

Street tree risk assessment at the food court of Sultan Muhammad IV Stadium in Kota Bharu, Kelantan

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Abstract. Urban street trees constitute a significant element of the metropolitan ecosystem, but they pose a certain risk when they are present with humans. The extreme effects of trees may manifest as harm and detriment to both communal and individual assets. In addition, the deterioration and death of old and valuable trees can affect the diversity and cultural value of this natural treasure. The purpose of this study was to conduct a tree risk assessment by conducting a visual investigation of the usual nine trees at the Sultan Muhammad IV Stadium food court, Kota Bharu, Kelantan. The evaluation was executed employing the Visual Tree Assessment (VTA) methodology, which was developed by the International Society of Arboriculture (ISA). The findings revealed that one tree was classified as being in the extreme risk group, five trees were classified as being in the high-risk category, and three trees were classified as being in the moderate risk category. The study emphasizes the importance of understanding tree risk and health to prioritize community safety and environmental sustainability in urban areas.

1 Introduction

Street trees are crucial and indispensable components of urban landscapes [1]. Those trees control the microclimate, sequester carbon [2], mitigate air pollution [3] and add value to urban areas as part of the green infrastructure, city identity, and history [4]. However, they also pose risks to humans, belongings, and infrastructure in the event of branch, stem, or entire failure, especially during storms [5]. Due to their unfavourable growth conditions and high stress levels, street trees require regular inspections. Under certain conditions, trees can become harmful or even lethal due to improper identification of their defects' signs and

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symptoms. Tree failures may occur when a combination of defects, conditions, and environmental factors are present. Therefore, it is critical to monitor and assess tree health and risk levels. This study was conducted in selected areas of Kota Bharu using the basic tree risk assessment, Visual Tree Assessment (VTA) method and rating the risk posed by the tree.

2 Basic Tree Risk Assessment

Tree risk assessment constitutes a methodical framework employed to identify, analyse, and appraise potential hazards associated with trees to improve public safety, protect workers, and increase tree lifespan. The risk level varies based on tree size, defect type, location, species, and target nature. Conventional methodologies for risk assessment take into account the probability of tree failure (potential for failure), the existence of potential targets, and the possible consequences of such failure [6–9]. Failure potential refers to the probability that a tree will break and fall within a specified timeframe. Factors considered include tree type, growth pattern, defects, branch attachment strength, root system health, lean, and site history. Targets are individuals or assets at risk of injury or harm in the event of tree failure. In the absence of a target, there is no danger, as tree failure would not result in any damage [7].

The basic tree assessment method, known as Visual Tree Assessment (VTA), is a straightforward, long-standing, and cost-effective approach to evaluating trees. VTA is a method that entails thoroughly examining a tree and its surrounding area from the ground, using a 360-degree visual assessment, considering various parameters such as crown structure shape, foliage color, bark texture, visible wounds, decay, roots, size, structure, and signs of root damage. Other parameters include structural anomalies within the tree, including splits, cracks, or leaning, and site conditions. Ground conditions affect the health of the roots [6–9].

3 Methods

3.1 Study Site

This study was conducted on the food court area of Sultan Muhammad IV Stadium in Kota Bharu, Kelantan. Given that the Sultan Muhammad IV Stadium was constructed in 1967, it is plausible that the street tree specimens around the area may have reached more than 50 years. The trees' locations are shown in Fig. 1.



Fig. 1. Study site at food court area of Sultan Muhammad IV Stadium.

3.2 Data Collection

The data collection for Visual Tree Assessment (VTA) was conducted from May 10 to 11, 2024, which involves directly observing and assessment of the root system, trunk, branches, and their surrounding environment. In order to carry out the assessment work, appropriate equipment plays an important role in obtaining more accurate and up-to-date tree information. The following equipment are used: diameter tape, distometer, rubber hammer, marker, tape, and stapler.

3.3 Data analysis

This study categorizes tree risk by failure likelihood, affecting the target and its consequences. The combined probability of failure to impact the target is categorized by the failure likelihood, which is categorized as improbable, possible, probable, or imminent. This study estimates the likelihood of a part failure impacting the target by calculating the occupancy rate of all targets within the target zone and considering any factors that could influence the failing tree as it approaches the target. The target impact likelihood is classified into 'Very low', 'Low', 'Medium', and 'High'. 'Very low' indicates that the failed tree or branch is unlikely to have an effect on the designated target, while 'Low' indicates that there is little chance that the target will be impacted. 'Medium' suggests that there is a nearly equal chance of the failed tree or branch affecting the goal, and 'High' indicates that the target may be impacted by the failing tree or branch. Table 1 guides the researcher in relating likelihood failure factors and likelihood targeting effects at a specific time period.

