Improving Campus Sustainability and Resilience by Selecting Climate - Appropriate Plants

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Abstract. The purpose of this study is to determine the planting species in a campus environment and assess their suitability for enhancing the quality of life. The study area chosen for this research is the Universiti Malaysia Kelantan (UMK) Campus Bachok, Kelantan. The objectives of this study are to identify the functions of planting at campus area and to make the suggestions of right planting selection. Using mix methods approach, survey and expert interviews was used to collect data in order to address the objectives to the fullest extent possible. A total of 200 respondents, including both staff and students from the faculty of Architecture and Ekistics, took part in the survey. The results shows the thirteen (13) dominant of planting species located around the campus area which are *Samanea saman* (Rain tree), *Salix babylonica* (Chinese weeping willow), *Terminalia Mantaly* (Umbrella tree), *Khaya senegalensis* (Mohagany), *Tabebuai rosea* (Trumpet tree), *Acacia mangium* (Brown salwood), *Hopea odorata* (Merawan siput jantan), *Filicium decipiens* (Fern tree), *Syzygium polyanthum* (Salam tree), *Plumeria Frangipani* (Kemboja), *Schizolobium parahyba* (Yellow jacaranda), *Ixora Javanica* (Siantan), *Monoon Longifolium* (Mempisang). Results indicate that functions of planting such as a barrier between roads, provided shaded area and to prevent landslide on the shore of the lake.

1 Introduction

Malaysia is located in Southeast Asia and has a tropical climate throughout the year. The country experiences high temperatures and humidity, with relatively uniform temperatures throughout the seasons [1, 2]. The impacts of climate change are becoming increasingly evident, with rising temperatures, water scarcity, and extreme weather events affecting our planet. In the face of these challenges, it is crucial that we adapt our practices and contribute to a more sustainable future. By selecting appropriate plants that align with our local climate, soil conditions, and ecosystem, it can establish thriving green spaces that contribute to the overall well-being of campus and the surrounding environment. These plants are native or

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adaptive to the local climate, allowing them to thrive with minimal resources and maintenance. By considering the environmental factors, such as climate, soil, and maintenance requirements, it can create vibrant landscapes that benefit both the campus community and the environment at large.

2 Literature reviews

2.1 Landscape design in campus area

Landscape design in campus areas plays a crucial role in creating inviting, functional, and sustainable environments for students, faculty, and visitors [4]. It involves the thoughtful planning, arrangement, and maintenance of outdoor spaces to enhance aesthetics, promote well-being, support educational goals, and contribute to overall campus sustainability. In a landscape design for a campus area, several elements are essential to create a functional and visually appealing environment [5]. By incorporating these elements into the landscape design, the campus area can become a dynamic and engaging environment that fosters learning, social interaction, and a connection with nature.

Table 1. Important Elements Incorporating In Campus Landscape Design

Elements	Functional
Plantings	Incorporate a diverse selection of plant species, including trees, shrubs, flowers, and groundcovers. Choose plants based on their suitability for the local climate, maintenance requirements, and aesthetic appeal. Consider incorporating native plants to support local biodiversity and ecosystem health.
Walkways and Pathways	Design well-defined and accessible walkways that connect different areas of the campus. Utilize materials such as concrete, paving stones, or permeable surfaces for durability and ease of maintenance. Ensure pathways are wide enough to accommodate pedestrian traffic.
Plazas and Courtyards	Design open plazas or courtyards that serve as central hubs for social activities, events, and gatherings. Consider the scale, proportions, and focal points to create an attractive and engaging space. Incorporate elements such as seating, fountains, artwork, or interactive installations to enhance the ambiance.
Way finding and Signage	Ensure clear way finding through the use of signage, maps, and directional indicators. Design signage that is informative, aesthetically pleasing, and consistent with the overall campus branding.
Sustainability Features	Incorporate sustainable design elements such as rain gardens, green roofs, or vertical gardens. Utilize permeable surfaces to promote storm water infiltration and reduce runoff. Integrate renewable energy sources, such as solar panels, to power outdoor lighting or charging stations.

