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Reviewing Tree Risk Inventory Framework for Tropical Urban Trees by Malaysia Experts

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Abstract

Malaysia lost 14.4% of its forests due to deforestation. As a result, the forests' ability to protect against physical disturbances was no longer practical. The study aims to review a framework of tree risk inventory for Malaysia's tropical urban trees. Some expert interview sessions were conducted with Malaysian experts to present the proposed framework. Found that 100% of the experts agree with the framework presented. Additional components were added to the framework based on the data collected. The study could increase the relevant organizations' knowledge of managing tropical urban trees and decrease the deterioration and decline of tropical urban trees in Malaysia.

Keywords: hazardous trees; tree monitoring; urban forestry, tree assessment

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1.0 Introduction

Malaysia lost 14.4% of its forests between 2000 and 2012, the highest rate in the world due to deforestation, according to a mapping team from the University of Maryland that tracked forest growth and loss using satellite imagery. As a result, the forests' ability to protect against storms, pollution, landslides, floods, and other physical disturbances was no longer practical. As an example, Baling, Kedah, Malaysia, experienced flooding following persistently heavy rain and swamped at least nine villages in the district within hours on July 4, 2022 (The Star, July 6, 2022). Forests offer more than just a habitat for animals and a means of subsistence for people and also protect watersheds, stop soil erosion, and lessen climate change. However, forests keep disappearing to serve human needs.

When the disaster flood happened, trees in urban settings also had to take the consequences. There are a few articles that reported the incidence of trees falling due to flood disasters, such as in Seremban, Negeri Sembilan (December 2021 and May 2022), and Gombak (January, 2022), Shah Alam, Klang, and Kuala Langat, Selangor (June 2022). Urban trees offer many advantages, including rainwater interception and moderated release into surface waterways, but flood disasters make the degradation of urban trees in Malaysia even worst. Therefore, the Ministry of Energy and Natural Resources Malaysia (KeTSa) organized a 100 million trees campaign as part of the program to make Malaysia green.

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Preferably, instructions and requirements for the management and care of the trees should come after the planting project (Sreetheran et al., 2006) to make sure no repeating mistakes happen after. Darkhani (2019) indicated that the sustainability of a country's landscape and green spaces depends on the effectiveness of the management. The management aims to improve the environment, public safety, and livability of the city (Hasan et al., 2018). Malaysia does not have enough skilled arborists, nevertheless, at all levels (Sreetheran et al., 2006). A new proper and systematic management and maintenance system is essential to improve the management practice of urban trees in Malaysia.

Practitioners of arboriculture and urban forestry must take into account a method of risk assessment that is appropriate for the tree or trees to be evaluated, the instruments needed, and the management purpose. Although more thorough advanced risk assessment levels are supposed to give more accurate information about the likelihood of failure (Koeser & Smiley, 2017), it is unclear how this additional information affects how well tree assessments track the status of tree risks over the course of a tree's life cycle. Therefore, a tree risk assessment should be less thorough to allow for more professionals in the field of urban forestry. However, it is essential to research the appropriate standards needed to evaluate the status of the tree starting at a young age.

Therefore, the study aims to explore the suggestions and comments by Malaysian experts regarding the proposed framework of tree risk inventory for tropical urban trees in Malaysia. The objective of this research is to identify suitable criteria for the proposed tree risk inventory framework for tropical urban trees in Malaysia.

2.0 Literature Review

2.1 Definition of Tree Risk Inventory

Tree risk is the risk that a hazardous tree may cause property damage or personal injury. It is a combination of the likelihood of a tree failure event and the severity of the possible consequences of that event (Purcell, 2015). Tree risk assessors frequently work with scant knowledge about the tree's structural state and the factors influencing its environment. Tree inventory, on the other hand, is a process of collecting data on trees, such as the number of trees located within the public right-of-way, the value of ecosystem services provided by trees, and the number of available planting sites. The process of conducting a tree inventory can be divided into four phases which are planning, implementation, application, and maintenance (Zoia, 2016). Hence, tree risk inventory is a process of collecting the data of trees by taking into account possible risks.

