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VISUAL TREE ASSESSMENT AND ESTIMATION OF TREE CARBON SEQUESTRATION FOR OUTDOOR STUDENT CENTRE

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Abstract

Environmental assessment is crucial for every project development, especially when the space is surrounded by many mature trees. Failing to understand the existing character and conditions of the site can result in design failures that may lead to the loss of ecosystem benefits. Many developments are constructed without consulting experts, leading to unstructured development. Therefore, this research aims to investigate the potential of a proposed outdoor space towards a better teaching and learning environment. This study analyses Visual Tree Assessment (VTA) and estimates the carbon sequestration of trees using qualitative and quantitative data. The objectives are to create a topographic layout map by assessing site conditions, examining tree species and their condition through limited VTA, and estimating the net carbon sequestration of the on-site trees. 59 trees were analysed, and a map was developed for overlay purposes. A composite map illustrates the correlation of comfort, movement, aesthetics, and social relations criteria for the Outdoor Student Centres. In conclusion, 82% of Pongamia pinnata trees are deemed unsuitable for the site and may be considered for removal for OSC development. The site's net tree carbon sequestration is estimated to sequester a minimum of 611 kg of carbon. Effective site planning is a crucial factor in this process to ensure optimal outcomes.

Keywords: Plant Identification, Visual Tree Assessment (VTA), Carbon Sequestration, Outdoor Learning, Mapping Overlay

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INTRODUCTION

The Outdoor Student Centre (OSC) is a proposed project for the UiTM Perak branch, providing outdoor learning spaces for both students and lecturers. Learning does not have to be confined to the classroom; it can happen anywhere, especially with online resources. According to Yaman (2018), a study among Landscape Architecture and Architecture students at Universiti Putra Malaysia (UPM), International Islamic University Malaysia (IIUM), and Universiti Teknologi MARA (UiTM) showed that outdoor learning spaces offer diverse experiences and improve students' performance, particularly in Problem-Based Learning (PBL). Additionally, learning outdoors offers health benefits and promotes healing through nature. O'Brien (2011) found that outdoor learning, whether through intensive hands-on activities or over the long term, enhances health and well-being. Overall, outdoor education provides valuable experiences and benefits to students.

According to Corel Mateo-Canedo (2023), an experimental study involving 273 undergraduate university students in Barcelona tested three learning exposures: indoors, outdoors, and online. The study evaluated the learning experience and conditions across six dimensions: learning impact, evaluative impact, hedonic experience, technical conditions, environmental conditions, and health security. Outdoor seminars were found to be more effective than indoor seminars with regards the learning experience, particularly in hedonic experience. However, indoor seminars received higher ratings than outdoor seminars in terms of learning conditions, with a significant difference observed in environmental conditions.

Based on the experimental study, university students achieved better scores in the online environment compared to face-to-face environments. Adapting to both outdoor and online contexts through active methodologies helps overcome technical, environmental, and teaching limitations, and improves health security. The approach also ensures a positive learning experience and adds flexibility to the teaching-learning processes. Teaching and learning in the university should be versatile, and providing outdoor spaces or green spaces for teaching and learning environments should be considered. The potential spaces for outdoor learning are proposed based on the existing features at UiTM Perak branch. According to Abdullah (2021), the analysis of significant design characteristics for outdoor learning in higher education emphasises safety, comfort, tranquillity, and proximity. Therefore, UiTM can utilize existing trees and the surrounding natural environment as key elements for outdoor education. UiTM Seri Iskandar campus, plans to develop an Outdoor Student Centre project at Dataran Usahawan. The proposed project encompasses a 3,600m² area with various tree species and a building known as Dataran Usahawan. Consequently, several phases are being strategized, including identifying tree species and assessing tree conditions through Visual Tree Assessment (VTA). This identification is part of the site inventory and site analysis process, focusing on biological attributes. This phase also included a further ecological investigation to understand the basic ground need of many habitats around. The VTA method is internationally recognized for tree inspection, identifying hazard symptoms, confirming defects, and assessing criteria for failure. Since the site is slated for development, the researcher initiates identification of trees that can be either pruned or preserved. Thus, the research aims to investigate the potential of an outdoor space for a teaching and learning environment with a tree study before allowing any tree to be cut down.