2.2 Creating sustainability and resilience campus via appropriate plants selection

Creating campus sustainability and resilience through the use of appropriate plants is essential for promoting a greener and more environmentally conscious campus. Carefully selecting and incorporating plant species that are well-suited to the local climate, soil conditions, and ecosystem, campuses can achieve multiple benefits. Firstly, appropriate plants contribute to climate adaptation by withstanding extreme weather events, droughts, and temperature fluctuations. These resilient plants require less water and maintenance, reducing the campus's environmental footprint and conserving valuable resources. Secondly, the use of native or drought-tolerant plants promotes water conservation and biodiversity [6,7,8].

Native plants are adapted to the local environment and often require minimal irrigation once established. They support local wildlife, including pollinators, and enhance the campus's ecological balance. By incorporating a diverse range of plant species, campuses can create vibrant ecosystems that preserve regional biodiversity and provide valuable educational opportunities for students to learn about sustainable landscaping practices and the importance of environmental stewardship. Additionally, appropriate plants contribute to energy efficiency by providing natural shade, reducing the need for excessive air conditioning, and acting as windbreaks, reducing heat loss during colder months [9]. This improves the overall energy efficiency of campus buildings and reduces carbon emissions. Ultimately, the use of appropriate plants in campus landscaping fosters a sense of environmental responsibility, enhances the campus's aesthetics, and creates a sustainable and resilient environment for the campus community to thrive [10].

Several factors need to be considered to ensure a successful and sustainable landscape in campus design. It is essential to choose plants that are native or well-adapted to the local climate and soil conditions. Native plants are typically more resilient and require less maintenance, as they have evolved to thrive in the specific region [11]. They are also more likely to support local wildlife and contribute to the overall ecological balance of the area. Additionally, selecting a diverse range of plants can create an aesthetically pleasing landscape, adding visual interest and promoting biodiversity. The maintenance requirements of the chosen plants should be taken into account. Campuses often have limited resources and personnel available for landscaping maintenance, so selecting low-maintenance plants can help reduce the workload and associated costs. Drought-tolerant species or those with low water requirements are especially beneficial, as they can withstand dry periods without extensive irrigation. Furthermore, choosing plants with minimal pest and disease issues can help minimize the need for chemical treatments and interventions. By considering these factors, the campus can have a sustainable and attractive landscape that enhances the overall campus experience while being mindful of environmental and resource constraints.

2.3 Universiti Malaysia Kelantan (UMK) as greenery campus design

Greenery in campus design refers is intentional planning and implementation of environmentally sustainable practices and principles in the design and operation of a campus. It involves creating a campus environment that minimizes its ecological footprint, promotes sustainability, and enhances the well-being of its community members. UMK is a public university located in Kelantan, Malaysia. In terms of green initiatives, UMK has made strides towards creating a sustainable campus environment. The university has implemented various measures to reduce its environmental impact and promote sustainability [12]. UMK focus on

using native plant species that are well-suited to the local climate and soil conditions in Kelantan. By using native plants, UMK create a more sustainable and resilient landscape that harmonizes with the natural surroundings. In addition, UMK prioritize planting trees throughout its campus. Trees offer numerous benefits, such as providing shade, improving air quality, reducing noise pollution, and sequestering carbon dioxide. Selecting a diverse range of tree species, including both evergreen and deciduous varieties, can create a visually appealing and vibrant campus environment throughout the year.

3 Research Methodology

This study used mix methods approach, survey and expert interviews was used to collect data in order to address the objectives to the fullest extent possible. A total of 200 respondents, including both staff and students from the faculty of Architecture and Ekistics, took part in the survey. Additionally, ten professional landscape architects were interviewed through online interviews. The selection of the respondents using random sampling and consent to participate in this study was obtained.