2.2 Tropical Urban Trees Issues

All trees are tall, large, and dense structures that can lose parts or catastrophically fail. The genesis of the fallen tree is not only damaging public assets, properties, or vehicles but can particularly injure the public. According to statistics, Subang Jaya Municipal Council (MPSJ) received 5512 occurrences of public complaints about trees falling during the three-year period from 2012 to 2014 (Iresponz, 2014). The causes of the failure of the tree installation and establishment are poor root system, insufficient water, excessive water, deep planting, compacted soil, and plant specimens as the trees usually fall by natural disasters such as the storms, floods, and hurricanes that bring the society and public feel unsafe and threat to their surrounding environment (Lazim & Misni, 2016).

Every tree is a towering, bulky structure that has the potential to fail horribly or lose sections. Moreover, they will undoubtedly endanger their surroundings. These potentially dangerous trees may have structural issues with their roots or branches and are called hazardous trees (Jonathan et al., 2011). Hazardous trees are those with structural flaws in the roots, stem, or branches that could cause the tree or a part of it to fail, which could result in property damage or personal injury (Joseph, 1992).

2.3 Tree Risk Assessment

Trees function as a cooling agent for urban dwellers, but tragedy happened that damaged the assets and properties besides injured the people made the Tree Risk Assessment (TRA) critical. However, if the trees are still planted without proper management from their early installation, the risk will always be there, and the cycle will always continue the same. TRA is the systematic process of identifying, analyzing, and evaluating tree risk (Smiley et al., 2012). It is a wide field of expertise that incorporates many fields of expertise (Matheny & Clark, 2009), and every method of risk assessment is combined with its own form of data collection. Figure 1 below illustrates levels of TRA as defined by the ANSI A300 Standards for Tree Care Operations.

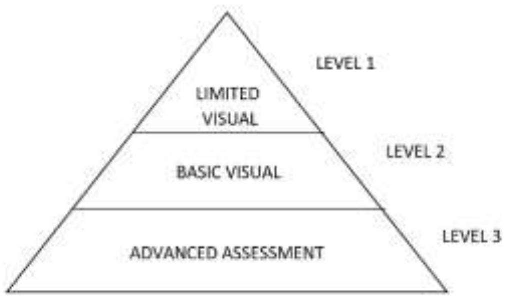

Figure 1: Tree risk assessment level
(Source:) *ANSI A300 Standards for Tree Care Operations*

Level 1 (limited visual) is often referred to as an assessment walk-by or a drive-by. It is most prevalent in urban forest scenarios where trees are abundant, and inspection services are comparatively limited. Level 2 (primarily visual), on the other hand, is a 360-degree field inspection that is more in-depth and usually involves measures of height and diameter. An assessor may use binoculars for crown inspections, a hollow-sounding mallet, a cavity inspection probe, and other typical inspection equipment. For level 3 (advanced assessment), the assessment may be an aerial assessment or an evaluation that requires the identification of quantitative deterioration, health assessment, assessment of wind load, and assessment of static load. This service is often offered at a premium to the consumer and is usually reserved for heritage or high-value trees, considering the more specialized methods and methodologies used.

2.4 Best Management Practice for Tropical Urban Trees

Based on the Best Management Practice Manual by the Institute of Landscape Architecture Malaysia (2021), there are a few things to do in carrying out the work process of tree inspection assessment in the field. The first thing is the registration of existing trees on site that meet the requirements of the Tree Preservation Order under Act 172 (Section 35A) and protection of green and open areas Act 171 (Part XII). The second is to do the tree inventory and inspection assessment on-site includes examining and checking for signs of damage or disease infection on any structure of the tree naturally or as a result of disturbing activities. Third, the designation of tree protection zones during development work that clearly defined and notified area notices prohibition of construction activities carried out near or within the zone area of tree protection. Forth restorative treatment for trees that have been removed or relocated from their original habitat. Lastly, essential information that is protected or preserved, or transferred needs to be recorded and documented. Figure 2 below summarizes the work process of tree inspection assessment in the field.

