

Determination Factors of Roadside Tree Species Selection Model for Sustainable Smart City

Ramly Hasan^{1*}, Wan Saiful Nizam Wan Mohamad¹, Ayub Awang¹, Firdaus Chek Sulaiman² and Ruzaini Zahari³

¹Department of Landscape Architecture, Faculty of Architecture & Ekistics, Universiti Malaysia Kelantan

²Park and Amenity Management, School of Geomatics Science & Natural Resource, College of Built Environment, Universiti Teknologi MARA

³Landscape Architecture Program, Faculty of Built Environment & Surveying, Universiti Teknologi Malaysia

Abstract. This study aimed to determine the factors that are essential in developing Malaysian Roadside tree selection species model for a sustainable smart city. Two objectives have been formulated; (i) to identify the current practices in selecting roadside trees and (ii) to explore the factors affecting in developing roadside tree species model. The methodology used in the study is in-depth interviews and collecting archival data. Thirty of landscape architects and related expertise will be sorted by random sampling at Klang Valley area. The study emphasised the consideration of landscape, arboriculture, forestry and academician practices that consider the long-term benefits and impacts of planting roadside trees. The findings of this study provide valuable insights into the factors that should be considered when selecting tree species for roadside planting in city areas. Fifteen (15) important factors has been identified that is size and growth habit, native and local species, adaptability, maintenance and requirements, wind resistance, non-invasive roots, canopy density, soil requirements, aesthetic value, wildlife support, cultural significance, stakeholder input, longevity, urban tolerance, pest and disease resistance. The results can be used to guide the related parties and promote sustainable development in cities.

1 Introduction

The selection of suitable tree species for roadside planting is critical for sustainable urban development. Urban trees provide a wide range of ecological, social, and economic benefits, such as improving air quality, reducing urban heat island effect, providing shade, and enhancing the aesthetic value of the city [1,2]. However, selecting the appropriate species for roadside planting can be challenging due to the various factors that need to be considered, such as the climate, site characteristics, aesthetic value, ecological functions, maintenance requirements, compatibility with infrastructure, and human safety [3]. Therefore, a comprehensive and systematic approach is necessary to develop a roadside tree species

* Corresponding author: ramly.h@umk.edu.my

selection model for sustainable smart cities. This model should take into account the unique characteristics of the city and the intended goals for the urban tree planting program. By incorporating these determinants, a well-designed roadside tree species selection model can contribute to the sustainability, liveability, and resilience of the city and provide multiple benefits to the urban ecosystem.

2 Literature review

2.1 Roadside tree species in Malaysia

Roadside trees play a crucial role in urban environments, providing numerous benefits such as shade, aesthetic appeal, air purification, noise reduction, and erosion control. Roadside trees are typically planted along streets, highways, and rural roads to enhance the visual appeal, provide shade to pedestrians and motorists, and contribute to the overall liveability of the area [4]. The selection of appropriate roadside tree species is important to ensure their adaptability to the local conditions, minimize maintenance requirements, and enhance their overall effectiveness.

2.2 Benefits of roadside trees

Roadside trees provide numerous benefits to both the environment and the community. Roadside trees act as natural air filters, absorbing pollutants such as carbon dioxide, nitrogen dioxide, and particulate matter from vehicle emissions [5,6,7]. Through the process of photosynthesis, trees convert carbon dioxide into oxygen, helping to improve air quality and reduce the impacts of air pollution. Roadside trees can act as a barrier, helping to reduce traffic noise by absorbing and deflecting sound waves. They contribute to creating a quieter and more peaceful environment for residents, pedestrians, and other road users. Trees planted along roadsides enhance the visual appeal of an area, adding greenery and natural beauty to the landscape. They contribute to a sense of place and improve the overall aesthetics of the community. Trees planted along roadsides enhance the visual appeal of an area, adding greenery and natural beauty to the landscape. They contribute to a sense of place and improve the overall aesthetics of the community. The root systems of roadside trees help stabilize the soil and prevent erosion along roadways. They hold the soil in place, reducing the risk of sediment runoff into water bodies and maintaining the integrity of road embankments. Trees planted along roadways can serve as a natural buffer, separating pedestrians from vehicle traffic and providing shade and shelter. They can help define and improve the safety of pedestrian pathways and encourage walking and cycling. Roadside trees can provide a calming and soothing effect, reducing stress levels and enhancing the overall quality of life for people living and working in the area. Roadside trees provide habitat and food sources for birds, insects, and other wildlife [8,9]. They contribute to urban biodiversity by supporting a range of species and ecological interactions.