The objectives are narrowed into three: Firstly, to produce the topographic layout map by measuring the site conditions. Secondly, was to investigate the tree species and their conditions in the site project by limited VTA. Lastly, to estimate the net carbon sequestration of the trees on site. These three stages of data are essential for the researcher to understand the character and potential of the site for an Outdoor Student Centre (OSC).

LITERATURE REVIEW

Student Outdoor Learning in Higher Education

According to Abdullah (2021), outdoor learning involves gaining knowledge outside of the conventional classroom or an enclosed learning space. The analysis of significant design characteristics for outdoor learning in higher education emphasises safety, comfort, tranquillity, and proximity. Maheran et al. (2017) concluded six design characteristics for proper outdoor learning spaces: flexibility and multiple use, comfort, movement, technology and ICT tools, aesthetics, and social relations. Therefore, to achieve a learning space that meets these design characteristics, UiTM needs to sacrifice several trees to develop a proper space. Trees grow over time and have a long-life cycle for replantation. Thus, initiatives to investigate tree conditions before cutting them down are indeed one of the necessary steps. UiTM can utilise existing trees and the surrounding natural environment as key elements for outdoor education.

The Existing Tree Conditions Assessment

A tree assessment task is specific information to present a tree condition's status. The task has been practised for over a century to sustain urban green initiatives. Landscape designers are also well aware of the success of the planting programs in the tree assessment task provided. It is mentioned that the assessment task for the existing tree in a particular site is the core component in the design process because it is premeditated to reveal the tree performance status for practical design solutions (Koeser et al., 2016). It guides the designer through realistic data obtained (Roman et al., 2013). This way, systematic design practices are ideal for ensuring outstanding tree performance and the continuity of the ecosystem services that existing trees provide.

According to Li (2022), tree health describes the growth condition of trees and focuses on protecting and restoring trees to a healthy state. The unhealthy tree is often related to primary stress factors, such as temperature, mineral deficiencies, and lack of watering. The attack by insects or disease is a secondary factor that attacks weakened trees. Diagnosing a tree on-site should consider six important keys as per suggested by Lily (2001), such as (a) accurately identify the plant, (b) look for a pattern or abnormality, (c) carefully examine the site, note the colour, size, and thickness of the foliage, (e) check the trunk and branches, and (f) examine the roots and root collar. The researchers should also built a checklist for general study when diagnosing trees on site.

According to Lily (2001), around 70-90% of tree health problems are caused by environmental conditions such as soil compaction, drought, moisture fluctuations, temperature extremes, mechanical injuries, or poor species selection on site. The cause is usually combined or complex with non-living stresses and living human/animal contributors. Thus, no direct or single solution can be suggested when analysing the tree health problems. When analysing the tree heath, the researchers look at the symptoms and signs to determine the cause. According to Lily (2001), a problem on the tree was rarely diagnosed with a single symptom. For example, the wilting symptoms might be caused by a lack of watering or root problems. Therefore, various tree assessment approaches have been created to aid professionals through the tree inspection process. The Basic Tree Assessment Method was developed in conjunction with the International Society of Arboriculture's (ISA) Tree Risk Assessment Best Management Practice (BMP) Manual (Smiley et al., 2017). Depending on the extent of the assessment, this tree assessment methodology is divided into three levels: Level 1 is a limited Visual Tree Assessment (eyes-only inspection, drive-by, or a walk-by assessment). Level 2 is a basic Visual Tree Assessment (ground-level inspection with simple hand tools). Level 3 is an advanced Tree Assessment (human climbing on a tree may involve together with a piece of diagnostic equipment).

