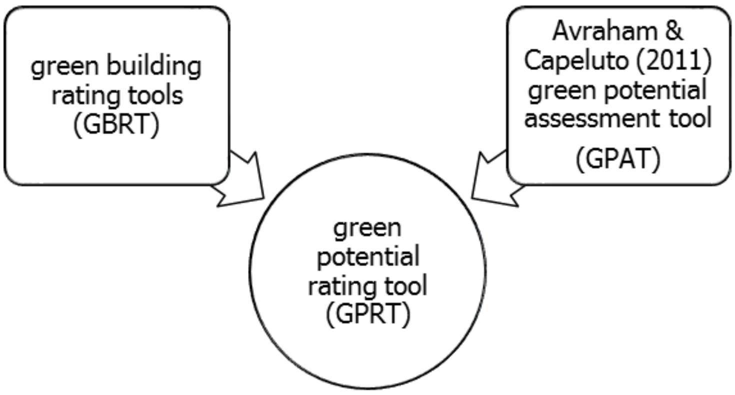

Figure 4 : Model for green potential rating tool (GPRT)

Review of Existing Building Assessment Tool

Green Potential Assessment Tool (GPAT)

Assessment of green potential is a fairly new concept in the building assessment industry. Thus far, an extensive review of literature discovered that there was only one tool that was developed with similar objectives to the GPRT.

Ben Avraham and Capeluto (2011), who were, to the authors' knowledge, the pioneering users of the term 'green potential', took another step from just assessing the sustainability of an existing building to developing a tool to assess its green potential. The tool was developed based on Israel Green Buildings Standard SI 5281. The team tested the tool on buildings that were built in the 50's and 60's when air-conditioners were not used comprehensively and on buildings that were built more recently with glass facades. Comparatively, they analysed points won by each building and tallied the scores.

The scores depicted the degree of flexibility of refurbishing the buildings using Israel Green Buildings Standard SI 5281 as the benchmark. The team devised a coloured visual scorecard that is easy to interpret. Reds on the scorecard denotes lower potential while greens denote higher potential. While the tool developed was very useful and practical, the assessment was too subjective and was not evidence-based. Granted, the team intended that the tool can quickly evaluate the building's green potential without having to collect any data.

The team also saw the potential of this tool as; first, to identify building potential so that it can be certified as a green building after refurbishment, and second, as a planning tool for sustainability zones for a building stock. For the latter, they envisioned that if the tool was used in an urban scale, it could be used to demarcate zones of different levels of green potential in an urban area.

The study by Ben Avraham and Capeluto was the conceptual foundation of the present paper. The present paper adopted their concept and applied it to the assessment of green potential in an urban scale. This concept is very useful to universities as a small city in the effort to become a sustainable campus.

Green Building Rating Tools (GBRT)

The awareness on sustainability nearly four decades ago has induced the birth of green buildings around the globe. In the early 1990s, Building Research Establishment (BRE), UK has pioneered the development of Building Research Establishment Environmental Assessment Methodology (BREEAM) to assess and certify these green buildings (Larsson & Cole 2001). The success of BREEAM has influenced other regions to formulate their own rating tools (Cole 2005). It has been reported that more than 600 tools concerning the environment have been developed since BREEAM (Building Research Establishment, UK, cited in Reed et al. 2009). Out of the 600 tools, more than 20 tools have been developed worldwide concerning green or sustainable buildings with adjustments made to the primary tool to suit the local environment and culture (Darus et al. 2009).

Not a mere conceptual instrument, BREEAM and many others of these tools are utilised commercially and authoritatively in many countries (Baldwin, Yates & Howard, cited in Banani, Vahdati & Elmualim 2013). These tools include Leadership in Energy and Environmental Design (LEED) for the USA, Comprehensive Assessment System for Built Environment Efficiency (CASBEE) for Japan, Green Globes for Canada, Green Star for Australia, Green Mark for Singapore, Green Building Index (GBI) for Malaysia and many more. Apart from ascertaining the level of sustainability of a particular building, the tool also acted as an incentive to building owners to add value to their property.

