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Evaluation of carbon reduction through integration of vertical and horizontal landscape design for hotel premises

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Abstract

Hotel premises is a fundamental component of the tourism and hospitality. The design, construction, operation and end-of-life-cycle processes of hotel premises built the environment by which it exerts both positive and negative impacts on the guest and surrounding environment. Carbon emission from hotel premises are one of the major sources for greenhouse effect in urban areas. To counteract these tendencies, it is therefore necessary to identify green building practices that can be implemented over the hotel building's carbon emission in order to reduce its environmental impact as minimize the operational cost while maximizing economic and social opportunities. This study proved that through a substantial integration of spatial landscape design in combination with the right selection of plant materials based on its characteristics, carbon sequestration rate in a hotel premise can be optimized. Consequently, the role of these plants and trees in sequestering carbon emission will be best understood and the greatest opportunity as a carbon sink may be explored. This study aimed to predict carbon sequestration rate by plant materials through integration of vertical and horizontal landscape design. The decisive outcome of this study is a green practice applied in monitoring carbon toxicity and a cost effective environmental friendly carbon neutralization.

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Introduction

The objective of the present study is to discuss the strengths and weaknesses of the current carbon calculator methodology and to review the key features for its improvement and to suggest a potential calculation and modelling system in a specific Tourism Accommodation Premise (TAP). As projected by the Intergovernmental Panel on Climate Change (IPCC) in 2010, the global temperatures would rise between 1 and 6ºC by the end of this century (Marsh, 2010). Global warming is causing chaotic climate change that can affect humanity and environment quality (Future Climate Change, 2013).

Global warming is the main threat to the environment and if it is not treated cautiously it will cause severe environmental impact. Between 1984 and 2004, carbon dioxide emissions in the whole world has increased by 43%, with an average annual increase of 1.8% (Lombard, 2008). IPCC recognized that the building sector has the greatest economic mitigation potential for reduction of GHG emission as these buildings are dominant energy consumption, particularly in developed and developing countries (Intergovernmental Panel on Climate Change, 2007).

Carbon audit, is a life cycle assessment tool which can be used for revealing the major sources and amount of GHG emissions. Thus, it can identify appropriate targets and opportunities for reducing the emissions from buildings (European Commission, 2009). Research and guidelines have been developed worldwide for promoting carbon footprint and audits, but an extensive review of the key features are not yet available. Among the significant research undertaken are the determination of carbon emissions based on simulated building energy consumptions (Kneifel, 2010) ; a modeling approach described by Pe'kala (2010) for optimal planning of energy systems that is subjected to carbon and land footprint constraints and preliminary comparison of the carbon footprints of 12 metropolitan areas (Sovacool, 2010). Unfortunately, studies which investigated the carbon emissions based on in-depth field data of individual buildings are not available in open literature (Joseph, 2012).

Recently, public interest in climate change and environmental issues has increased. These distresses have alarmed the management team of each specific industry. In Singapore and Hong Kong, the hotels are in the category of energy-intensive building (Deng, 2000; Lai, 2008; Priyadarsini, 2009). The predicted amount of carbon emissions due to energy use in the hotel industry is significant (Chan, 2002). Carbon footprint report and audit for specific hotel building is still an ambiguous phase among these hoteliers. In having deficient of such crucial information, hoteliers and managers are not yet fully alert about the fact that the carbon emissions from their facilities has reached hazardous state.

Carbon sequestration is defined as the process of capture and long-term storage of atmospheric CO_2 (Sedjo, 2012). This is an important mitigation option to reduce the largest portion of Green house gasses emissions (such as CO_2) (Mandlebaum, 2011). The role of plants and trees in carbon sequestration in urban area is probably best understood and appears to offer the greatest opportunity as a carbon sink.