The tree condition index contains a risk-rating assessment characterised by four levels - low, moderate, high, and extreme (Chuon et al., 2011), equivalent to tree health status into good, moderate, poor, and very poor. This assessment is being done especially in future development settings. It would help identify tree defects in the proposed areas, calculating the hazard of the existing trees and the possibilities of their failures. This likely damage rigorousness could happen due to their failures and, most importantly, recommending pre-incident preventive and corrective design solutions. This would help in preventing unnecessary losses due to future tree failures.

Measuring Tree and Carbon Sequestration

The carbon sequestration in a tree refers to capturing atmospheric carbon dioxide through photosynthesis and storing it in plants' parts like stems, leaves, and roots. The value of carbon sequestration of a tree is different based on the locality and precision of the date taken. This research paper cites a tropical tree in Singapore located on the roadside to be used in similarity to this research locality. However, the tree girths are measured on-site. According to Tan (2010), to obtain a net carbon sequestration, tree girth and carbon sequestration value are needed with simplified formula as shown in Figure 1.

Net Carbon Sequestration (kg C / year)	=	Tree Girth	x	Per Tree Carbon Sequestration Rate (kg C / tree / year)

Figure 1: Formula for Net Carbon Sequestration Estimation.
Source: Tan (2010)

The age of a tree can be identified by its girth. According to Tan (2010), tree girth is classified into four types, as shown in Figure 2. Figure 2 summarises that the tree is categorised into four types based on the tree Diameter at Breast Height (DBH). It was measured quickly on the site by using a DBH tape.

Girth 1	Girth 2	Girth 3	Girth 4
DBH < 0.5m	DBH 0.5m to	DBH 1m to	DBH >1.5m

Figure 2: Four size categories of DBH of a tree based on Tan (2010)

Mapping Overlay

Ian McHarg (1920–2001) was a significant innovator and proponent of the map overlay method (Steiner, 2019). He studied how to design new roadways damaging as little as possible natural heritage and biodiversity to develop an eligibility analysis through a technique called 'overlay mapping,' consisting of overlapping different thematic maps. The map overlay is often used by landscape architects, planners, and geographers to analyse 'the green landscape pattern (Kuitert, 2013). In this study, the overlay map techniques identify two related programs: the tree's spatial program and the path circulation human behaviour program. The overlay is a GIS operation that superimposes multiple data sets to identify relationships between the data programs. In this study, overlaying techniques identify the plant species and tree condition with the human behaviour pattern circulation in the sites. Thus, the overlay techniques create a composite map by combining the geometry (circulation behaviour) and attributes (plant identification and tree conditions) of the input data sets for the inventory and analysis data before the design development stage. Overlay features in a map in AutoCAD is a simple technique to identify the critical features being considered.

It can also make the comparison of spatially related. According to Autodesk (2018), overlays compare two feature classes or spatially related layers, while according to Vemuri (2016), the transparency of layers is reduced and controlled to allow the researcher to compare each piece of data visually.

METHODOLOGY

The site proposal for OSC has been selected by Bahagian Pengurusan Fasiliti (BPF), UiTM Perak branch, based on the nearby existing building named Dataran Keusahawanan, which already focuses on student entrepreneurship development. This study employed a mixed-method approach, and the researcher analysed both qualitative and quantitative data. There were two types of data collection techniques: first, a topographic survey, and second, a tree health condition assessment. A topographic survey was considered quantitative data. As a measurement tool, a unit of theodolite was used to GPS log the location of any structure and levelling found on site. It is an optical instrument for measuring angles between designated visible points in the horizontal and vertical planes. Site surveys completed by licensed surveyors will typically include the locations of existing trees. The site was calculated with a 3,600m2 area, and the measurement was done in approximately a week when the sky was clear. The GPS log was then transferred into AutoCAD drawing and presented quantitative data in the form of drawing.

