

Research paper

## Health and Risk Assessment of Campus Trees at National Ilan University Using Visual Inspection

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### ABSTRACT

This study applied the Taipei City Tree Safety Assessment Form to comprehensively evaluate health and public safety risks of 150 trees representing 10 species on the campus of National Ilan University. The assessment framework covered four key aspects—crown, trunk, roots, and surrounding environment—enabling the identification of species-specific health conditions and risk characteristics. The results revealed significant interspecific differences, with four trees (approximately 7%) classified as Grade A—(most severe) requiring immediate attention. About 31% of the sampled trees exhibited poor growth conditions, with species-specific proportions ranging from 7% to 68%. Based on injury severity assessment (excluding anthropogenic damage), the species exhibiting the poorest health conditions were *Sapindus mukorossii* Gaertn., *Cassia fistula* L., and *Ficus microcarpa* L.f. The most frequent deficiencies were associated with trunk structural defects (such as decay and cavities), crown decline, and restricted root environments, reflecting the considerable influence of environmental and structural factors on tree health and safety. The study further discovered that adverse planting environments and inadequate pit design exacerbated tree risks. The findings of this study emphasize the necessity of prioritizing the management of high-risk trees and demonstrate the practical utility of the assessment form for campus tree inspections, while highlighting the importance of continued refinement informed by field experience and empirical data to enhance its long-term applicability.

**Keywords:** Tree health, safety and management, Risk assessment, Visual tree assessment (VTA)

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## INTRODUCTION

Trees are vital components of urban and campus green spaces, providing ecological and environmental benefits while contributing to human well-being and quality of life. However, their growth is often threatened by both natural environmental factors and human activity, including pest infestations, diseases, mechanical injuries, and unfavorable habitat conditions, which may result in safety hazards like branch failure or tree collapse. In public areas with high pedestrian traffic, such as university campuses, ensuring the structural safety of trees is particularly important to ensuring personal safety and preventing property damage. Therefore, establishing a scientific and systematic risk assessment and management framework is essential for the sustainable development of campus green infrastructure.

To effectively assess the health and safety status of campus trees, this study adopted the Visual Tree Assessment (VTA) method as the primary evaluation tool. VTA is a widely recognized, non-destructive technique in which trained professionals systematically inspect tree crowns, trunks, root systems, and the surrounding environment to identify potential risk factors such as structural defects, disease symptoms, and environmental stressors. This method provides notable advantages in cost-effectiveness and operational efficiency, making it a practical foundation for preliminary tree risk assessments conducted by management organizations.

The International Society of Arboriculture (ISA) categorizes VTA into three levels based on inspection depth and diagnostic accuracy: Level 1 (limited visual), Level 2 (basic risk assessment), and Level 3 (advanced assessment) (Dunster et al. 2017,

Li et al. 2022). This tiered framework enables the method to be adapted to varying site conditions and levels of complexity. Previous studies have either applied ISA's basic risk assessment framework (Li et al. 2021) or developed localized tools derived from ISA principles (Chiou and Lin 2024). In Taiwan, Taipei City Government introduced the "Taipei City Tree Safety Assessment Form," which incorporates both tree health and urban safety indicators. However, empirical research on its practical application and effectiveness remains limited.

Internationally, VTA has been widely incorporated into urban greening and risk management systems and is regarded as a mainstream tool for tree risk assessment. Studies have shown that VTA can effectively identify potential structural weaknesses and provide a scientific basis for risk classification, thereby supporting the formulation of targeted management strategies (Linhares et al. 2021, Nocetti and Brunetti 2024). Arboricultural organizations and municipalities have consequently developed various VTA-based frameworks, incorporating elements such as visual observation of form, evaluation of vitality, identification of pests and diseases, assessment of mechanical injuries, and documentation of structural and environmental conditions (Dunster et al. 2017, Lilly et al. 2022). Despite the method's general applicability, practical implementation of VTA may vary across regions due to differences in geography, climate, dominant tree species, environmental conditions, and policy frameworks, all of which can influence indicator weighting and risk interpretation.

For example, some tree species in specific regions may exhibit heightened susceptibility to local pests or diseases or demonstrate variable tolerance to soil compaction and wind stress. In such cases, applying international

standards without adaptation may fail to capture localized risk realities. To improve assessment precision and policy relevance, it is necessary to integrate local experience and on-site data to develop a context-sensitive assessment and management model. International standards should serve as a flexible framework that guides, rather than dictates, localized evaluations.