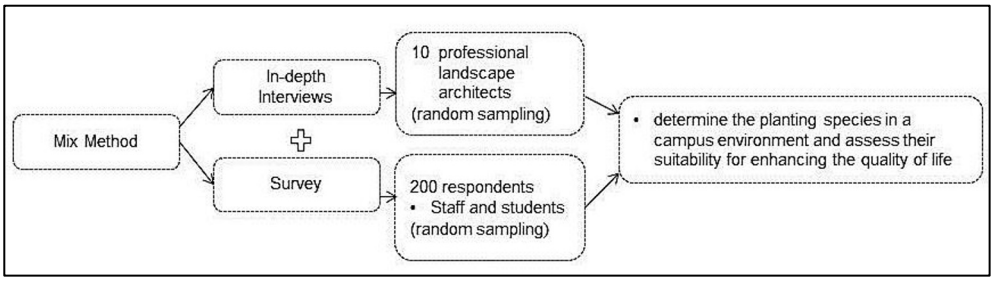

Fig 1. Flow Chart of Research Methodology in This Study

4 Result and discussion

4.1 Improving campus sustainability and resilience through climate – appropriate plants

Improving campus sustainability and resilience through planting selection is an effective strategy that can yield numerous benefits. By carefully selecting and incorporating climate-appropriate plants, campuses can enhance their ecological balance, conserve resources, and adapt to changing environmental conditions.

Based on the interviews results, nine (9) of the respondents stated by choosing appropriate plant species are naturally adapted to the local climate, soil conditions, and ecosystem in Malaysia. Native plants are generally more resilient, requiring less water and maintenance compared to non-native species. They also support local biodiversity by providing food and habitat for native wildlife. By selecting plant species that have low water requirements can withstand periods of drought. These plants are well-suited for water conservation efforts and can thrive in regions where water scarcity is a concern. They reduce the need for excessive irrigation and contribute to overall water efficiency on campus. In addition, prioritize plants species that have natural resistance to common pests and diseases in the local area. This reduces the reliance on chemical pesticides and promotes a healthier, more ecologically balanced campus environment. To improve campus sustainability and resilience through climate, people need to consider the soil conditions on campus when selecting plants.

Different plants have specific soil preferences, so choosing species that are well-adapted to the existing soil type will ensure better growth and reduce the need for soil modifications or amendments.

Furthermore, respondents state that integrate a variety of plant species to enhance campus biodiversity. By creating diverse plant communities, campuses can support a range of pollinators, birds, and other wildlife it can contribute to ecological resilience and the preservation of local ecosystems. Consider plants that can serve educational purposes, such as botanical gardens or arboretums that provide learning opportunities for students and the community. Additionally, respondents state that prioritize plants that create outdoor spaces for recreational activities, such as shaded seating areas, sports fields, or walking trails. Evaluate the resources available for plant maintenance, including water and time. Choose plants that are well-suited to the campus's maintenance capabilities to ensure their long-term health and vitality.