Tree health condition assessment as a second collection of data is part of qualitative data. Before the tree and site environment were assessed, the drawing from the topographic survey was used to highlight the different tree species on site carefully. The tree identification was made by understanding the different colours, forms, and patterns on leaves, trunks, flowers, fruit, and tree shapes. Tree health assessments are narrowed into four quality levels: good condition to represent a low tree risk rating, moderate condition to represent a medium risk, bad condition to represent high risk and very bad condition to represent extreme tree risk rate. This quality data was collected in approximately a week of observation. Other site qualities being assessed are human behaviour patterns, which were conducted in roughly a week. The total observation was approximately two months, from February until April 2022. Site observations for quantitative and qualitative data were needed, as the data obtained in this phase will guide the design proposal of the OSC project. The inventory and analysis data attributes highlighted in this proposal are cultural, physical, and biological attributes, including human movement, topography, hydrology, climate, and vegetation. The site analysis summarises the site's suitability based on the attributes that influence the project under consideration. Therefore, the opportunities associated with a site are unique natural resources that warrant protection. In this context of site projects, the opportunities that may enhance the site's aesthetic and environmental quality are the existing trees that have contributed to a pleasing ambience and comfortable environment.

Based on the initial study made for carbon sequestration, the researcher found limited data for several species. The value of the carbon sequestration rate of trees is limited to *Cinnamomum iners, Mimusops elengi, Pongamia pinnata, Swietania macrophylla*, and *Syzigium campanulatum* only. The value used in this research is cited from Tan (2010) as shown in Table 1. This value is secondary data obtained from the citation work conducted on the tropical Singapore tree.

Table 1: Net Carbon Sequestration (kg C year/tree)

Tree species	Girth 1	Girth 2	Girth 3	Girth 4
Annona muricata	-	-	-	-
Cinnamomum iners	5	10	16	29
Mimusops elengi	4	5	14	16
Michelia champaca	-	-	-	-
Pongamia pinnata	3	9	-	-
Swietania macrophylla	5	10	17	30
Syzigium campanulatum	4	9	17	49

Source: Table modification from Tan (2010), page 12-13

RESULTS

Topographic Survey

Due to the minimal data of the existing base map that the clients have provided, the topographic survey needs to be mapped and the distance of the existing trees and the contour of the existing sites needs to be located. Data from the topographic survey was produced, as in Figure 3. The outcome of the survey is presented in Table 2. With the data, a Certified Arborist and a Landscape Architect have identified and investigated the tree's location and conditions by observing the site and digitally recording the boundaries and elements on site. Taking a colour photograph and specimens of leaves to investigate the conditions of trees' health and recording in a comprehensive notebook can help orient the analysis and make the digital mapping process more efficient.

Table 2: Site data conveyed on a topographic survey

Category	Site data conveyed
Topography	Elevation contours, Spot elevations for high points and low points
Vegetation	Location, species, VTA and Carbon Sequestration of trees
Hydrology	Surface water and stormwater flow
Structures	Buildings
Circulation	Streets, Curbs, and gutters Parking areas

(Source:) The authors

Based on the topographic map in Figure 3, the site has a high potential for an outdoor learning space due to its proximity to Dataran Usahawan and other facilities. Additionally, the tranquil environment, provided by the surrounding trees, supports this potential.