This study was conducted on the campus of National Ilan University, which features diverse tree species, dynamic environmental conditions, and complex growth challenges. A systematic risk assessment was performed to evaluate the overall health of campus trees, identify high-risk individuals, and investigate key factors contributing to tree decline and structural instability. Given the wide diversity of tree species on campus, this research focused on 10 commonly seen and representative species, which were considered sufficient to reflect the main patterns of health and risk. In addition, due to limitations in research resources and time, a representative sampling approach was adopted as a trial assessment rather than a full census. Importantly, the primary objective of this study was not to conduct a comprehensive tree-by-tree survey, but rather to evaluate the applicability of the Taipei City Tree Safety Assessment Form under campus conditions. Localized assessment tools were applied to examine their practicality and provide references for future management in comparable environments. The goal was to generate clear risk classifications and actionable recommendations to support the university in developing scientifically informed, efficient tree maintenance strategies, ultimately enhancing campus safety and improving standards of tree health management.

## MATERIALS AND METHODS

This study aimed to evaluate the health status and potential safety risks of commonly occurring tree species on the campus of National Ilan University. To achieve this, a systematic Visual Tree Assessment (VTA) was conducted in accordance with the criteria and procedures specified in the Taipei City Government's Tree Safety Assessment Form (version dated: September 6, 2024).

This study focused on representative and common tree species due to sampling and resource constraints. This focus does not suggest that the risks associated with less common or unrepresentative species were disregarded. Rather, the core objective was to validate a practical assessment methodology using these representative species. In future applications, this same method can be readily extended by campus management to other tree species, thereby expanding the scope and enabling comprehensive evaluation and management of safety risks of all campus trees.

Traditional tree safety assessments often focus on larger individuals. In contrast, this study adopted a more comprehensive sampling: any tree, regardless of its size, can pose a safety threat due to branch breakage or tree fall during extreme weather. Accordingly, our assessment included not only conventionally high-risk large trees, but also species with smaller diameter at breast height (DBH) or crown sizes, thereby providing a more comprehensive framework that accounts for all potential sources of risk.

### Study subjects and location

The assessment was carried out on the campus of National Ilan University and focused on ten representative and frequently observed tree species. A total of 150 trees

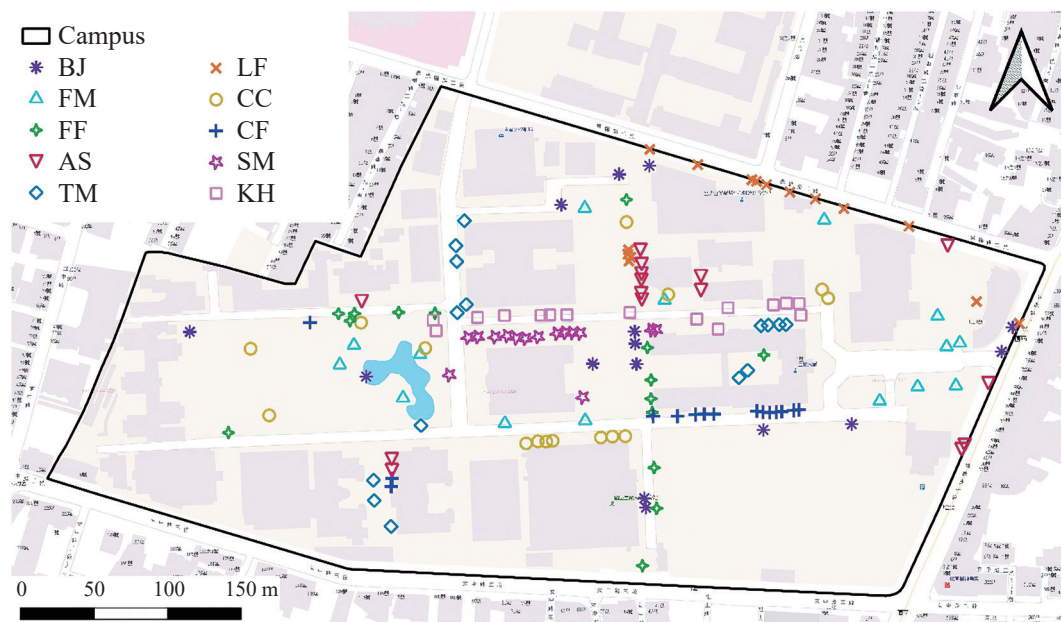
were assessed, with 15 individuals randomly selected for each species. The ten selected species, along with their scientific names and corresponding codes used throughout this study, are: *Bischofia javanica* Bl. (BJ), *Liquidambar formosana* Hance. (LF), *Ficus microcarpa* L.f. (FM), *Cinnamomum camphora* (L.) J. Presl (CC), *Fraxinus formosana* Hayata (FF), *Cassia fistula* L. (CF), *Alstonia scholaris* (L.) R. Br. (AS), *Sapindus mukorossi* Gaertn. (SM), *Terminalia mantalyi* H. Perrier. (TM), and *Koelreuteria henryi* Dummer. (KH) (Figure 1).

