Applying low carbon landscapes at the Premier Polytechnic of Sultan Salahuddin Abdul Aziz Shah, Shah Alam, Malaysia

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Abstract: Campus physical development plan is an efficient tool in shaping campus life to promote a sustainable living community, especially for students. The purpose of this study is to enhance the quality of campus outdoor environment by applying low carbon to green landscapes and sustainable development. Premier Polytechnic of Sultan Salahuddin Abdul Aziz Shah (PSA) was selected as a proposed model for the government's planning to turn the polytechnic into a green campus. Applying and practising green and low carbon development in the PSA campus areas has reached a total reduction of 12.51% carbon sequestration via tree planting. This finding will help to produce a physical model of outdoor planning and design in generating low carbon campuses in Malaysian polytechnics.

Keywords: carbon sequestration; physical model; outdoor environment; green campus; Malaysia.

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1 Introduction

Campus acts as an institution for students’ creative thinking and contributes to tangible effects of social and cultural vitality. It has been noted that higher education institutions in Malaysia have improved tremendously towards sustainable campuses (Mat et al., 2009; Yusof, 2010). Currently, many local universities and colleges are at various stages of integrating sustainable components in campus planning and management. Polytechnic is one of the higher education institutions in Malaysia which has set the target for sustainability in its human capital as well as the environment (DPE, 2010). Besides, human economic activities are the largest sector that has caused greenhouse gas emissions (Lashof and Ahuja, 1990). According to the Blueprint PolyGreen for

Malaysian Polytechnic, a greenhouse gas release in Malaysia had increased by 55% in the year 2000 as compared to the year 1994 (DPE, 2010). This means the carbon dioxide (CO_2) per capita release in Malaysia is at 7.1 higher per capita tones more than the average release of CO_2 for countries in the Asia Pacific, a total of 2.6 per-capita tones precisely. This value is very high and should be decreased if Malaysia wishes to achieve the target fixed by the government that is 40% per capita GDP intensity reduction towards the year 2020 (COP, 2009; Mohsen, 2016).

Therefore, the initiative in producing green campuses plays an important role in generating sustainable development and mitigating climate change effects. As the Blueprint PolyGreen Polytechnic Malaysia (Othman et al., 2015) parallels with the movement of time, the Government Policy Department of Polytechnic Education, as well as TVET-ESD campuses, it wishes to exercise green initiative into their education system. It will bring change to the management system and consequently contribute toward the Malaysian aspiration achievement to develop polytechnic campuses sustainably. There is a lack of study of low carbon campuses in Malaysia. Hence, this study aimed to enhance the quality of campus outdoor environment by applying low carbon green landscapes and sustainable development. Hopefully, the findings of this study will help to produce a physical model of outdoor planning and design in generating low carbon campuses of Malaysian polytechnics.

2 Literature review: low carbon landscapes

Carbon sequestration is defined as the process of capture and long-term storage of atmospheric CO_2 (Sedjo and Sohngen, 2012). This is an important mitigation option to reduce the largest portion of GHG emissions (Mandlebaum and Nriagu, 2011). Through carbon sequestration, the effects of global warming and the attendant climate change can be reduced (Solomon, 2007). The most common example in nature takes place during the photosynthesis process of trees and plants, which stores carbon as CO_2 that is absorbed during growth. As the carbon is being soaked up, this would otherwise rise and trap heat in the atmosphere. Notably, trees and plants are essential players in efforts to stave-off global warming through a process called climate change mitigation.

Premier Polytechnic of Sultan Salahuddin Abdul Aziz Shah (PSA) was selected as a proposed model in the government's planning to produce green campuses for the Polytechnics and to increase the capacity of technical and vocational education and training (TVET) and education for sustainable development (ESD) in the Commonwealth countries. As stakeholders in TVET, all polytechnic institutions are directly involved in supporting and implementing initiatives that are TVET-ESD-related, which are in line with the aspirations of the country. The approach taken for its implementation is in making students as key participants of technology and instils green practices at the polytechnic. Design approaches and strategies are used to solve the campus environmental issues towards green and sustainable development based on two criteria of green areas: open spaces and green reserves in the campus. This design study aspired to achieve the national target of 10% carbon reduction. This study aimed at enhancing the quality of campus outdoor environment by applying low carbon green landscapes and sustainable development plan with three primary objectives. First was to analyse and to promote a green landscape campus characters and principles towards low carbon campuses. Second, to strengthen the campus design with green landscapes and

