

# Identification of Tropical Planting Selection for Sustainable Campus Design

Noorliyana Ramlee<sup>2\*</sup>, Zulhilmi Zahari<sup>1</sup>, Nor Hamizah Abdul Hamid<sup>2</sup>, Wan Saiful Nizam Wan Mohamad<sup>2</sup>, Syahidah Amni Mohamed<sup>3</sup>, Ramly Hasan<sup>3</sup>, Nurul Izzati Othmani<sup>4</sup>, and Muhamad Fadhli Ramlee<sup>5</sup>

<sup>1</sup>Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan, Kampus Bachok, 16300 Bachok, Kelantan, Malaysia

<sup>2</sup>Sustainability and Urban Design, Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan, Kampus Bachok, 16300 Bachok, Kelantan, Malaysia

<sup>3</sup>Architectural Heritage and Cultural Studies, Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan, Kampus Bachok, 16300 Bachok, Kelantan, Malaysia

<sup>4</sup>Human Centered Design, Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan, Kampus Bachok, 16300 Bachok, Kelantan, Malaysia

<sup>5</sup>Solar Energy Research Institute (SERI), Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

**Abstract.** Tropical planting plays a crucial role in sustainable campus design in Malaysia. Incorporating tropical planting into campus design not only enhances the aesthetic appeal but also offers numerous environmental benefits. This research aims to identify suitable tropical plant species for sustainable campus design. The selection of appropriate plant species plays a crucial role in creating environmentally friendly and aesthetically pleasing campus landscapes. The study employs an observational research approach to gather data on plant characteristics, growth patterns, ecological requirements, and overall sustainability. Data was collected at Universiti Malaysia Kelantan Bachok Campus. The results revealed that selection criteria for plants were based on their adaptability to tropical climates, aesthetic appeal, low maintenance requirements, and positive ecological impact. This paper outlines the strength of tropical plantings selection for sustainable campus design based on native trees, shade trees, climbing plants and vines, ground covers, ornamental shrubs, and medicinal and aromatic plants. Some of the tropical plants such as mahogany, kapok tree, frangipani offer numerous benefits in sustainable campus design, contributing to climate resilience, water efficiency, biodiversity conservation, and a vibrant and healthy campus environment. Thus, this research will provide valuable insights for landscape architects, campus planners, and any related built environment professionals in developing sustainable campus designs in tropical regions.

## 1 Introduction

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\* Corresponding author: [liyana.r@umk.edu.my](mailto:liyana.r@umk.edu.my)

Campus sustainability refers to the integration of environmental, social, and economic considerations into the planning, design, construction, operation, and management of an educational institution [1]. It is about building and maintaining a campus environment that minimizes negative impact on the planet, promotes social well-being and supports long-term economic viability. Campus sustainability encompasses a wide range of interconnected aspects, including environmental sustainability in which this aspect focuses on reducing the ecological footprint of the campus [2–9]. It involves practices such as use of renewable energy sources, preservation of green spaces, and promotion of biodiversity. In Malaysia, there are diverse types of plantings from native to exotic plants that came from all over the world that can fit into Malaysia climate and soil conditions. While exotic plants have some benefits such as aesthetic appeal and can increase the overall diversity of plant species in Malaysia, there are also the challenges in using exotic plants in Malaysia [10] for sustainable design campus such as genetic pollution, where genes from cultivated species hybridize with closely related native species. On the other hand, one of the significant concerns with foreign plants is their potential to become invasive. Some species can escape cultivation and spread rapidly, outcompeting native vegetation, disrupting natural ecosystems, and negatively impacting biodiversity. Exotic plants can pose a threat to native plant species [10,11], many of which are already endangered or at risk due to habitat loss and other human activities. Competition for resources, habitat degradation, and hybridization with native species can lead to genetic dilution, reduced population sizes, and even local extinctions. Therefore, this research aims to identify suitable tropical plant species for sustainable campus design. The selection of appropriate plant species plays a crucial role in creating environmentally friendly and aesthetically pleasing campus landscapes [12].