These species were selected based on their ecological significance, prevalence on campus, and representation of both native and commonly cultivated trees in subtropical

urban environments. The spatial distribution of all sampled trees is shown in Figure 1. Field investigations were conducted over a seven-month period, from December 2024 through June 2025.

### Method for tree health assessment and risk level classification

Although the Visual Tree Assessment (VTA) method is widely applied internationally, this study adopted the standardized evaluation form issued by the Taipei City Government, because it better aligns with Taiwan's local climate, common tree species characteristics, and the practical needs of urban green space management. This choice ensured contextual relevance and consistency



**Figure 1.** Campus tree survey map on National Ilan University campus

Notes:

<sup>1</sup> *Bischofia javanica* (BJ), *Liquidambar formosana* (LF), *Ficus microcarpa* (FM), *Cinnamomum camphora* (CC), *Fraxinus formosana* (FF), *Cassia fistula* (CF), *Alstonia scholaris* (AS), *Sapindus mukorossi* (SM), *Terminalia mantalyi* (TM), *Koelreuteria henryi* (KH)

<sup>2</sup> The base map is sourced from the National Land Surveying and Mapping Center's (NSLC) Web Map Tile Service WMTS service, which connects to a general electronic map of Taiwan (new version). URL: <https://wmts.nslc.gov.tw/wmts> date accessed: 2025/05/28.

with local policy frameworks. The form's practicality for diagnosing tree health, assessing environmental safety, and predicting overall tree safety risks was validated through field application.

The study systematically conducted visual health assessments for each campus tree surveyed, based on four key aspects outlined on the Taipei City Government's Tree Safety Assessment Form (version dated September 6, 2024). This form, whose principles are derived from the International Society of Arboriculture (ISA). This study also aims to determine if the form is suitable for use in the Yilan area. The assessment framework looks at the four aspects: crown, trunk, roots, and Habitat environment. Specific evaluation criteria include branch density, presence of biological hazards, root damage, and overall site conditions (Table 1). A scoring system was applied to quantify the severity of defects. Certain highrisk indicators were designated as critical factors. Trees exhibiting three or more critical factors were automatically classified as highrisk.

Tree health was categorized into three levels according to total scores and critical factor counts: Good ( $\leq 30$  points), Fair (31-45 points), and Poor ( $> 45$  points or  $\geq 3$  critical

factors). Additionally, trees meeting specific critical risk conditions were classified as Significant Hazard (Grade A) and designated for immediate remedial action. These conditions were:

- More than 80% of the tree crown shows wilting.
- Cavities extend deeper than two-thirds of the trunk's cross-sectional diameter, with openings larger than one-third of the circumference.
- Stem cracks reach depths equal to the stem diameter.
- Trees with trunk diameters over 30 cm can be swayed by manual force.
- Infection by brown root disease poses public safety concerns.
- Structural damage is diagnosed as irrecoverable.
- Trunk decay affects more than half of the cross-sectional area.