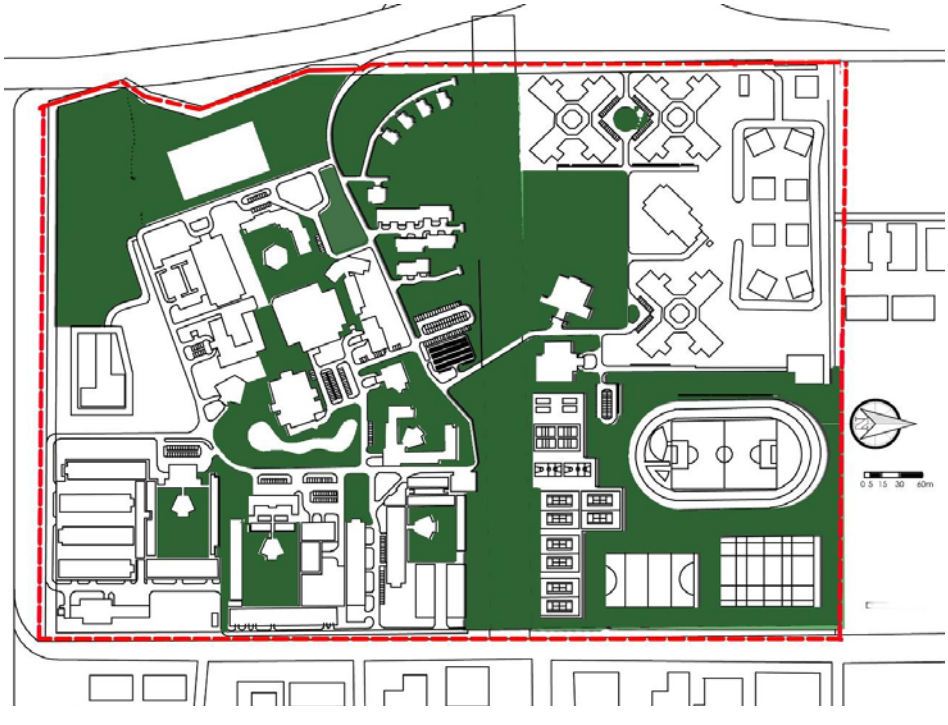
sustainable development. Third, to provide low carbon and high-quality campus environment.

3 Research method

This research incorporated two types of methods, i.e., two criteria of green areas which were calculated using two different formulas. By having these two criteria, the research was more significant, accurate, and relevant because most of the development of the urban areas in Malaysia contained the two land uses, which are open space and urban green reserve.

PSA was selected as the study area because this campus is located in a saturated zone of Klang Valley. Shah Alam, which is the Selangor's state capital, experiences high carbon emission and pollution in its atmosphere (Hashim et al., 2004). As a premier campus, PSA needs a green, clean, and fresh outdoor environment. PSA started as the eighth polytechnic in Malaysia in January 1997, which covers 157,634.83 m^2 (15.76 ha). PSA has six academic departments that offer quality courses. Its demography data covers the whole number of the campus community of PSA. The number of population in the PSA is 4,727 (4,339 students and 388 academic staff). As can be seen in Figure 1, this campus has plenty of outdoor space that can potentially be developed and designed as a sustainable, green, and low carbon environment. The rate of carbon sequestration depends on the growth characteristics of the tree species. The greatest rate is during the younger stages of tree growth, which are between 20 to 50 years (County, 2013).

Figure 1 Open space area around PSA campus built environment (see online version for colours)



Hence, researchers can roughly estimate the amount of carbon sequestered in a tree and divide by the tree's age to obtain a yearly sequestration rate. The calculation of carbon sequestration is based on Kato (1978) formula (Majid and Nurudin, 2015; Misni et al., 2015b). The data and information for every tree component can be gathered from the tree inventory by using the elements of tree biomass (tree's wood/trunk/stem, branch and leaf).

According to Vanlisuta (2014), the most sui\ formula to be used for areas such as an open space that consists of many tree species, various ages of trees, and several types of green cover is the Myers and Goreau formula. It is determined by the summation of the overall numbers of biomass per hectare. The fundamental of this formula is to estimate the amount of carbon sequestrated in a hectare per year and divide that amount by the number of trees per hectare. The Malaysian forest trees can sequester roughly 147 to 325 tons of carbon per hectare in aboveground biomass per year (Hoshizaki et al., 2004). For this study, an average of carbon sequestration 250 tons was used as a parameter in the calculation (Misni et al., 2015b). Primary data were collected via a tree inventory, an observation, and a land use survey. The analysis revolved around identifying the tree species planted in the green reserve and open space, tree characteristics, existing land use pattern, the trend of current activity, committed built-up analysis, and other relevant analysis. All data were tabulated in table form and mapped in plan form for a more precise analysis process.