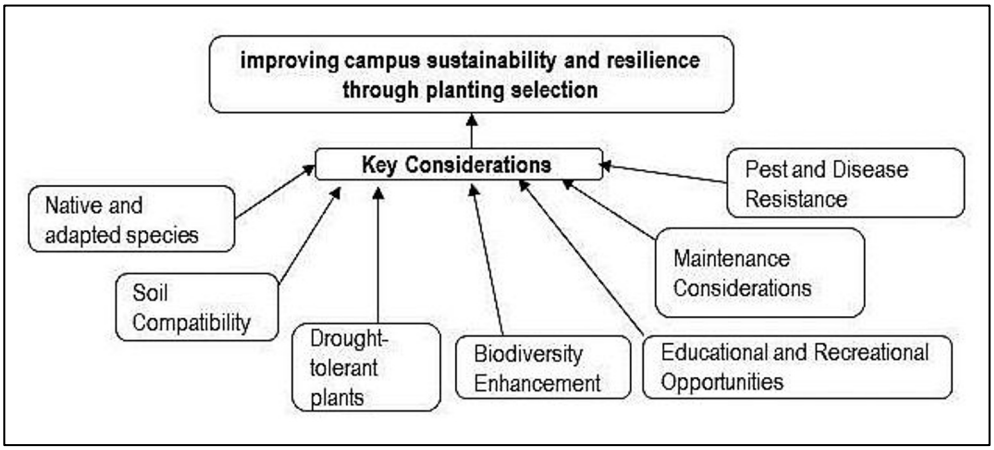

Fig 2. Coding Analysis on key considerations for improving campus sustainability and resilience through Climate - Appropriate Plants

4.2 Role of planting at campus area

Respondents elaborated that plants play a vital role in campus areas, contributing to a range of benefits that positively impact the environment, aesthetics, and well-being of the campus community. By recognizing the importance of plants in campus areas, educational institutions can create greener, more sustainable, and student-friendly environments. Through thoughtful plant selection, proper maintenance, and integration into campus planning, the benefits of plants can be maximized, creating a harmonious and thriving campus ecosystem.

Table 2: Roles of Planting at Campus Area

Rank	Roles of planting	Reasons
1	Climate Regulation	Provide shade and cooling effects, mitigating the heat island effect in urban campus environments. They can help reduce ambient temperatures, improve thermal comfort, and reduce energy consumption by providing natural shade to buildings and outdoor spaces.
2	Air Quality Improvement	Improving air quality by absorbing pollutants such as carbon dioxide, nitrogen dioxide, and particulate matter. Through the process of photosynthesis, trees release oxygen and act as natural air filters, reducing air pollution and improving overall air quality in campus environments.
3	Sustainability and Resilience	Incorporating sustainable landscaping practices, such as using native or drought-tolerant plants, rainwater harvesting, and efficient irrigation systems, can contribute to the campus's overall sustainability goals. Well-planned plantings can also enhance the campus's resilience to climate change, such as by reducing storm water runoff and soil erosion.
4	Aesthetic and Psychological Benefits	Well-designed and maintained plantings enhance the visual appeal of campus areas, creating a welcoming and vibrant atmosphere. The presence of green spaces, flowering plants, and trees can contribute to a sense of place and identity, fostering a positive campus experience for students, faculty, and visitors.
5	Storm water Management	Urban trees assist in managing storm water runoff by intercepting rainwater on their leaves, branches, and bark. This reduces the amount of water that reaches the ground, helping to prevent flooding and erosion. Trees also act as natural water filters, removing pollutants as water infiltrates into the soil.
6	Educational Opportunities	Campus areas with a variety of plant species provide valuable educational opportunities. Students can learn about botany, horticulture, environmental science, and sustainability through hands-on experiences and engagement with plants. Campus gardens or arboretums can serve as living laboratories for research and educational programs.

4.3 Suggestions of climate- appropriate plants that contribute to a cooler and greener campus development

To create a cooler and greener campus environment, selecting the right plants is essential. Several characteristics should be considered to ensure their suitability and effectiveness in creating a functional and visually appealing landscape. According to the respondents, some

characteristics and species need to consider when selecting plants for campus design such as in Table 3.

Rank 1 indicates *Samanea saman* (Rain Tree) is a large and majestic tree that can make a beautiful addition to a campus landscape. The tree's large canopy and nectar-rich flowers attract various pollinators, including bees and butterflies. Additionally, the seed pods can provide a food source for birds and small mammals, contributing to biodiversity on campus. Rank 2 indicate *Salix babylonica* (Chinese weeping willow) is unique weeping form, with long, pendulous branches that create a cascading effect. The tree's slender leaves are green on the upper side and gray-green on the underside, adding an attractive and ethereal quality to the landscape. Rank 3 indicates *Terminalia mantaly* (Umbrella tree) is attractive foliage and unique growth habit. The tree has dense, evergreen leaves that are glossy and dark green in colour, providing a lush and vibrant appearance. It also produces small, inconspicuous flowers and round fruit that turns from green to brown as it matures.