This paper aims to explore the role of plant materials in TAP carbon neutrality. Therefore, literature pertaining to previous studies and review of experiment on carbon offsetting within the localities of hotel industry have been conducted. Current carbon sequestration rate and emission calculator methodology in the past studies have provided series of suggestions and recommendations. However, these are listed in order to assist the hoteliers and all stakeholders in managing their TAP carbon emission rating.

Materials and method

For calculating the total build up areas and green areas of the selected site, the base map of Empayar Muzaffar Hotel, Melaka was obtained from the authorities. The bill of

Table 1 : Vegetation specs of Empayar Muzaffar Hotel, Melaka

	Species	Overall height/feet	Total diameter /inch	Age	Qty	CSR/ tCO_2e
TREE						
1.	*Baekea frutescen*	6.56	11.81 - 27.56	28 year	11	5.95
2.	*Bucida molineti*	6.56 – 9.84	11.81 - 19.69	20 year	32	13.24
3.	*Dalbergiacochinchinensis*	6.56 – 9.84	19.69 - 27.56	28 year	26	21.09
4.	*Plumeria alba*	6.56	19.69 -27.56	28 year	5	2.70
Palm						
1.	*Cocos nucifera*	9.84	3.94 – 7.87	8 year	18	1.98
2.	*Livistoniarotundifolia*	9.84 - 13.12	3.94 – 5.91	6 year	11	0.68
3.	*Roystoneaoleracea*	9.84 - 13.12	3.94 – 5.91	6 year	40	2.49
Shrub						
1.	*Muraraya paniculata dwarf*	0.66	0.59	1 year	2190	0.09
2.	*Phyllanthus myrtifolius*	0.66	0.79	1.5 year	2320	0.17
3.	*Cyathealatebrosa*	3.28	0.59	1 year	58	0.01
4.	*Jasminummultiflorum*	1.31	0.39	1 year	650	0.02
5.	*Philodendron selloum*	1.31	0.47	1 year	525	0.03
6.	*Thunbergia grandiflora alba*	0.66	0.79	1.5 year	150	0.01
7.	*Wrightiaantidysenterica*	1.31	0.79	1.5 year	750	0.09

Table 2 : Distribution of carbon sequestration rate by types of plants

TYPE	VALUE/tCO_2e
Trees	42.98
Palms	5.15
Shrubs	0.43

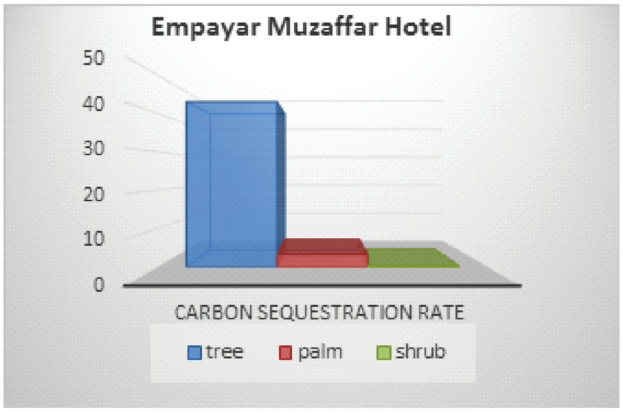

Fig. 1 : Carbon Sequestration Rate Based on Types of Plants

quantities (BQ) of landscape plant was also retrieved in order to identify the exact quantity of the plant materials and to identify the specifications of vegetation including the overall height and breast height diameter of the existing vegetation for determination of age. After identifying all data needed on site, the Carbon Sequestration Rate or CSR was calculated for every species of vegetation according to the following formula :

CSR formula for trees and shrubs:

Total Green Weight (TGW) I: W = 0.25D2H (1.2)

Total Dry Weight (TDW) I = TGW I x 0.725

Total Carbon Weight (TCW) I = TDW I x 0.5

Total CO_2 Weight (TCO_2W) I = TCW I x 3.6663

Total CO_2 Weight (TCO_2W/year) I/YEAR

CSR formula for turf, creeper & climber:

Total Dry Weight (TDW) = 0.56 x area in meter squared

Total Carbon Weight (TCW) = TDW x 0.427

Total CO_2 Weight (TCO_2W) = TCW x 3.6663

Carbon Rating System Point tCO_2e = TCO2W/1000

Results and Discussion

Case study at Empayar Muzafar Hotel, Melaka : Table 1 shows the vegetation details of Empayar Muzaffar Hotel. The carbon sequestration value for each species of the vegetation was identified. After calculating the sequestration value of each plant species and categories, a graph that combined the obtained value for further evaluation was made. Fig. 1 indicates the relationship between plant categories and total carbon that can be sequestrate by them.

From Fig. 1, it can be depicted that the highest value that can be sequestrated was from tree categories. Total carbon sequestration that occurs among tree species in this hotel was 42.98 tCO_2e. The number was extremely high as compared to the palm and shrubs categories which were 5.15 tCO_2e and 0.43tCO^2e, respectively. At this particular premise trees were dominant CSR agent. Specification of trees such as age, diameter and height influenced their CSR ability as they possessed higher specification as compared to other species. The study proved that the diameter and the height of the plant played an important role in this premise. From the analyzed data, it can be concluded that although build up area was higher than green area, the total carbon sequestration was still high recommended for a tourism premise. The total carbon sequestration that occurred at the hotel were sequestrated among the existing plants. These were present in the green area of the hotel premises.

CSR by plant materials with application of horizontal and vertical landscape design : The findings suggest that with the increase in percentage of green areas in the hotel, the total CSR for the hotel would be much greater. In addition, if more varieties of vegetation are introduced, the CSR would increase. Besides characters of the plants, criteria such as diversity of plants age, diameter and height significantly influence the carbon sequestration rate. Interestingly, in Empayar Muzaffar Hotel, majority of the CSR was done by trees which sequester approximately 43 tCO_2e.

It can be concluded that one of the promising approach to reduce carbon emission in the atmosphere is by selecting an appropriate plant material as well as optimization of spatial and space organization of green spaces. Besides, character of the plants, criteria such as soil, plant material age, trunk diameter and trunk height very much influence the carbon sequestration rate. The assessment of this study showed that carbon sequestration rate by trees was the highest, for a long period of time as compared to other plants such as ground covers. This study also established that even with limited green space areas for TAP context, the carbon sequestration rate can be further increased with the right selection of plants, at the right place with the right spatial and space organization of green spaces. The significant outcomes of this assessment will be a novel landscape design approach to neutralize carbon emission which is cost effective and environment friendly.

This study suggests that hotels and resorts those are implementing environmental strategies can increase their business of hotel industries. This finding will refine and upgrade existing carbon calculations (which only focuses on the field specialist) to make it accessible to laymen having no professional background. Thus, this contribution also will addresses the above mentioned gaps by developing manuals for new carbon sequestration rate assessments at the regional and local level. This study validates that the carbon sequestration modeling system is a effective tool for all TAP managers. When more plant materials are made available, a database of carbon emission benchmarks can be established. Further more, this study can bring plant materials based on landscape design as a key performance indicator of facilities for management at TAP. This key performance guidelines will assist the managers in increasing green spaces at their TAP buildings. This will ensure them to comply with the sustainable building development policy. The suggestions can help to conduct smoother and more proper TAP carbon audits in future.

Calculation of carbon (C) stored and sequestered by plants at TAP is the actual and critical assessment of the real potential role of a landscape setting in reducing atmospheric CO_2. The calculation of biomass provide reasonably accurate estimation of the amount of carbon that was sequestered from trees over the years and is one of the most cost effective and efficient methods to remove carbon dioxide from the atmosphere. These results can be used to help in assessing the actual and potential role of TAP landscape setting in reducing atmospheric CO_2 in urban areas. In addition, they provide insights for decision-makers and also for the public to better understand the role of landscape, and make better management plans for urban forests, parks or other green areas.

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