Figure 2 Small amounts of existing trees around PSA campus environment (see online version for colours)

4 Results and discussion

Carbon sequestration along green reserve was calculated from individual trees using Kato's (1978) formula. It identifies five criteria for each tree, which includes species, trunk diameter, height, age and general condition. The calculation of carbon sequestration in an open space is the sum of the overall number of trees per hectare. Currently, the total carbon sequestration in PSA did not reach the target that is nationally needed, which is 10% of carbon reduction via carbon sequestration. Referring to Table 2, the present site study's contribution to carbon reduction per person per year compared to the average carbon footprint for 4,727 populations was very small, around 0.61%. This result shows that the existing environment is hot and unhealthy as a study environment. Many numbers of trees were tiny and not balanced with the numbers of users. The balance of 9.39% carbon reduction needs to be offset via campus carbon sequestration strategies and designs.

Figure 3 A proposed physical outdoor plan for PSA campus outdoor environment (see online version for colours)

The proposed design approach and idea is to create an outdoor environment of campus areas, which is environmentally friendly, healthy, green, and fresh by reducing the carbon emissions of at least 10%. The layout master plan is produced based on the conceptual idea and design strategies and approaches for a green environment and liveable space for the campus community with the concept of 're-regeneration' as shown in Figure 3. The existing building is maintained. The outdoor design approach and ideas are related to low carbon campus landscape elements such as green belt setting together secondary forest, green parking, lake, outdoor café, courtyard, pedestrian plaza, park and lawn.

The proposed plan shows the functional and liveable spaces that give different experiences for the campus community. At the main entrance of the campus, this area provides a sense of welcoming and gives the campus the spirit upon entering the area of study zone. One example is the connection with a green network that gives a sense of direction for the campus community by supporting the plantation of native tropical trees namely *Pteleocarpa pampanga* along the road, which offers shade and guidance for users. Every space in the study area has a function physical element and vegetation that reflects the green environment and showcases the image of a premier polytechnic itself. Thus, pedestrian pathways and bicycle lanes are proposed as part of the low carbon campus design for reducing carbon emissions in the campus area. A tropical native species called *Pteleocarpa lamponga* were also planted along the road to give it a streetscape identity and to provide safety and comfort feeling for the users. Another example of implementing green strategies is at the parking areas. *Messua ferrea* provide not only shades for the cars parked, but also absorb the carbon emissions at the same time.

Table 1 Tree biomass characteristics

Trees species	*Trunk dia. (mm)*	*Height (mm)*	*Canopy dia. (mm)*	*Planting dist. (mm)*	*Total (nos/m^2)*
Messua ferrea	800	7,000	6,000	6,000	121
Ptelocarpa lamponga	800	7,000	7,000	7,000	1,036
Cananga odorata	900	8,000	7,000	7,000	75
Fragraea fragrans	900	9,000	7,000	6,000	22
Cinnamomun iners	900	8,000	7,000	6,000	19
Peltaphorum pterocarpum	800	8,000	7,000	7,000	68
Tabebuia rosea	800	8,000	7,000	7,000	235
Khaya senegalensis	1,400	8,000	7,000	8,000	97
Lagerstroemia speciose	800	8,000	7,000	8,000	139
Samanea saman	1,200	8,000	7,000	8,000	87
Mimusops elengi	900	7,000	6,000	6,000	89
Secondary forest total area					4,650 m^2
Total					1.988

Table 1 shows the selected number of tree species that can function as a good absorber for carbon emissions, ornamental trees, and screening of trees to create a green campus environment (JLN, 2008; Misni et al., 2015a). Thus, trees can generate innovative and creative environment settings around campus and act as an attraction to the campus community and visitors while walking and cycling around the campus. The trees

proposed for campus areas are considered mature trees aged between 15 and 20 years. Therefore, in line with the low carbon environment, the selected tropical native species of trees are mostly fast-growing species, easy to maintain, and great in carbon sequestration (JLN, 2008).

The proposed trees were assumed as mature trees. The biomass characteristics and estimation for carbon sequestration for each tree are listed in Tables 2 and 3. The proposed trees were *Messua ferrea*, *Ptelocarpa lamponga*, *Cananga odorata*, *Fragraea fragrans*, *Cinnamomun iners*, *Peltaphorum pterocarpum*, *Tabebuia rosea*, *Khaya senegalensis*, *Lagerstroemia speciose*, *Samanea saman* and *Mimusops elengi*, which share similar characteristics such as low maintenance and cost, as well as high survival rate (JLN, 2008).