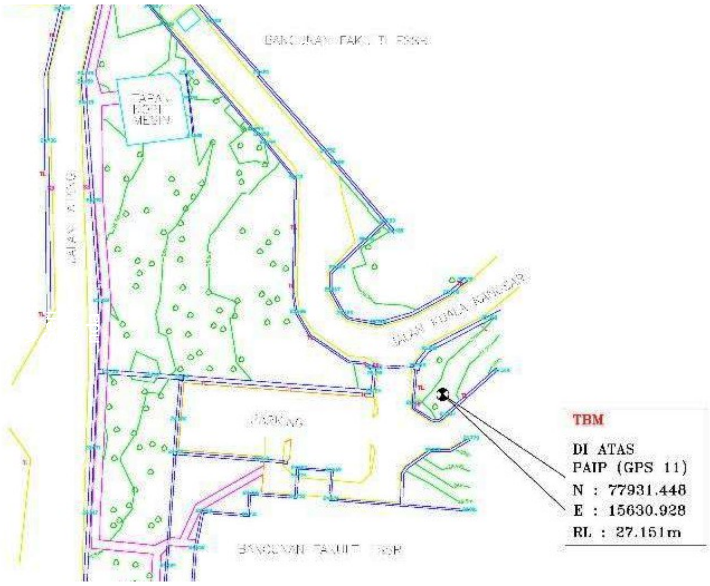

Figure 3: Topographic Survey Plan
Source: The authors

Plant Collecting and Identifying

Data of plant identification was conducted from the 24th to the 25th of February 2022 and was recorded in a comprehensive notebook. Elements of trees, such as leaves, branches, flowers, and fruit, were recorded. The purposes of collecting plants are to obtain records and specimens of the plant for personal collection and a dataset of UiTM's tree collection. It can also have a great value as a reference for identification (Bowles, 2004). Another purpose of plant collecting is for the researcher to identify an unknown species during fieldwork later. According to Bowles (2004), the researcher should collect at least one specimen of each species. For example, during the fieldwork study, the researcher found that modification leaves appeared in several leaves and specimens were collected and studied for possible causes on site.

A knife was used to obtain leaves from the stem during plant sampling. According to Bowles (2004), twigs should always be cut off cleanly with a sharp knife or pruners, and breaking the twig can ruin a specimen or cause unnecessary harm to the tree. However, the research is limited to the on-ground sampling and not until the underground portion, like roots, trailing, or underground stems. The researchers could still identify the plants from the above-ground sampling, so they did not go further underground, as Bowles (2004) suggested. During plant tree sampling, the researcher took comprehensive note of the collection number, the plant's name (if the researcher can be identified on-site), description of the tree, specific details of the micro-habitat, and date of sampling.

Plant Identification and Tree Health Conditions

The researchers identified seven tree species with 59 numbers in the designated plot. *Swietenia macrophylla* tree is the highest number (30 nos) of trees found on the site. Followed by *Pongamia pinnata* (11 nos), *Syzigium companulatum* (7 nos), *Cinnamomum iners* (5 nos), *Mimusops elengi* (4 nos), *Michelia champaca* (1 nos), and one new tree that just has been planted Annona muricata. The basic tree assessment method (Smiley et al., 2017) was used in this study to investigate tree health conditions. These showed a diverse tree vigorousness, foliage size and colour, pests or biotic affection, abiotic effects, and species failure profiles in the branches, trunk, or roots. Table 2 presents the health profiles of the trees in the study. Most trees in this study had a high vigour classification, accounting for 84.7% (N = 50) of the total trees. This was followed by trees with standard vigour classification, which comprised 11.9% (N = 7), and only 3.4% (N = 2) had low vigour classification. This study discovered that most trees have a standard foliage profile of 96.6%, which accounted for 57 trees. However, two species, namely *Pongamia pinnata* (Mempari), have chlorotic and necrotic problems. Only 15.3% of the trees had problems with biotic effects, which came to 9 trees. This situation only involved nine *Pongamia pinnata* (Mempari) species affected by the competition for sunlight from an adjacent tree and compacted soil. This causes the trees to be prone to failure in the branches and roots.

An analysis of the tree health profiles discovered three health condition classifications: good, moderate, and poor (Figure 4). The trees with poor health conditions were less than 4% of the total, only 3.4% (N= 2) from 59 trees. 11.9% (N = 7) were in moderate health condition, and the majority, 84.7% (N = 50) of trees, were in good health condition. Trees identification and location plans, as in Figure 4 and Figure 5.