## 2 Literature Review

Tropical plantings support the conservation of local biodiversity by providing habitat and food sources for native species [13]. It also can contribute to the preservation of local ecosystems and promote biodiversity conservation. In terms of climate adaptation and mitigation, they provide shade, reducing the need for artificial cooling and decreasing energy consumption. Tropical plants, particularly trees, are effective in sequestering carbon dioxide from the atmosphere through photosynthesis. By planting and maintaining a healthy tree canopy, campuses can help mitigate climate change and reduce greenhouse gas emissions. Trees also provide shade, which can significantly reduce energy consumption for cooling buildings and outdoor spaces. The dense foliage of tropical plants also helps in capturing and sequestering carbon dioxide, thereby mitigating climate change. The shade provided by trees and vegetation can significantly lower ambient temperatures [14], creating more comfortable outdoor spaces and reducing the reliance on air conditioning. The dense root systems of tropical plants help absorb and slow down rainwater, reducing stormwater runoff and preventing soil erosion [15]. This improves water infiltration, replenishes groundwater reserves, and reduces the strain on drainage systems, thereby mitigating flood risks. On the other hand, tropical plantings enhance the visual appeal of the campus, creating an inviting and calming atmosphere [16]. Research suggests that exposure to green spaces and nature can have positive effects on mental health, well-being, and cognitive functioning, contributing to a more pleasant and productive learning environment [17]. Tropical plantings offer valuable educational opportunities for students and the campus community. They can serve as living laboratories [5], providing hands-on experiences in ecology, botany, horticulture, and environmental science [18]. Students can learn about the importance of native species, sustainable gardening practices, and the interconnections between plants, animals, and ecosystems. Tropical plantings can also celebrate and honour the cultural and traditional significance of native plants in Malaysia. Many tropical plants have long-standing

cultural and medicinal uses in local communities, providing opportunities to promote and preserve traditional knowledge and practices [19].

### **3 Research Methodology**

The study site is located at Universiti Malaysia Kelantan Bachok Campus, Malaysia, one of the campuses of Universiti Malaysia Kelantan besides Jeli and Pengkalan Chepa. This campus is the newest and the main campus without a proper planting planning. Therefore, this study used the Universiti Malaysia Kelantan overall compound to propose plantings guidelines by using tropical plantings for the sustainable campus design that could be implemented to the other campuses. The study was carried out using qualitative approach. The study employed site observation based on architectural attributes, site measurements, soil analysis, vegetation inventory, ecological assessment, cultural and historical assessment and identification of site constraints and opportunities. The interview was done with the staffs and the students in Universiti Malaysia Kelantan Bachok Campus. The data collection was conducted from September to December 2021. The data was then analysed by using SWOT analysis, a standard analysis procedure used in architectural practise [20]. The data gained during the data preparation process was triangulated with data gained from the interview and secondary resources analysis to establish the validity. Comparison the data form multiple sources is needed to ensure that the method provides accurate and meaningful information about the site and helps to gather a comprehensive and well-rounded understanding of the site. The findings were then presented to the landscape expertise from the Institute of Landscape Architecture of Malaysia (ILAM) during July to be reviewed.