Table 1. Estimating the tree failure likelihood impacting a specific target.

Likelihood of Failure	Likelihood of Impacting Target			
	Very low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

Source: [6]

The study evaluates consequences based on target value and potential harm using a matrix for tree risk assessment. The matrix considers factors like size of part, fall characteristics, fall distance, and risk target protection elements. The risk level (Table 2) is determined by combining the rating of likelihood and consequence factors, resulting in a range of "Negligible" to "Severe" consequences.

Table 2. Tree failure likelihood of impacting target and the severity of the consequences.

Likelihood of Failure & Impact	Consequences			
	Negligible	Minor	Significant	Severe
Very likely	Low	Moderate	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low

Source: [6]

4 Results and discussion

This study identified two tree species after examining and analyzing a total of nine trees. The dominant species found were *Pterocarpus indicus* (67%), followed by *Samanea saman* (33%). Notably, the Landscape and Urban Cleansing Control Department's "No Roads Without Trees" program extensively planted the *Samanea saman* and *Pterocarpus indicus* as popular choices for urban greening as early as the 1900s. The umbrella-shaped canopy of *Samanea saman*, also referred as the rain tree, is easily recognised. The tree typically reaches a height of 15–25 metres, and its canopy diameter is frequently greater than its height. *Pterocarpus indicus*, locally known as Angsana, are two species of flowering trees. The tree's dome-shaped crown and drooping branches offer shade to pedestrians, while its vibrant yellow flowers provide an impressive yet short-lived display. Both are flowering tree species in the Fabaceae family. According to the results in Table 3, most tree trunks are usually codominant (Fig.2), with asymmetric forms that have large stems potentially splitting at attachment points. The presence of included bark weakens branch attachments, and dominant trunks are weaker than single-trunked trees. A weak branch union can cause branches to break easily, especially during adverse weather. A study by [10] found that tree failure is not solely influenced by codominant branches, branch unions characterized by included bark, multiple stems arising from a common location, and excessively elongated branches, there are various elements that can affect the outcomes of tree failure.

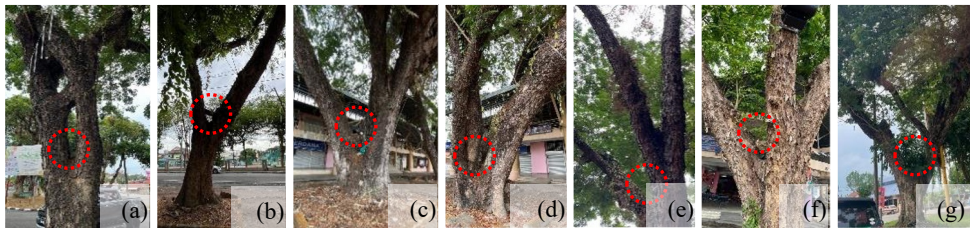


Fig. 2. Codominant stems.

Poor pruning techniques can negatively impact tree health. Improper pruning creates wounds, weakens branch structures, and increases susceptibility to breakage. Regular maintenance of urban trees is crucial to ensuring their safety and effectiveness. Topping, or removing the upper part of a tree's main stem or branches, can have negative effects on tree health, including epicormic growth. The result shown that all of the trees have excessive epicormic growth (Fig.3). Epicormic branch formation is considered a response stress [11]. Studies in silviculture and ecology indicate that tree vigour plays a crucial role in determining the probability of producing epicormic sprouts. Less vigorous trees tend to have a greater abundance of epicormic sprouts, highlighting the influence of previous topping pruning [12,13]. Excessive epicormic growth can weaken branches, as shoots from dormant buds form weaker attachments to the tree, creating points of vulnerability where branches are more likely to break or fall [11].



Fig. 3. Epicormic growth.

Table 3. Tree Assessment and Risk Rating.