Overlaying Composite Maps

The analysis of topographic layout map and existing tree health conditions were mapped together in Figure 6 to produce overlaying composite maps. A total of nine (9) out of 11 trees (82%) from *Pongamia pinnata* species were categorized in moderate and poor conditions health are not suitable on the site. Sustainable or 'green' development respects the natural environment and ensures, for example, that the trees are protected and incorporated into the site plan (Petit et al., 2004). After considering all the attributes and the site analysis process, especially on the tree's identification and analysis, the proposal design vision narrows down to the sustainable design planning paradigms for building a better student centre community on campus. Sustainable in this proposal design has three fundamental precepts: 1. Design with nature which are existing natural resources such as trees, 2. Design with campus culture where the more outdoor classroom centre, and 3. Design a place for students to interact and recreational.

Health profile of trees

Red ants and termite colony doesn't gave negative impact to the trees.

No	Species	Vigour			Foliage		Pests/ living thing/ Biotic factor	Non-living things/ Abiotic factor	Species failure profile		
		Low	Normal	High	Normal	Chlorotic and Necrotic			Branches	Trunk	Upper Roots
1	Annona muricata (Durian Belanda)	-	-	1	1	-	-	-	-	-	-
2	Cinnamomum iners (Kayu Manis)	-	-	5	5	-	-	-	-	-	-
3	Mimusops elengi (Bunga Tanjung)	-	-	4	4	-	-	-	-	-	-
4	Michella champaca (Cempaka Kuning)	-	-	1	1	-	-	-	-	-	-
5	Pongamia pinnata (Mempari)	2	7	2	9	2	-	9	7	-	2
6	Swietania macrophylla (Mahogany)	-	-	30	30	-	-	-	-	-	-
7	Syzigium companulatum (Kelat)	-	-	7	7	-	-	-	-	-	-
	Total	**2**	**7**	**50=84.7%**	**57=96.6%**	**2**	**-**	**9**	**7**	**-**	**2**

- Degradation of chlorophyll
- Death / Degradation of cells of plant tissue

Health condition of trees

No	Species	Tree Health				Total	Notes
		Good	Moderate	Poor	Very Poor		
1	Annona muricata (Durian Belanda)	1	-	-	-	1	
2	Cinnamomum iners (Kayu Manis)	5	-	-	-	5	
3	Mimusops elengi (Bunga Tanjung)	4	-	-	-	4	
4	Michelia champaca (Cempaka Kuning)	1	-	-	-	1	
5	Pongamia pinnata (Mempari)	2	7	2		11	Adjacent trees compete for sunlight and compacted soil
6	Swietania macrophylla (Mahogany)	30	-	-	-	30	
7	Syzigium companulatum (Kelat)	7	-	-	-	7	
	Total	**50**	**7**	**2=3.4%**	**-**	**59**	

Figure 4: The tree health profile and conditions for limited VTA.
Source: The authors

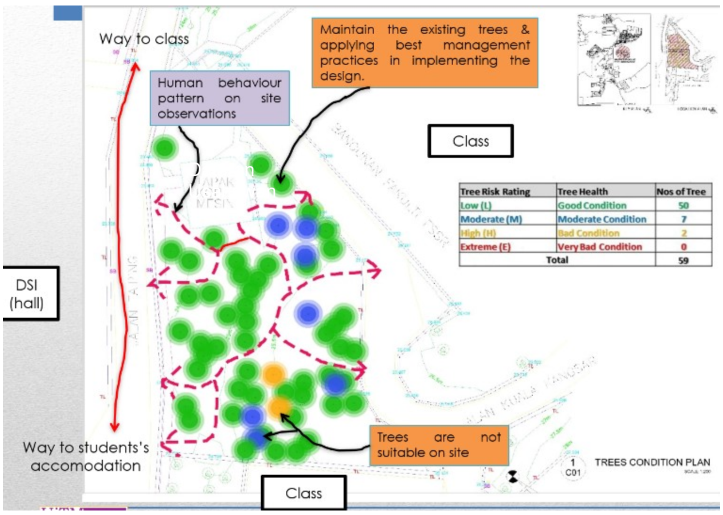

Figure 5: Overlaying composite maps. A total of 82% of *Pongamia pinnata* fall under poor and moderate health conditions, highlighted in blue and yellow.
Source: The authors

According to John Sawhill, former president of The Nature Conservancy, in the end, our society will be defined not only by what we created but also by what we refuse to destroy. Thus, the idea of the proposal is more on mitigating the impacts of the previous site uses, such as maintaining the existing tree and applying the best management practices in implementing the design through sustainable site design planning.