The level of sustainability of a building is ascertained through a scoring system that is easily assessed on a completed building. By allocating points from a list of indicators, a building's score will be referred to a predetermined band for rating. Each of the tools devised a different scoring structure and rating band. Interestingly, these scoring structures and rating bands, do not vary much from each other. Perhaps, the diminutive variation is due to the fact that all tools were largely developed based on either BREEAM or LEED (Reed et al. 2009). Depending on the priority and focus of the country, each of the tools differs only from the indicators outlined and their scoring allocation.

Malaysia and Singapore too, developed a GBRT that do not vary much from tools from other countries. To display the differences between these two tools and five global main tools, Table 1 presents a summary of indicators of each GBRT. The table shows that energy efficiency, material & resources, indoor environment quality, site planning, water efficiency and design & innovation are the most commonly used indicators for green building assessment.

Table 1: Summary of indicator listed in green building rating tools worldwide

	BREEAM	LEED	CASBEE	Green Globes	Green Star	Green Mark	GBI	Total
Country of origin	UK	USA	Japan	Canada	Australia	Singapore	Malaysia	
Energy efficiency	/	/	/	/	/	/	/	7
Material & resources	/	/	/	/	/	/	/	7
Indoor env. quality (IEQ)	/	/	/	/	/	/	/	7
Site planning	/	/	/		/	/	/	6
Water efficiency	/	/		/	/	/	/	6
Design & innovation	/	/			/	/	/	5
Emissions and effluents	/			/	/			3
Management	/			/			/	3
Transport	/				/			2
Awareness & education		/						1

Malaysia, concerned with the detriment that follows rapid physical development, embarked on devising its own GBRT, the Green Building Index (GBI) which was based on Singapore's Green Mark and Australia's Green Star (Greenbuildingindex

Sdn. Bhd. 2011). Prior to the launch of GBI in 2009 (Greenbuildingindex Sdn. Bhd. 2009), no rating was given on buildings that were designed, constructed, or operated sustainably (Darus et al. 2009). The absence of a 'label' onto green or sustainable buildings caused building developers to shy away from the green building initiative. As an incentive, the government, together with professional bodies devised GBI to attract developers to integrate sustainability into real estate. Credits and special certification is given to green buildings as a recognition of sustainable lifestyle (Yusoff & Wen 2014).

To further relate to the objective of GPRT, the indicators from GBI for non-residential existing building (NREB) are adopted. Table 2 lists the indicators utilized to assess green buildings according to six categories. The table shows that point allocation is not equally distributed. This implies that some indicators carry more weight than others.

The indicators were fashioned to assess only completed buildings. A number of the indicators are not applicable to assess green potential. Therefore, it is crucial to scrutinize each indicator for adoption and modification so that the collection of evidence is possible and measurable.

Table 2: Indicator and sub-indicator of GBI assessment for non-residential existing building (NREB)

Indicator	**Sub-indicator**	**Points**	**Total**
Energy efficiency	Minimum EE Performance	2	38
	Lighting Zoning	3	
	Electrical Sub-metering	2	
	Renewable Energy	5	
	Advanced or Improved EE Performance - BEI	15	
	Enhanced or Re-commissioning	4	
	On-going Post Occupancy Commissioning	2	
	EE Monitoring & Improvement	2	
	Sustainable Maintenance	3	
Indoor environmental quality	Minimum IAQ Performance	1	21
	Environmental Tobacco Smoke (ETS) Control	1	
	Carbon Dioxide Monitoring and Control	1	
	Indoor Air Pollutants	2	
	Mould Prevention	1	
	Thermal Comfort: Design & Controllability of Systems	2	
	Air Change Effectiveness	1	
	Daylighting	2	
	Daylight Glare Control	1	
	Electric Lighting Levels	1	
	High Frequency Ballasts	1	
	External Views	2	
	Internal Noise Levels	1	
	IAQ Before & During Occupancy	2	
	Post Occupancy Comfort Survey: Verification	2	