Tagging	Scientific name	DBH	Height	Crown & Branches										Trunk		Roots		Likelihood to fail	Likelihood of Impacting Target	Risk rating matrix		
				Asymmetry	Codominant	Hangers	Epicormic	Epiphyte	Sparse foliage	Sign of decay	Necrotic leaf	Twig dieback	Wound wood	Twisted	Lean	Sign of decay	Buried root				Lifted	Gridling
T1	<i>Pterocarpus indicus</i>	2.45	14.5	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Probable	Likely	High
T2	<i>Pterocarpus indicus</i>	2.20	14.0	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Probable	Likely	High
T3	<i>Samanea saman</i>	6.15	22.0	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Imminent	Very Likely	Extreme
T4	<i>Samanea saman</i>	7.45	22.0	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Probable	Likely	High
T5	<i>Pterocarpus indicus</i>	2.70	20.0	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Probable	Likely	High
T6	<i>Pterocarpus indicus</i>	2.66	18.0	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Probable	Likely	High
T7	<i>Pterocarpus indicus</i>	2.20	16.0	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Possible	Somewhat likely	Moderate
T8	<i>Pterocarpus indicus</i>	3.10	20.0	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Possible	Somewhat likely	Moderate
T9	<i>Samanea saman</i>	4.00	20.0	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Possible	Somewhat likely	Moderate

Local climatic conditions can influence the prevalence of pests and diseases that threaten tree health. Warmer temperatures may lead to increased insect activity, while high humidity can promote fungal diseases. Wood decay in living trees is considered a disease, and it is also evident on the tree stems and roots. Cavity is decay indicator. Most trees show signs of decay in the trunk. Only one tree (T3) showed signs of decay in its root. As fungi digest the wood, they decrease its strength [11]; therefore, the location of decay within a tree is an important factor in identifying decay that influences tree safety. According to [14], hollows, cavities, and fungi on trees pose potential hazards to public and infrastructure, including falling branches and wind-toppled trees. Standing tree decay can weaken these structures, increasing the likelihood of structural failure.

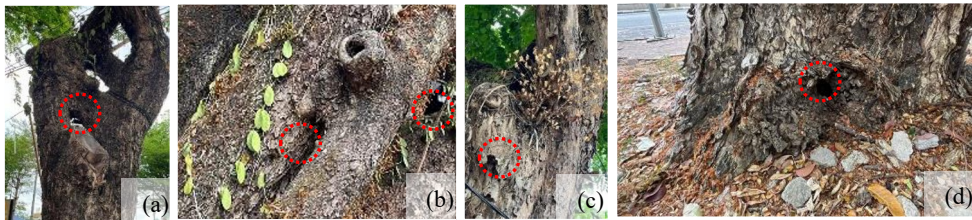


Fig. 4. Tree cavities.

The study also evaluated tree health by examining roots, twig dieback, sparse foliage, and lifted pavement. Some trees showed sparse foliage and leaning, while only one (T5) tree had necrotic leaf problems and twig dieback, and one (T3) showed root decay. Decay is a common defect often linked to tree failure. Root decay is considered more hazardous than crown, branches, and trunk decay due to its crucial role in anchoring a tree and providing stability [14]. Previous study also indicate that certain instances of tree failure are linked to soil properties and tree root architecture, which are crucial factors in determining tree stability [15]. Infrastructure, including buildings and roads, can exacerbate tree decline due to limited root space, water and nutrient competition, and potential physical damage from human activities. The study underscores the need for a comprehensive risk assessment that considers these environmental factors. The study assessed the likelihood of tree failure using various factors, classifying one tree as 'imminent', five trees as 'probable', and three trees as 'possible'. All these trees, situated near pedestrian paths and main vehicle routes had a high likelihood of failing to impact the target. Thus, tree T3 had a high probability of impacting the target, while trees T1, T2, T4, T5, and T6 had a moderate probability. T7, T8, and T9 are somewhat likely to affect the target. After evaluating the consequences based on target values and potential harm using a tree risk assessment matrix, this investigation revealed that the risk classification for tree T3 is 'extreme', while T1, T2, T4, T5, and T6, are 'high' risk. Trees T7, T8, and T9 pose a moderate risk.

5 Conclusion

Mature street trees in play a crucial role in our cities, but they also come with risks that need careful management. Poor pruning techniques and inadequate root zone conditions can negatively impact tree health. Improper pruning creates wounds, weakens branch structures, and increases susceptibility to breakage. Inadequate root zones, poor soil conditions, and poor soil compaction exacerbate these issues. Regular maintenance of urban trees is crucial to ensuring their safety and effectiveness. By considering these elements, urban planners and arborists can better protect trees and ensure their longevity in urban landscapes.

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