Estimation of Tree Carbon Sequestration

A variety of methods can be used to estimate carbon sequestration in trees. If more precise data can be obtained such as diameter and height of biomass if available, they can be fairly accurate for estimation. However, trees on the site are assessed based on VTA and girth only for estimating the net carbon sequestration. The researcher also measured the girth of trees on the site and found that the trees fall into Girth 1 until Girth 3 category. A simple method is used to explain how the trees were influenced in offsetting atmospheric carbon.

Table 3: Estimation of Net Carbon Sequestration

Tree species	Girth (A)	Tree count (B)	Per Tree Carbon Sequestration Rate (kg C/tree/year) (C)	Net Carbon Sequestration (kg C / year) (D = B X C)
Annona muricata	G1	1	NA (1)	1
Cinnamomum iners	G2	2	10	20
	G3	3	16	48
Mimusops elengi	G1	1	4	4
	G2	3	5	15
Michelia champaca	G1	1	NA (1)	1
Pongamia pinnata	G1	10	3	30
	G2	1	9	9
Swietania macrophylla	G2	10	10	100
	G3	20	17	340
Syzigium campanulatum	G1	4	4	16
	G2	3	9	27
			Total	**611 kg C/year**

Source: The authors

Based on the formula in Figure 1 and the index shown in Table 1, the researcher estimated the net carbon sequestration of the tree in a 3600m^2 plot site. The carbon sequestration rate of *Anona muricata* and *Michelia Champaca* is unavailable in Tan (2010); thus, the researcher made a minimum estimation of 1 kg C/tree/year for each species. The trees also have one tree count for each species; thus, the minimum net tree carbon sequestration of the site was generated in Table 3. The net carbon sequestration of trees in the plot area of 3600m^2 is at least 611 kg C / year.

According to Donev (2023), 1 kg of Carbon equals to 3.67 kgCO_2. Thus, 611 kg of Carbon equals to 2,242.37 kg of CO2 or 2.24 ton of CO_2

equivalent. According to a carbon footprint calculator, Carbon Footprint (2023), 2.24 ton of CO_2 equivalent is like the offset of an average car petrol driving for approximately 13,000 km, and a car usually travels 10,000 km per year. In summary, a total of 59 trees in a 3600 m2 area are able to sustain more than a year for capturing the emission of a single car driving approximately 13,000 km distance.

To conclude, the proposed project of OSC must take into account the significant value of carbon that has been sequestered over the years by the existing trees. To ensure sustainable development, it is crucial to implement a strategic replantation plan that not only compensates for the loss of carbon storage but also aims to increase the overall carbon sequestration capacity by planting an equal or greater number of trees. This approach will help maintain the ecological balance and contribute positively to the environment in the long term.

DISCUSSION

This study has addressed the subject of proper outdoor learning centres for university students by examining the existing physical element (Maheran et al., 2017). The study contributes to the field by presenting a composite map overlayed based on the topographic study and existing tree condition factors, which may be a concealed but crucial guide in the design proposal. The outcomes of this study will assist and extend the understanding of preparing outdoor learning centres for university students. The findings of this study are consistent with the outcomes of previous research. Many studies from the literature review consider existing physical elements, including campus trees, a significant subject for outdoor learning centres (Abdullah et al., 2022; Maheran et al., 2017; Mann et al., 2021; Mirrahmi et al., 2011).