Table 2: continued

Indicator	Sub-indicator	Points	Total
Sustainable Site Planning & Management	GBI Rated Design & Construction	1	10
	Building Exterior Management	1	
	Integrated Pest Management, Erosion Control & Landscape Management	1	
	Green Vehicle Priority - Low Emitting & Fuel Efficient Vehicles	1	
	Parking Capacity	1	
	Greenery & Roof	4	
	Building User Manual	1	
Material & resources	Materials Reuse and Selection	1	9
	Recycled Content Materials	1	
	Sustainable Timber	1	
	Sustainable Purchasing Policy	1	
	Storage, Collection & Disposal of Recyclables	3	
	Refrigerants & Clean Agents	2	
Water efficiency	Rainwater harvesting	3	12
	Water recycling	2	
	Water efficient - irrigation/landscaping	2	
	Water efficient fittings	3	
	Metering & Leak Detection System	2	
Design & innovation	Innovation & Environmental Initiatives	9	10
	Green Building Index Facilitator	1	
	Total		100

Green Potential Rating Tool (GPRT)

Proposed Indicators

In theory, this research improvises on Ben Avraham and Capeluto (2011)'s rating tool which only covers physical characteristics of the buildings assessed. This was mainly because it was developed based on the guidelines of GB certification authority in Israel which gives little attention to the social values of a green building.

However, this rating tool is used to rate buildings that are already designed and built according to green building certification criteria (Xu, Chan & Qian 2012). Therefore, most data measured to rate the buildings are prepared during construction and are readily available. On the contrary, the objective of GPRT is to assess the green potential of the building before it is refurbished into green buildings. Many of the indicators listed in Table 2 are unmeasurable because it has not been implemented (i.e. lighting zoning, renewable energy etc.). They are also challenging to measure due to some limitations faced by the authors.

While having the most similarity in terms of indicators and aim, GBRTs are still somewhat a different tool from GPRT. Table 3 compares both assessment tools. The most important comparison is that GBRT is done after the green building is completed and, ready to be certified as a green building. Meanwhile, GPRT is an assessment that is done prior to the refurbishment of a conventional building into a green building. The objective of both tools are likewise different. The GBRT informs the assessor on the 'greenness' of a building, while, GPRT ascertains how far along is a building from being a green building.

Table 3: Comparison between green building rating tool and GPRT

GBRT	GPRT
• Assessed AFTER the building is completed	• Assessed BEFORE the refurbishment is done
• To assess how 'green' a building is	• To assess how 'green' a building could be
• To assess actual performance (Xu, 2012)	• To rank buildings according to green potential
• For green certification	• For selection of buildings to refurbish
• To assess individual buildings, often designed to be 'green'	• To compare between 2 or more buildings

Based on the review of GBRTs shown in Table 1, the research scrutinises each indicator in order to achieve the objective of the study. GBI sub-indicators are simplified into more realistic and measurable sub-indicators as shown in Table 4. From the proposed sub-indicators listed in Table 4, all indicators are now quantifiable and measurable, except for the pre-existing passive design elements.

The proposed procedures of the assessment are metering and occupant survey. The two methods have been presented in numerous studies as the best instruments to measure the respective indicators (Alajmi 2012, Frontczak 2012). In terms of the comparison between two or more buildings, a simple tally system is adopted. Two points are awarded to the building with evidence that meets the benchmark, while no point is given to the building that does not. Where the buildings compared are equal in score, one point is awarded. An example is demonstrated in Table 5. As demonstrated, building A possesses higher green potential compared with building B with the total point of 22 against 12 respectively. Similar tallying system applies to any number of buildings assessed.