### **4 Results and Findings**

#### **4.1 The strength and opportunities of tropical plants for sustainable campus design in Malaysia.**

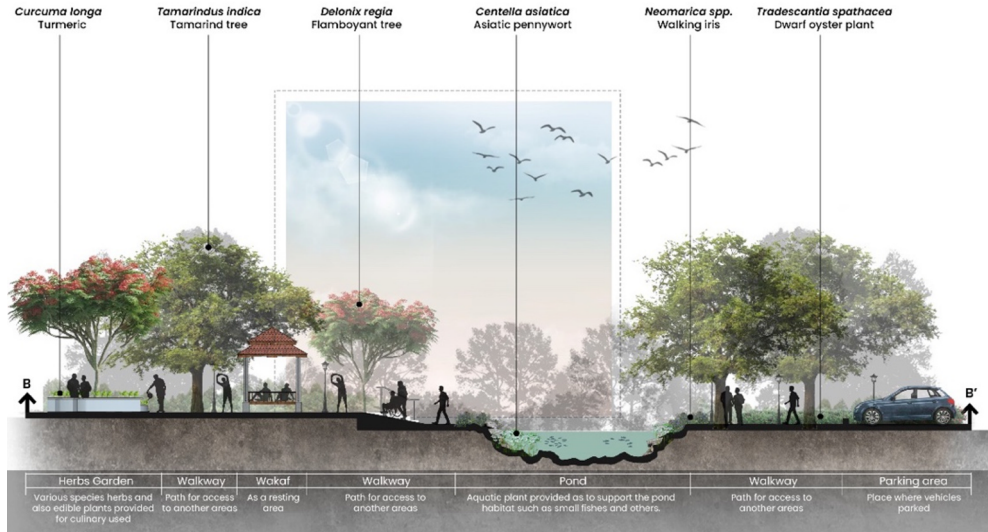
Several areas and spaces were proposed in the campus design which include campus woodlands, open green spaces, campus entrances, parking lots, pedestrian walkways and many other spaces as outlined in Table 1. The example of tropical plantings which were referred from the planting collection book and cross checked with various secondary references including websites and books. [10,19,21,22] regarding to the function of the plants was categorised and recommended based on the areas and spaces proposed in the campus design. It is identified that there are six categories of plants that can used as guidelines in planning for sustainable campus design including i) Native Trees, ii) Shade Trees, iii) Climbing Plants and Vines, iv) Ground Covers, v) Ornamental Shrubs, and vi) Medicinal and Aromatic Plants. The selection of plants that is considered into the planning of sustainable campus design are based on the adaptability to tropical climates, aesthetic appeal, low maintenance requirements, and positive ecological impact. Table 1 tabulated the tropical planting in sustainable campus design guidelines that are recommended to be applied in Universiti Malaysia Kelantan Bachok Campus specifically and to other campuses in Malaysia generally.