2.3 Important of roadside tree species selection model

The roadside tree species selection model explained the process of choosing the appropriate trees to be planted along roadside areas. This model is a comprehensive framework that takes into account various factors such as climate, site characteristics, urban design goals, maintenance requirements, and ecosystem services [10]. By incorporating these considerations, the model ensures that the selected tree species are well-suited to the local

environment, enhance the urban landscape, and provide numerous benefits to the community. Traditional approaches to roadside tree selection often relied on limited knowledge and subjective preferences, leading to suboptimal choices and potential issues down the line. However, with the roadside tree species selection model, decision-makers can make well-informed choices based on scientific data, local expertise, and a holistic understanding of the urban environment.

2.4 The role of green spaces in smart city

Greenery and plant life have been proven to have numerous health benefits, which could be instrumental in building smart cities that truly improve the quality of life [11, 12]. Green spaces play a vital role in smart cities by providing numerous environmental, social, and economic benefits. When integrated with smart technologies, these green spaces become even more impactful. Green spaces, roadside area contribute to environmental sustainability in smart cities [13, 14]. They help mitigate the urban heat island effect by providing shade and evaporative cooling. They also improve air quality by absorbing pollutants and releasing oxygen, reducing the impact of vehicle emissions and industrial activities. As smart cities face the challenges of climate change, green spaces can help with climate adaptation and resilience. They act as green infrastructure, absorbing and storing excess rainfall, reducing the risk of flooding. Green spaces play a crucial role in managing storm water runoff in smart cities [15]. They can be designed as natural or engineered systems that absorb and filter rainwater, reducing the burden on conventional drainage infrastructure. Green spaces can also provide refuge for wildlife and buffer against extreme weather events. Green spaces have economic advantages for smart cities [16,17]. They enhance property values, attract investments, and stimulate tourism. Well-designed green spaces can create jobs in landscaping, maintenance, and programming. Smart technologies can aid in the efficient management and maintenance of green spaces, optimizing resource allocation and reducing operational costs.

2.5 Roadside trees as solution for smart city

By incorporating roadside trees into smart city planning and design, cities can harness the numerous benefits they offer, creating more sustainable, liveable, and resilient urban environments. The integration of smart technologies can further enhance the management and monitoring of these trees, optimizing their effectiveness and ensuring their long-term success. Smart cities aim to have clean and healthy air. Roadside trees act as natural air filters, absorbing pollutants and particulate matter from vehicle emissions and industrial activities. They help improve air quality by reducing the concentration of harmful gases and enhancing the quality of the breathable air in the urban environment. By planting trees strategically along busy roadways, smart cities can create more peaceful and pleasant living environments for residents and workers [18,19]. Trees along roads can help manage storm water runoff by absorbing rainfall and reducing surface runoff. Their root systems act as natural infiltration systems, helping to recharge groundwater and reduce the strain on urban drainage systems. This can contribute to better water management and reduce the risk of flooding in smart cities. Trees along roads add greenery, beauty, and a sense of nature to the urban landscape. They provide visual relief from concrete and asphalt, making the city more appealing and inviting. Access to green spaces and nature has been linked to improved mental health and well-being, contributing to a happier and healthier community. Integrating smart technologies, such as sensors and IoT devices, can enhance the management and monitoring of roadside trees

[20,21]. These technologies can provide real-time data on tree health, soil moisture, air quality, and other environmental factors. This data can be used to optimize maintenance schedules, irrigation systems, and overall tree care, ensuring the health and longevity of the roadside trees.