Table 4: Proposed modified GPRT sub-indicator

Indicator	GBI Sub-indicator	GPRT Sub-indicator (Modified)	Instrument
Energy efficiency	Advanced or Improved EE Performance - BEI	calculation of BEI	power logger
	EE Monitoring & Improvement	electricity consumption monitoring	power logger
Indoor environmental quality	Thermal Comfort: Design & Controllability of Systems	Thermal comfort : user satisfaction	occupant survey
	Thermal Comfort: Design & Controllability of Systems	Thermal comfort : user controllability	occupant survey
	Daylighting	Visual comfort: user satisfaction (natural)	occupant survey
	Daylight Glare Control	Visual comfort: user controllability (natural)	occupant survey
	Electric Lighting Levels	Visual comfort: user satisfaction (artificial)	occupant survey
	Electric Lighting Levels	Visual comfort: user controllability (artificial)	occupant survey
	External Views	Visual comfort: user satisfaction (external view)	occupant survey
	Internal Noise Levels	Acoustic comfort: user satisfaction	occupant survey
	Internal Noise Levels	Acoustic comfort: user controllability	occupant survey
	IAQ Before & During Occupancy	Indoor Air Quality : user satisfaction	occupant survey
	Post Occupancy Comfort Survey: Verification	Overall comfort : user satisfaction	occupant survey
Sustainable Site Planning & Management	Parking Capacity	parking provision per occupancy	observation
Water efficiency	Metering & Leak Detection System	water consumption monitoring	water meter
	Metering & Leak Detection System	calculation of water consumption per occupancy	water meter
Design & innovation	Innovation & Environmental Initiatives	Pre-existing passive design elements	observation

Table 5: Demonstration of tallying the score for green potential assessment

Indicator	Sub-indicator (GPRT)	Benchmark	Building A	Point A	Building B	Point B
Energy efficiency	Calculation of BEI	lower is better	lower	2	higher	0
	Electricity consumption monitoring	lower is better	lower	2	higher	0
Indoor environmental quality	Thermal comfort : user satisfaction	higher is better	higher	2	lower	0
	Thermal comfort : user controllability	higher is better	higher	2	lower	0
	Visual comfort: user satisfaction (natural)	higher is better	lower	0	higher	2
	Visual comfort: user controllability (natural)	higher is better	lower	0	higher	2
	Visual comfort: user satisfaction (artificial)	higher is better	lower	0	higher	2
	Visual comfort: user controllability (artificial)	higher is better	lower	0	higher	2
	Visual comfort: user satisfaction (external view)	higher is better	higher	2	lower	0
	Acoustic comfort: user satisfaction	higher is better	lower	0	higher	2
	Acoustic comfort: user controllability	higher is better	equal	1	equal	1
	Indoor Air Quality : user satisfaction	higher is better	higher	2	lower	0
	Overall comfort : user satisfaction	higher is better	higher	2	lower	0
Sustainable Site Planning & Management	Parking provision per occupancy	higher is better	equal	1	equal	1
Water efficiency	Water consumption monitoring	lower is better	lower	2	higher	0
	Calculation of water consumption per occupancy	lower is better	lower	2	higher	0
Design & innovation	Pre-existing passive design elements	higher is better	higher	2	lower	0
			TOTAL	22		12

Conclusion

To summarize, this review of existing assessment tools and narrative of the development of the GPRT has shown how green potential assessment could contribute towards ensuring campus sustainability. The green potential rating tool ensures that campus sustainability is achievable not only in theory but also in practical. The green potential rating tool is developed by modifying the indicators of the existing green building rating tools due to lack of existing tools for green potential. The current research will be continued by testing the GPRT on selected conventional buildings in a university. The test is conducted to evaluate workability of the tool for assessing green potential. As it is, the tool is sufficient as a simple method to assess green potential, however, it can still be improvised further by validating the proposed indicators and scoring system through expert opinions and insights. It would be an evolution from this and previous research. Apart from filling the gap in knowledge, these findings will also assist the government, campus administrators and managers to strategize their efforts towards achieving campus sustainability.

Acknowledgements

The authors would like to thank the University of Malaya for funding this study through the Postgraduate Research Fund (Project no. PG098-2013A) and the Low Carbon Assessment Strategy – University of Malaya towards a Low Carbon University Campus Flagship project (Project no. FL027-2012B).

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