Table 3: Suggestions of Planting Species that Contribute to a Cooler and Greener Campus Development

Rank	Suggestion Planting Species	Justification
1	*Samanea saman* (Rain tree)	Provides excellent shade, making it valuable for creating comfortable outdoor spaces on campus. The dense canopy helps to reduce ambient temperatures, offering relief from the heat and creating a cooler microclimate.
2	*Salix babylonica* (Chinese weeping willow)	Provides excellent shade with its dense, drooping canopy. Its graceful branches create a cool and serene environment beneath the tree, making it a desirable choice for providing shade in outdoor gathering spaces or walkways on campus.
3	*Terminalia Mantaly* (Umbrella tree)	The tree's flowers and fruit can attract birds and insects, contributing to biodiversity and providing opportunities for educational observation and engagement.
4	*Khaya senegalensis* (Mohagany)	Potential to sequester significant amounts of carbon dioxide from the atmosphere, thus aiding in the campus's efforts to reduce its carbon footprint and mitigate climate change.
5	*Tabebuai rosea* (Trumpet tree)	Profuse flowering can add colour and beauty to the campus landscape, creating an eye-catching focal point. The flowering period can coincide with important events or celebrations, enhancing the overall campus atmosphere.
6	*Acacia mangium* (Brown salwood)	The spreading canopy offers excellent shade, creating comfortable outdoor spaces for students, faculty, and visitors to gather, relax, or study. Its dense foliage can

		provide relief from the sun, promoting a cooler microclimate.
7	*Hopea odorata* (Merawan siput jantan)	Requires minimal maintenance once established. Pruning should be limited to shaping the tree or removing dead or damaged branches. Regular monitoring for pests or diseases is recommended to ensure the tree's long-term health.
8	*Filicium decipiens* (Fern tree)	Attractive foliage and unique appearance. The tree has large, fern-like leaves that provide a lush and tropical look to the landscape. Its canopy can offer a visually appealing contrast to other trees on campus.
9	*Syzygium polyanthum* (Salam tree)	Contributes to air purification by absorbing carbon dioxide and releasing oxygen. Its presence on campus can help improve air quality and create a healthier environment for the campus community.
10	*Plumeria Frangipani* (Kemboja)	Require minimal watering once they have developed a strong root system. Depending on the climate and available space, can be grown in containers or as patio plants.
11	*Schizolobium parahyba* (Yellow jacaranda)	Nitrogen-fixing tree, which means it has the ability to convert atmospheric nitrogen into a usable form for plants. This trait can enrich the soil with nitrogen, benefiting surrounding plants and contributing to soil fertility.
12	*Ixora Javanica* (Siantan)	Can be used effectively as an edging or border plant in garden beds or along walkways. Its dense foliage and continuous flowering can create a defined and aesthetically pleasing boundary.
13	*Monoon Longifolium* (Mempisang)	The cultivation of Mempisang trees on campus can foster collaborations with agricultural or horticultural initiatives.

5 Conclusions

In conclusion, selecting climate-appropriate plants is crucial for improving campus sustainability and resilience. By carefully choosing the right plants for a campus landscape, several benefits can be achieved such as can improve microclimate, educational opportunities, water conservation, environmental benefits and long term resilience. Selecting plants that are well-suited to the local climate, the campus landscape becomes more resilient to environmental challenges, such as drought, extreme temperatures, or pest infestations. This reduces the need for excessive maintenance, replacement, and interventions, resulting in long-term sustainability. In addition, the selection of climate-appropriate plants provides

educational opportunities for students to learn about sustainable landscaping practices, the importance of native flora, and the role of plants in environmental stewardship. It promotes awareness and understanding of the interconnectedness between human activities and the natural world.

6 Acknowledgement

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