Based on a review, Maheran et al. (2017) concluded with the six criteria for proper outdoor learning spaces: flexibility and multiple-use, comfort, movement, technology and ICT tools, aesthetics, and social relation. This study presents the overlaid composite map, which is strongly associated with relaxation in the space with surrounding trees (comfort), good accessibility of the site with surrounding facilities (movement), strong visual appeal (aesthetic), and good community interaction (social relation). While other two criteria, flexibility and multiple-use, and technology and ICT tools, are not analysed in this research, thus, limiting the study. The consideration of comfort, movement, aesthetic and social relation criteria in this project has been thought in the form of appreciating existing trees as a 'comfortable' space for a learning environment, 'movement' in the form of human behaviour patterns on-site, 'aesthetic' in the form of space function or arrangement in the site, and 'social relation' in the form of connectivity space between existing building. Trees are identified, examined, and acknowledged throughout the site analysis as assets that can yield multiple ecological, economic, and social benefits. Trees on site provide shade, reduce heat, and give a cooling effect near the Dataran Usahawan building. Trees serve multiple design functions that directly benefit users. The environment where they can provide shade serves as windbreaks, with the significant shape of trees also giving an aesthetic value and providing a spatial enclosure for an outdoor classroom.

Tree spatial programs focus on data tree conditions collected from the site observation and photographs. Tree structures are considered on the root/formation, trunk condition and branch assembly and arrangement. Meanwhile, tree health considers the crown indicators, including vigour, density, leaf size, quality, and stem shoot extension. In addition, the circulation of the human pathway was analysed in its movement pattern to emphasise the effect of tree conditions and species influencing the behaviour pattern.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the researcher summarises the first objective which is to produce the topographic layout map by measuring the site conditions. The result of the topographic layout was presented using a unit of theodolite, and the location of each structure or object was logged by GPS. The map was generated using AutoCAD in Figure 3. For the second objective which is to investigate the tree species and their condition in the site project by limited VTA, the research is limited to Level 1 and Level 2 only. Level 3, which involves climbing the tree to check the crown, is not being conducted. The health and profile of the trees are presented in Figure 4. 82% of *Pongamia pinnata* are unsuitable for the site and can be considered eliminated for the OSC design stage. Lastly, the third objective was to estimate the net carbon sequestration of the trees on site. The site's net of tree carbon sequestration is estimated to sequester a minimum of 254 kg C in a year. 59 trees in the plot area are needed to sustain for one year to capture the emission of a single car of approximately 13,000 km.

For the OSC design stage, the overlaying composite map in Figure 6 shows the area that needs to be considered when designing for future development. This data is vital for the researcher and designer to design the outdoor space for students that meets the needs of a quality environment and the convenience-walking ambience for the student to occupy the whole area as the outdoor classroom. In the context of future design development, the data on tree conditions and species existing is essential and significant to help the landscape architect design the area with the objective of sustainable development. As most of the areas were considered to receive good tree health conditions, thus, this area has a potential for core area space development of outdoor learning classrooms.

However, the area or tree locations of *Pongamia pinnata* that were categorised in moderate and poor tree conditions can also be considered if the designer plans to improvise the site area. For future reference, the tree selections must be chosen wisely before planting, as *Pongamia pinnata* is unsuitable for growing on-site based on abiotic factors (the competition for sunlight from an adjacent tree and compacted soil). This is shown by the symptoms of failure in the branches and roots.

In summary, for future site planning at a larger scale, it is recommended to use Unmanned Aerial Vehicle (UAV)-based GIS technologies to obtain data on tree coverage percentages, as this technique provides faster results (Abdullah, 2021). However, due to potential limitations in precision for detailed studies, human engagement remains essential. UiTM administration and management should be fully aware of the design space and function, making careful decisions about which trees to cut for future development. Effective site planning is crucial to ensure optimal outcomes, which includes conducting thorough environmental impact assessments, collaborating with environmental experts and local communities, and implementing continuous monitoring and evaluation mechanisms. By integrating these recommendations, OSC can achieve a harmonious balance between development and environmental sustainability.

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