**Table 1.** Tropical Planting in Sustainable Campus Design Guidelines.

Plant Categories	Criteria	Example of Plants	Function of Plant	Recommended campus area
Native Trees	Native tree species are well adapted to the local climate and soil conditions.	<ul style="list-style-type: none"> <li>• Yellow Flame (<i>Peltophorum pterocarpum</i>),</li> </ul>	<ul style="list-style-type: none"> <li>• Well-adapted to tropical climates and provides shade and aesthetic appeal.</li> </ul>	<ul style="list-style-type: none"> <li>• Campus Woodlands or Forested Areas</li> </ul>
		<ul style="list-style-type: none"> <li>• Pongam Tree (<i>Pongamia pinnata</i>),</li> <li>• Merbau (<i>Intsia palembanica</i>.)</li> </ul>	<ul style="list-style-type: none"> <li>• Ability to fix nitrogen in the soil and its oil-rich seeds, which can be used for biofuel production.</li> <li>• Contribute to forest ecosystems and have cultural significance in some regions.</li> </ul>	<ul style="list-style-type: none"> <li>• Open Green Spaces</li> <li>• Buffer Zones and Perimeter Plantings</li> <li>• Courtyards and Plazas</li> <li>• Pedestrian Walkways and Pathways</li> <li>• Parking Lots</li> </ul>
Shade Trees	Trees with broad canopies provide ample shade to outdoor spaces, reducing the need for artificial cooling.	<ul style="list-style-type: none"> <li>• Tamarind Tree (<i>Tamarindus indica</i>),</li> </ul>	<ul style="list-style-type: none"> <li>• Provides ample shade and is known for its tangy and edible fruit. Drought-tolerant and well-suited to tropical climates.</li> <li>• Known for its valuable timber.</li> </ul>	<ul style="list-style-type: none"> <li>• Campus Quad or Plaza</li> <li>• Pedestrian Walkways and Pathways</li> <li>• Outdoor Seating Areas</li> <li>• Parking Lots</li> <li>• Sports Fields and Recreation Areas</li> </ul>
		<ul style="list-style-type: none"> <li>• Mahogany (<i>Swietenia macrophylla</i>).</li> <li>• Flamboyant Tree (<i>Delonix regia</i>),</li> <li>• The Kapok Tree (<i>Ceiba pentandra</i>),</li> </ul>	<ul style="list-style-type: none"> <li>• Stunning display of vibrant red or orange flowers as it has a wide-spreading canopy that provides excellent shade.</li> <li>• A tall and majestic tree with a large canopy that provides ample shade.</li> </ul>	<ul style="list-style-type: none"> <li>• Campus Courtyards</li> <li>• Building Entrances</li> <li>• Outdoor Classrooms and Learning Spaces</li> <li>• Campus Perimeter</li> </ul>
Climbing Plants and Vines	Climbing plants and vines to cover walls and trellises, providing natural insulation, and reducing heat gain. They can also enhance the aesthetic appeal of buildings.	<ul style="list-style-type: none"> <li>• Bougainvillea (<i>Bougainvillea rosa-sinensis</i>)</li> <li>• Confederate Jasmine (<i>Trachelospermum jasminoides</i>),</li> <li>• Morning Glory (<i>Ipomoea</i> spp.),</li> </ul>	<ul style="list-style-type: none"> <li>• Known for its vibrant and showy bracts in various colours, providing a burst of colour and shade.</li> <li>• Emit a pleasant scent.</li> <li>• Suitable for covering walls and trellises and can tolerate both full sun and partial shade.</li> <li>• Known for its air-purifying qualities and can help improve indoor air quality.</li> </ul>	<ul style="list-style-type: none"> <li>• Trellises and Arbors</li> <li>• Walls and Fences</li> <li>• Outdoor Seating Areas</li> <li>• Campus Facades</li> <li>• Vertical Gardens</li> <li>• Campus Entrances</li> </ul>

			<ul style="list-style-type: none"> <li>• Pedestrian Walkways and Pathways</li> <li>• Outdoor Art Installations</li> </ul>
Ground Covers	Ground covers help reduce soil erosion, retain moisture, and add visual interest to open areas.	<ul style="list-style-type: none"> <li>• Asiatic Pennywort (<i>Centella asiatica</i>),</li> <li>• Creeping Fig (<i>Ficus pumila</i>).</li> <li>• Spiderwort (<i>Tradescantia zebrina</i>),</li> </ul>	<ul style="list-style-type: none"> <li>• Spreads quickly and forms a dense mat, making it effective in controlling soil erosion.</li> <li>• Often used to control erosion on slopes or to add greenery to vertical surfaces.</li> <li>• Known for its resilience and adaptability to different soil conditions, making it a suitable choice for sustainable campus design.</li> <li>• Campus Lawns</li> <li>• Garden Beds and Borders</li> <li>• Campus Entrances</li> <li>• Slopes and Banks</li> <li>• Parking Lot Islands</li> <li>• Courtyards and Plazas</li> </ul>
Ornamental Shrubs	Ornamental shrubs used to add colour and texture to the landscape.	<ul style="list-style-type: none"> <li>• Hibiscus (<i>Hibiscus rosa-sinensis</i>),</li> <li>• Ixora (<i>Ixora</i> spp.),</li> <li>• Frangipani (<i>Plumeria</i> spp.).</li> <li>• Mussaenda (<i>Mussaenda</i> spp.),</li> <li>• Copperleaf (<i>Acalypha wilkesiana</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• Attracts pollinators.</li> <li>• Can be used as a focal point in landscaping designs.</li> <li>• Known for its long bloom season and attracts pollinators.</li> <li>• Used as an accent shrub or grown in containers.</li> <li>• Known for its large, colourful bracts that surround the small flowers.</li> <li>• Attractive, colourful foliage in shades of green, red, orange, or bronze.</li> <li>• Building Entrances</li> <li>• Courtyards and Plazas</li> <li>• Garden Beds and Borders</li> <li>• Outdoor Seating Areas</li> <li>• Campus Edges and Perimeter Plantings</li> <li>• Campus Quadrangles or Greenspaces</li> <li>• Outdoor Art Installations</li> <li>• Parking Lot Islands</li> </ul>
Medicinal and Aromatic Plants	Medicinal and aromatic plants can be incorporated into campus gardens and green spaces. These plants not only provide visual appeal but also offer educational opportunities	<ul style="list-style-type: none"> <li>• Lemongrass (<i>Cymbopogon citratus</i>),</li> <li>• Ginger (<i>Zingiber officinale</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• Has medicinal properties and is commonly used in traditional medicine for its digestive and calming effects.</li> <li>• Commonly used for alleviating nausea, promoting digestion, and supporting immune health.</li> <li>• Used for its anti-inflammatory, antioxidant, and immune-boosting effects.</li> <li>• Healing Gardens or Medicinal Plant Gardens</li> <li>• Botanical Gardens or Arboretums</li> <li>• Teaching Gardens or Greenhouses</li> <li>• Campus Wellness Centres or Health Clinics</li> <li>• Outdoor Seating Areas</li> </ul>