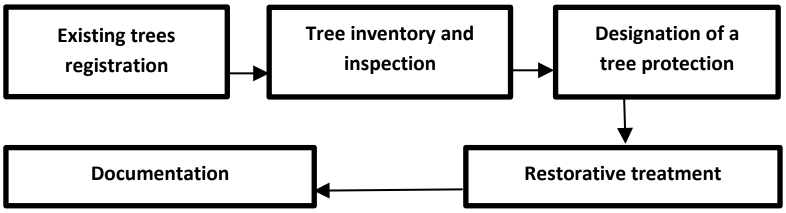

Figure 2: Work Process of Tree Inspection Assessment in the Field
(Source:) *Institute of Landscape Architecture Malaysia (2021)*

3.0 Methodology

Using exploratory case analysis was one of the study methods used. The study is organized into three stages: data collection, data analysis, and reporting, as seen in Figure 2. Ten Malaysian experts were individually interviewed in person. Open-ended interview questions were pre-tested and asked as a memory help to give respondents freedom and flexibility to respond in line with the exploratory study (McNamara, 2017). AtLAS.ti version 8.4.25, research software, audio recordings, and transcribed text were all cataloged and categorized. Finally, content analysis determines the codes, groups, and subjects (Mayring, 2014).

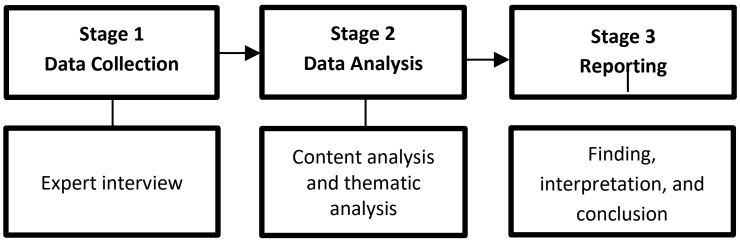

Figure 3: Study procedures

Thematic analysis was used to map and analyze the themes. The analysis entails delving into the relationship between the categories and the subject, identifying trends, and outlining a strategy (Maguire & Delahunt, 2017). The conclusion is reached after discussing the findings and their interpretations and deriving it from the study's goals.

Table 1. Interviewees' information

Interviewee	Field of work	Education	Years of experience
E1	Arborist	Local	Expert
E2	Arborist	Local	Expert
E3	Contractor	Local	Beginner
E4	Landscape Architect	Local	Intermediate
E5	Arborist	Local	Expert
E6	Local Authorities	Local	Expert
E8	Local Authorities	Local	Intermediate
E9	Academician	Abroad	Intermediate
E10	Landscape Architect	Local	Expert

Notes: Beginner (< 10 years) / Intermediate (10 < 20 years) / Expert (> 20 years)

The interviews were conducted for an extended period from 2020 until 2021, as the Movement Control Order was directed a few times in Malaysia. A total of 10 experts were chosen for the expert interview sessions. They consist of arborists, lecturers, landscape architects, and representatives from municipalities. Showcards were used during interviews regarding tree risk inventory criteria. Interviews were conducted in their offices, and some were conducted online. They were asked questions while being recorded with their permission. The interview results were then coded using Atlas-ti and Microsoft Excel. These interviewees are professionals and experts directly or indirectly involved with the management of tropical urban trees in Malaysia. Each interviewee was given an alphanumerical code (E1-E10), and the information about each interviewee is included in Table 1.

4.0 Findings

4.1 Prior Knowledge Regarding TRA

Interviewees were asked about their prior knowledge regarding the Tree Risk Assessment (TRA) methods. Five types of TRA methods have been selected and questioned by the interviewers. The results are classified into five types of TRA categories, as illustrated in Figure 4.