3 Research methodology

This study used qualitative approach which based on analysis of qualitative data collection. The purpose of the qualitative approach is for in-depth interviews conducted with landscape architects in the local authority. Secondly, are using literature reviews. A critical literature review was conducted on theories related to tree species selection and factors are influencing in selecting tree species were studied. The selections of the respondents for in-depth interview are one senior Landscape Architect based on experience and knowledgeable in selecting tree species at Kuala Lumpur City Hall, Petaling Jaya City Council, Selayang Municipal Council and Subang Jaya Municipal Council. The selection of local authority is based on their promise to share information with researchers. All the important process is described using coding technique.

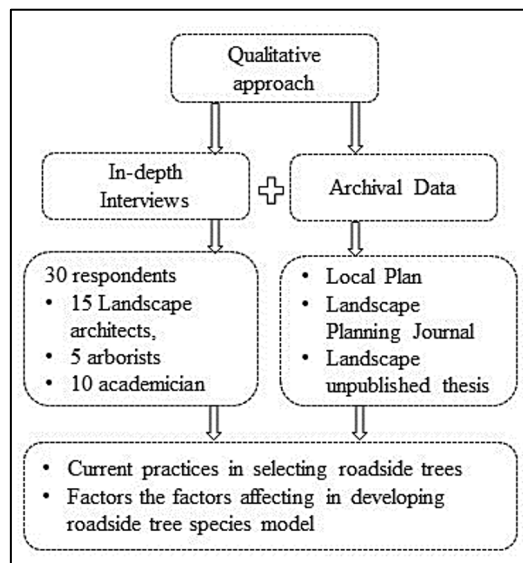


Fig. 1. Flow chart of research methodology in this study

4 Result and discussion

4.1 Current practices in selecting roadside trees

In Malaysia, the selection of roadside trees typically follows a combination of practices that consider various factors such as climate, local expertise, site conditions, and available resources. While specific practices may vary among different cities and regions. Local expertise and knowledge play a significant role in selecting roadside trees in Malaysia. Local tree species that are well-adapted to the climate, soil conditions, and urban environment are often preferred. These species have proven track records of survival and resilience in the specific region and are familiar to local arborists and horticulturists. There is a growing emphasis on promoting native and indigenous tree species in roadside tree selection. These

species are naturally suited to the local ecosystem and have adapted to local climate conditions over time. They are often favoured for their ecological benefits, including supporting native biodiversity and requiring less maintenance. Malaysia's climate, characterized by high temperatures, humidity, and abundant rainfall, influences the selection of roadside trees. Tree species that can tolerate these conditions, including heat, moisture, and occasional flooding, are favoured. Species with good shade-giving qualities are also preferred to mitigate the urban heat island effect. Stakeholder engagement and public participation play a role in selecting roadside trees. Input from residents, community groups, and local organizations is sought to understand their preferences and priorities. This helps ensure that the selected tree species align with community needs and aspirations, fostering a sense of ownership and connection with the urban forest. Functional considerations are taken into account when selecting roadside trees in Malaysia. Factors such as tree height, crown spread, growth rate, and root system characteristics are assessed to ensure compatibility with site conditions, existing infrastructure, and overhead utility lines. This helps minimize potential conflicts and maintenance issues in the future. Some cities collaborate with research institutions and universities to conduct studies and trials on suitable tree species for roadside planting. These collaborations help gather scientific data on growth rates, tolerance to urban stresses, and environmental benefits of different tree species. The findings inform the selection process and contribute to the knowledge base for urban forestry in Malaysia. Local regulations and guidelines set by municipal authorities and relevant agencies provide a framework for roadside tree selection. These regulations may specify requirements such as minimum tree sizes, allowable species, and setback distances from infrastructure. Compliance with these regulations ensures safety, functionality, and consistency in roadside tree planting.