Table 2 Average carbon sequestration per tree species per year in PSA

Tree species	*Total trees (nos.)*	*Average carbon sequestration (kg) (Misni et al., 2015a)*	*Estimate carbon sequestration (kg)*
Messua ferrea	121	1,875	226,875
Ptelocarpa lamponga	1,036	1,129	1,169,644
Cananga odorata	75	1,596	119,700
Fragraea fragrans	22	1,158	25,476
Cinnamomun iners	19	1,111	21,109
Peltaphorum pterocarpum	68	2,895	196,860
Tabebuia rosea	235	1,211	284,585
Khaya senegalensis	97	4,507	437,179
Lagerstroemia speciose	139	2,530	351,670
Samanea saman	87	1,125	97,875
Mimusops elengi	89	1,184	105,376
Total	1,988	20,321	3,036,349

Table 3 Carbon sequestration via green reserve

Carbon sequestration item	*Estimated carbon sequestration*
Carbon sequestration	3,036.349 tons
Population of PSA	4,727
Carbon sequestration per person per year	0.64 tons
Carbon footprint per person per year	7.100 tons
Carbon sequestration for 4,727 population	33,561.7
Contribution of carbon reduction per person per year compared to the average carbon footprint for 4,727 population	9.05%

The results show the 1,988 trees that were planted in the campus green reserve areas. Among them is *Ptelocarpa lamponga*, mostly planted in the green reserve area in 1,036 units. Planted along the road, this species was estimated to contribute approximately 1,169,644 kg carbons sequestration per year at an average of 1,129 kg carbons per tree. Besides, it has the highest carbon sequestration regarding the number of trees compared to other species. The most elevated contribution of carbon sequestration

for the individual tree at the site study area was *Khaya senegalensis* with 4,507 kg per year with the estimated total of about 437,179 kg for the entire 97 trees. Other tree species that have contributed higher carbon sequestration based on the number of trees in the site study were *Tabebuia rosea* with 284,585 kg carbon per year, *Cananga odorata* with 119,700 kg carbon per year, and *Lagerstroemia speciose* with 351,670 kg carbon per year. Based on the analysis, the total amount of carbon sequestration for 1,988 numbers of trees was 3,036,349 kg carbon, which equals to 3,036.349 tons of carbon. The carbon sequestration for green reserve in the study area was 3,036.349 tons. According to the Ministry of Natural Resources and Environment in Malaysia, the average carbon footprint per person per year in the country was 7.1 tons. Thus, this study found that the carbon sequestration for 4,727 populations in the campus green reserve had achieved approximately 9.05%. The areas of open spaces in this study are around a quarter of the whole campus.

The open spaces were planted with a high density of tropical native tropical trees and were designed as secondary tropical forest. The total area for open space is 4.650 hectares which was estimated for carbon sequestration of as much as 1,162.5 tons per year. Every hectare of open space has contributed 250 tons per year. The total carbon sequestration for open space for 4,727 populations was 3.46%. Table 4 reveals the total carbon sequestration via green reserve and open space was 4,198.85 tons per year with 4,727 populations in 7.1 tons per person per year of carbon footprint, whereby the total carbon reduction was 12.51% per year. The results have shown that the site study has achieved the minimum national target of 10%.

Table 4 Total carbon sequestration via green reserve and open space in PSA

Carbon sequestration item	*Estimated carbon sequestration*
Carbon sequestration at green area	3,036.349 tons
Carbon sequestration at open space	1,162.5 tons
Total carbon sequestration	4,198.85 tons
Population campus community	4,727
Carbon sequestration per person per year	0.89 tons
Carbon footprint per person per year	7.100 tons
Contribution of carbon reduction per person per year (green reserve) compared to the average carbon footprint for 4,727 population	9.05%
Contribution of carbon reduction per person per year (open space) compared to the average carbon footprint for 4,727 population	3.46%
Contribution of carbon reduction per person per year (green reserve + open space) compared to carbon footprint for 4,727 population	12.51%
Carbon reduction targets via carbon sequestration	10%

The estimated number of trees required for every single person living on the campus was five to absorb and store their carbon footprint in daily activities to reach green, fresh, and healthy lifestyle on campus. Overall, carbon reduction target via carbon sequestration by trees around the campus area has been succeeded with 12.51% compared to the 10% national target, in line with the design strategies of the green campus environment and low carbon campus landscapes following the Blueprint PolyGreen for Malaysian Polytechnics

5 Conclusions

In keeping with the green development and low carbon development in campus areas, carbon sequestration via tree planting was discovered as the most effective baseline study that should be generated. This was an essential factor in the current contribution of the planning and design strategies for generating and managing carbon sequestration in the campus area as a result of the 12.51% carbon reduction. From the aspect of design strategy and approaches, by applying mature tropical native tree species, with a quarter of open space combined with green reserve, can create an interesting and functional low carbon campus landscapes as a productive learning environment for the campus community in PSA. Furthermore, the target for low carbon campus via in the Blueprint PolyGreen for Malaysian Polytechnics was achieved. Thus, this finding is an important value for PSA as a campus model for the current contribution. It will help to produce physical planning and design strategies for generating low carbon campuses by carbon sequestration in Malaysian polytechnic campuses.

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