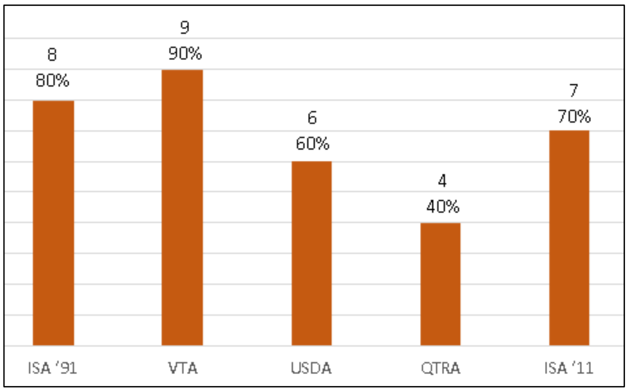

Figure 4: Prior knowledge regarding the TRA methods

The study determined that among the five methods, the highest percentage of familiarity is Visual Tree Assessment (VTA) and ISA Tree Hazard Evaluation (ISA '91), which have 90% and 80%, respectively, followed by ISA Tree Risk Assessment (ISA '11) with a percentage of 70%. 60% of the interviewees were familiar with Quantified Tree Risk Assessment (QTRA), while only 40% of them were familiar with USDA Forest Service Community Tree Risk Evaluation Method (USDA). E9 highlighted that most of the certified arborist and tree workers in Malaysia are familiar with VTA, and VTA are ubiquitous among them since it is a level 1 assessment and both ISA method are also quite common since all certified arborist in Malaysia were taught by experienced and specialist speakers from ISA Certified Arborist. E1, E2, E5, E6, E8, and E9 are the informants that are familiar with all of the selected TRA since their experience in TRA is quite long. Most of the informants that are familiar with the VTA are also familiar with both ISA '11 and ISA '91.

4.2 Experience Regarding TRA

Interviewees were questioned about their experience in using the TRA methods. The results are classified into yes and no categories, as illustrated in Figure 4.

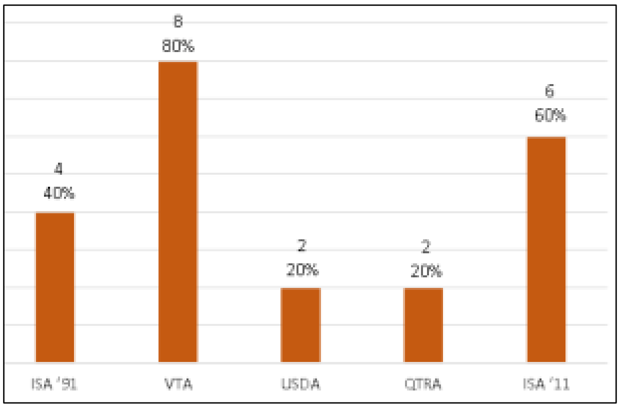

Figure 4: Experience regarding the TRA methods

The finding indicated that most of the interviewees only had experience using VTA (80%), while ISA '91 only got 40% voted compared to ISA '11 (60%). Both USDA and QTRA have the lowest percentage, where only 20% of the interviewees have experience using them.

Second, based on E1, E2, E5, and E9, ISA '11 is more commonly used among arborists than ISA'91, which utilized a number as the rating formula. This is because the rating system used in ISA '11 is in a matrix table. Two interviewees that have experience using USDA are the same interviewees that have experience using the QTRA, which are E2 and E5. They are also the only interviewees that have experience using all of the selected TRA.

Meanwhile, E1, E6, E8, and E9 have the same situation where all of them have experience using the VTA, ISA '11, and ISA '91 but did not have experience using USDA and QTRA. E1 also explain that usage of USDA and QTRA as TRA method in Malaysia are not widespread compared to other selected TRA. Each arborist, however, still has a preferred approach when determining how to evaluate a tree.

4.3 Viewpoint Regarding Tree Risk Inventory Framework

The Framework of the Tree Risk Inventory for Tropical Urban Trees in Malaysia was presented to interviewees to collect their reviews and comments. Generally, the framework has eight main criteria and some attributes needed to assess a tree. The presented framework is shown in Table 2.