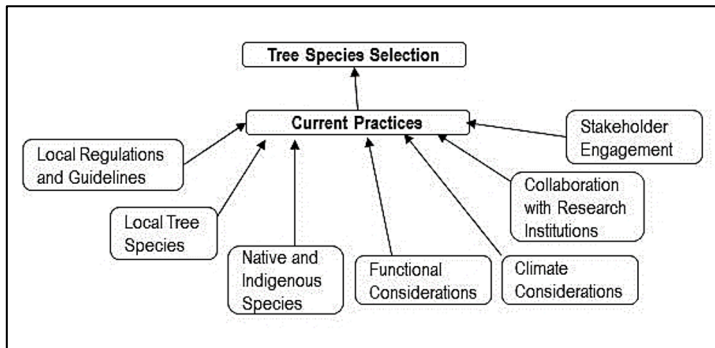


Fig. 2. Analysis on Current Practices in Selecting Roadside Tree Species

4.2 Factors affecting in developing roadside tree species model

Factors such as local climate, soil conditions, available space, and maintenance resources should be taken into account to ensure successful roadside tree planting and long-term sustainability. The factors are affecting in developing Malaysian roadside tree species model. By considering these factors, a comprehensive roadside tree species selection model can be developed to guide the selection of suitable tree species that will thrive in the specific roadside environment, provide desired benefits, and contribute to the overall sustainability and well-being of the community.

Table 1. Determinants of Factors Effecting in Developing Roadside Tree Species

Rank	Factors	Elaborate by interviewees
1	Size and growth habit	Tree species with appropriate sizes and growth habits that won't obstruct sightlines, utility lines, or cause obstructions to traffic are preferred.
2	Native and local species	Native or locally adapted tree species are often favoured as they are more likely to be well-suited to the local environment, support local ecosystems, and require less maintenance.
3	Adaptability	Species that can tolerate local climate, soil conditions, and pollution levels are chosen for roadside planting to ensure their survival and long-term health.
4	Maintenance requirements	Species that have manageable maintenance requirements in terms of pruning, disease resistance, and pest control are preferred for roadside planting.
5	Wind resistance	Consider the tree species' ability to withstand high winds and storms without significant damage.
Rank	Factors	Elaborate by interviewees
6	Non-invasive roots	Species with non-invasive root systems are chosen to avoid potential damage to sidewalks, pavements, and underground utilities.
7	Canopy density	Consider the density of the tree's canopy to determine the amount of shade it will provide and its impact on visibility for drivers and pedestrians.
8	Soil requirements	Consider the tree species' soil preferences, including soil type, pH levels, and drainage capacity.
9	Aesthetic value	Consider the tree species' visual appeal, including its foliage, flowers, bark texture, and seasonal interest, to enhance the aesthetic quality of the roadside.
10	Wildlife support	Select tree species that provide food, shelter, and nesting opportunities for birds, insects, and other wildlife, contributing to urban biodiversity.
11	Cultural significance	Assess the cultural or historical significance of the tree species to the local community or region.
12	Stakeholder input	Consider input from relevant stakeholders, including local communities, urban planners, and landscape architects, to incorporate preferences, cultural values, and specific project goals.

13	Longevity	Assess the tree species' expected lifespan to ensure long-term benefits and minimize the need for frequent replacements.
14	Urban tolerance	Evaluate the tree species' ability to withstand urban conditions, such as pollution, compacted soil, and limited root space.
15	Pest and disease resistance	Select tree species that have natural resistance or tolerance to common pests and diseases prevalent in the area.

5 Conclusions

In conclusion, the determination factors of a roadside tree species selection model for sustainable smart cities play a crucial role in creating environmentally-friendly and aesthetically pleasing urban landscapes. The determination factors of a roadside tree species selection model for sustainable smart cities should incorporate ecological suitability, functional benefits, aesthetic qualities, maintenance requirements, and community engagement. By considering these factors, cities can create green corridors that enhance the liveability, environmental sustainability, and visual appeal of their urban landscapes. Trees can offer a range of advantages such as air purification, noise reduction, temperature regulation, and storm water management. The model should consider the specific needs and goals of the smart city and select tree species that maximize these functional benefits. The key factors that contribute to the selection of tree species, ensuring their long-term viability and contribution to the overall sustainability of the city. Factors such as native and tree species selection for a specific location involves a crucial role in this process and need adapted to the local climate, soil, and ecological conditions, making them a more sustainable and environmentally friendly choice. Malaysian roadside tree species selection model should prioritize the maintenance requirements of the selected tree species. Choosing species that are resilient, disease-resistant, and low-maintenance helps minimize the cost and effort associated with tree care. Considering the growth patterns, root systems, and potential impact on infrastructure is also crucial to ensure long-term sustainability and safety.

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