and potential benefits for the campus community. • Turmeric (*Curcuma longa*) and Meditation Spaces



**Fig. 1.** Examples of tropical plantings that can be used in Herbs Garden, Walkway, Wakaf, Pond and Parking Area.

As shown in Figure 1, native plants such as can be combined with climbing plants such as Golden Pothos (*Epipremnum aureum*), and shade trees such as Flamboyant Tree (*Delonix regia*) or Tamarind tree (*Tamarindus indica*) for pedestrian walkways and parking lots. Shade trees reduced the need for artificial cooling while native trees are well adapt to the local climate and soil. For outdoor seating areas, a combination of shade trees (e.g. Mahogany), climbing plants and vines (e.g. Morning Glory), ornamental shrubs (e.g. Frangipani) and medicinal and aromatic plants (e.g. Tumeric). Ground cover such as Asiatic Pennywort (*Centella asiatica*), and Walking Iris (*Neomarica spp.*) can be used to repair slope and banks as they spread quickly and form a dense mat. They are very effective in controlling soil erosion. Dwarf Oyster Plant (*Tradescantia spathacea*) is another example of ground covers that can be used for campus courtyard or plaza as it is a low-maintenance plants and can tolerate a range of light conditions. These plants have dense root systems which help absorb and slow down rainwater, reducing stormwater runoff and preventing soil erosion [15]. Students can enjoy the comforting and healing environment offered by the plantings while sitting with their friends at the outdoor seating area [17].

## 5 Conclusions

In conclusion, this paper proposes guidelines for sustainable campus design in Malaysia based on native trees, shade trees, climbing plants and vines, ground covers, ornamental shrubs, and medicinal and aromatic plants. Tropical plants such as mahogany, kapok tree, frangipani, and more other species are naturally suited to the local climate and environmental conditions. They have evolved to thrive in the specific temperature, rainfall, and soil characteristics of tropical regions. These tropical plants also have developed water-efficient

strategies to survive in regions with limited water resources or seasonal rainfall patterns which contribute to water conservation efforts and reduce the need for excessive irrigation. Besides, tropical plants create vibrant and visually appealing landscapes that enhance the aesthetics of the campus contributing to a more pleasant and productive learning environment. Lastly, promoting tropical plants into campus design play a vital role in carbon sequestration, absorbing carbon dioxide from the atmosphere and storing it in their tissues. This helps mitigate climate change by reducing greenhouse gas emissions and enhancing the overall carbon balance. Therefore, integrating tropical planting into campus design not only creates aesthetically pleasing landscapes but also fosters a more sustainable and harmonious relationship between humans and nature.

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