Table 2: Tree Risk Inventory Framework for Tropical Urban Trees in Malaysia

Assessment phases		Criteria	
PHASE 1	**PLANNING POLICY**	Tree characteristics	Site condition
PHASE 2	**IMPLEMENTATION**	Tree health	Tree defect
		Site condition/factor	Hazard abatement
PHASE 3	**RISK PROTECTION**	Tree characteristics	Tree defect
		Tree health	Load factor
		Site condition/factor	Hazard rating
		Target assessment	Hazard abatement
	RISK TREATMENT	Tree characteristics	Tree defect
		Tree health	Load factor
		Site condition/factor	Hazard rating
		Target assessment	Hazard abatement

Interviewees were asked about their views on the preliminary conceptual framework of the Tree Risk Assessment Model for Tropical Urban Trees in Malaysia. The results are classified into agreeing, not agree, and no answer categories, as illustrated in Figure 5.

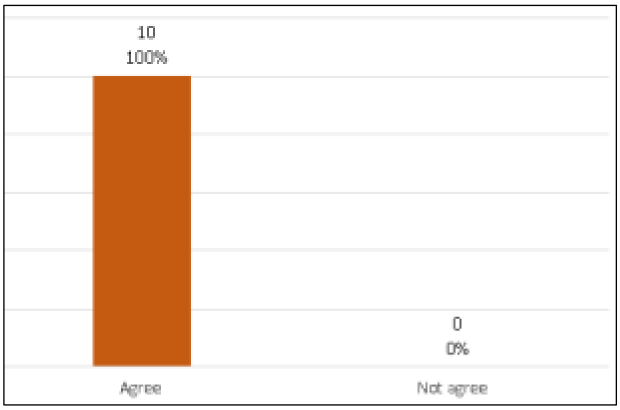

Figure 5: Viewpoint on the Tree Risk Inventory Framework

A total of 10 (100%) interviewees agreed with the presented framework, and everyone was in agreement that the framework is an excellent beginning point for a better management system for all tropical urban trees in Malaysia. According to E2, this framework also needs to take into account external and environmental elements that may have an impact on the health and performance of tropical urban trees. E5, E9, and E10 also mentioned this issue, while E4 emphasized the grey infrastructure that may also have an impact on the growth of the trees.

Second, E1 also suggested that rather than waiting for the tree experts to do the TRA, every tree worker should have at least a basic understanding of how trees adapt to their surroundings and the local climate. E10, on the other hand, concentrated on how trees need to deal with construction stresses such as soil compaction, mechanical injuries, and root loss during grading.

Third, E6 also recommended that tree workers should also focus on tree planting practices because there is a lack of best management practices during tree planting, while E1 also urged to include them all into the framework. Overall, all participants agree that the presented framework should be used widely in order for us to achieve a better management practice for tropical urban trees in Malaysia.

5.0 Discussion

Generally, this framework will benefit not only inventory but also decision-making. This conclusion was confirmed through in-depth discussion with the interviewees.

In general, VTA and both ISA '91 and ISA'11 are the most famous TRA used by arborists in Malaysia might because they are likely to have the most suitable criteria for tree risk assessment. VTA and ISA '11 is a TRA method that analyzes the risk. Besides that, the proposed framework was accepted and improved by Malaysian experts and is expected to become a starting point for enhancing the management of tropical urban trees in Malaysia. The fact that none of the interviewees disagreed with the framework was likely because everyone agreed that tropical urban trees in Malaysia need a better management system with the full enforcement of policy and action by the federal government.

After assessing all of the data and taking into account specific extra inputs, Table 3 indicate the revised framework for the Tree Risk Inventory for Tropical Urban Trees in Malaysia. The framework is divided into 3 phases; each phase consists of its own criteria for tree risk inventory.

Table 3: Revised Tree Risk Inventory Framework for Tropical Urban Trees in Malaysia

PHASE 1	PHASE 2	PHASE 3
1. Tree characteristics 2. Site condition	1. Tree health 2. Site condition/factor 3. Tree defect 4. Hazard abatement	1. Tree characteristics 2. Tree health 3. Site condition /factor 4. Tree defect 5. Load factor 6. Target assessment 7. Hazard rating 8. Hazard abatement

<table>
<tr><th>Criteria</th><th>Attributes</th><th>Criteria</th><th>Attributes</th><th>Criteria</th><th>Attributes</th></tr>
<tr><td rowspan="4">1. Tree characteristic</td><td rowspan="4">species, age, latitude & longitude, canopy spread</td><td rowspan="2">1. Tree Health</td><td rowspan="2">Foliage color/ density, shoot growth, vigor, epicormic, twig dieback, biotic, abiotic</td><td>1. Tree Characteristics</td><td>species, DBH, estimated age, form, live crown ratio, canopy spread, pruning history, special value</td></tr>
<tr><td>2. Tree Health</td><td>Foliage color/ density, shoot growth, vigor, epicormic, twig dieback, biotic, abiotic, sound wood dev.</td></tr>
<tr><td rowspan="2">2. Site condition</td><td rowspan="2">Irrigation, dripline, soil condition, obstruction, wind, topography, site changes</td><td>3. Site condition</td><td>Site character, Irrigation, dripline, soil condition, obstruction, wind, topography, site changes</td></tr>
<tr><td>4. Tree defect</td><td>Root, tree lean, dead twig/ branches, sapwood damage, soil cracking, buttress</td></tr>
<tr><td rowspan="4">2. Site condition</td><td rowspan="4">Planting space, type of soil</td><td rowspan="2">3. Tree defect</td><td rowspan="2">Root, tree lean, dead twig/ branches, sapwood damage,</td><td>5. Load factor</td><td>Wind exposure, relative crown size, crown density, interior branches, vines/moss</td></tr>
<tr><td>6. Target assessment</td><td>Occupancy, target protection, target zone, restriction practical</td></tr>
<tr><td rowspan="2">4. Hazard abatement</td><td rowspan="2">Prune, removes tree/target</td><td>7. Hazard rating</td><td></td></tr>
<tr><td>8. Hazard abatement</td><td>Prune, removes tree/target.</td></tr>
</table>

<table>
<tr><th>RHIZOSPHERE STRESSED</th><th colspan="3">PRACTICE&ESTABLISMENT</th><th colspan="5">TERRESTRIAL STRESSED</th></tr>
<tr><td>Rooting Environment</td><td>Plant quality</td><td>Planting and post-planting</td><td>Tree Ecophysiology</td><td>Abiotic Stress</td><td>Biotic Stress</td><td>Construction Stress</td><td>Performance of Tree Biometric</td><td>Grey Infrastructure</td></tr>
</table>

Table 3 shows the research conclusion after analyzing all the data and considering some additional inputs. The framework is divided into three phases: 1) Planning and Policy phase; 2) Implementation phase; 3) Risk Protection and Treatment phase, and eight main criteria: 1) tree characteristic; 2) tree health; 3) site condition; 4) target assessment; 5) tree defect; 6) load factor; 7) hazard rating; 8) hazard abatement. In Phase 1 of the assessment, the only main criteria involved are 1) tree characteristics and 2) site condition. In Phase 2 of the assessment, the main criteria applied are 1) tree health, 2) site condition, 3) tree defect, and 4) hazard abatement. Lastly, in Phase 3, all eight main criteria will involve.

On the other hand, the lower side of the table indicates three categories of tree growth and establishment challenges. These categories are mutually related, which could affect the tree's growth and survival. The categories are Rhizosphere Environment, Practice and Establishment, and Terrestrial Stressed.

6.0 Conclusion and Recommendation

It is crucial to have one particular approach to risk inventory for tropical urban trees in Malaysia. Numerous tasks, including data collecting, monitoring, risk analysis, assessment, maintenance, management system, and tree planting design, can be carried out using this method.

It is recommended that additional research be conducted on the user requirement specification for tropical urban tree risk management to make the framework a system. Sustainability also needs to be addressed, and the changing needs and demands of urban users must be taken into account.

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Paper Contribution to Related Field of Study

This study's contribution is to provide insights for researchers and professionals to undertake future research that helps to enable the local authorities in Malaysia to get full advantage of the existing landscape in Malaysia.

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