To account for the influence of site usage on safety risk, survey areas were classified into three environmental risk zones—High, Medium, and Low—based on the intensity and type of nearby human activity. Using the Comprehensive Tree Safety Assessment Matrix (Table 2), each tree was then assigned an overall risk level from Grade A to Grade D

**Table 1. Tree health assessment framework**

Assessed aspect	Items assessed (Excerpt)	Basis of scoring
Crown condition	Density of branches and leaves, leaf size, uniformity of branch growth, condition of unhealthy branches, live crown ratio (4 items)	Points deducted based on the severity of abnormal conditions
Trunk condition	Biological hazards, height-to-diameter ratio, tilt, trunk structure, main trunk damage, bark loss, types of damage, recovery after branch injury (8 items)	Evaluates structural integrity and symptomatic performance
Root condition	Sprouting, root collar coverage, girdling roots, unilateral protrusions or cracks, root decay, root injuries (6 items)	Focuses on belowground health
Habitat environment	Planting space, wind damage, soil condition, drainage (4 items)	Assesses external growth conditions

Data source: Taipei City Government "Tree Safety Assessment Form" (Version dated September 6, 2024).

according to its health status and environmental risk. This classification served as the basis for decision-making regarding follow-up treatment and maintenance strategies.

## RESULTS

Tree growth and location characteristics

Table 3 presents the average diameter, height, and crown width of the ten surveyed tree species on the campus of National Ilan University. The results revealed significant variations in growth form among the species. FM exhibited the largest average diameter (62.0 cm) and the widest crown (7.1 m), indicating a robust structure with a broadly spreading canopy. In contrast, AS reached the greatest average height (16.7 m) but had

a relatively narrow crown (3.8 m), reflecting a predominantly vertical growth habit. FF showed the smallest average diameter (17.1 cm), appearing more slender in form. These measurements provide a quantitative baseline for understanding the structural characteristics of the campus tree community and serve as a reference for subsequent analyses of tree health and risk.

Table 4 further summarizes the spatial distribution and tree pit types of the ten surveyed species. Species with a high proportion of individuals planted along sidewalks included BJ, LF, CC, AS and TM, each with over 50% of individuals in such locations. The predominant habitat for CF, (93.3%), SM, (53.3%) and KH (53.3%) was median strips. Regarding tree pit configurations

**Table 2. Comprehensive tree safety assessment matrix**

Health level (based on total deductions or critical factors)	Environmental public safety risk assessment	Comprehensive risk level
Good ( $\leq 30$ points)	Low / Medium / High	Grade D / D / D
Fair (31-45 points)	Low / Medium / High	Grade D / C / C
Poor ( $> 45$ points, or $\geq 3$ critical factors)	Low / Medium / High	Grade D / C / B
Meets major hazard conditions		Grade A (Major hazard)

Note: This matrix applies only to the risk level classification of non-major hazard trees. Risk level descriptions: Grade A—requires immediate action; Grade B—high risk, should be prioritized; Grade C—moderate risk, monitoring needed); Grade D—low risk, can be observed.

**Table 3. Tree species and their average diameter, height, and crown width**

Tree species	Diameter (cm)	Height (m)	Crown width (m)
BJ	48.8 (16.4)	10.0 (1.8)	5.3 (1.3)
LF	29.0 (7.1)	9.7 (3.5)	3.4 (0.8)
FM	62.0 (15.7)	8.3 (2.3)	7.1 (2.0)
CC	31.6 (12.8)	10.0 (4.9)	4.8 (2.0)
FF	17.1 (5.6)	9.5 (3.1)	3.1 (1.1)
CF	19.0 (3.8)	8.7(2.7)	3.8 (1.7)
AS	49.7 (18.4)	16.7 (3.1)	3.8 (1.3)
SM	22.3 (5.3)	10.7 (2.0)	3.8 (0.6)
TM	34.7 (8.8)	12.7 (2.4)	5.3 (1.8)
KH	20.9 (3.8)	7.4 (1.5)	3.6 (1.1)

Note: Values in parentheses indicate Standard deviation.

*Bischofia javanica* (BJ), *Liquidambar formosana* (LF), *Ficus microcarpa* (FM), *Cinnamomum camphora* (CC), *Fraxinus formosana* (FF), *Cassia fistula* (CF), *Alstonia scholaris* (AS), *Sapindus mukorossii* (SM), *Terminalia mantalyi* (TM), *Koelreuteria henryi* (KH).

**Table 4. Sampled number of tree species, their locations, and tree pit attributes locations (%)**

Tree species	Park	Square	Green space	Sidewalk	Median
BJ	0 (0.0)	3 (20.0)	1 (6.7)	10 (66.7)	1 (6.7)
LF	0 (0.0)	1 (6.7)	4 (26.7)	10 (66.7)	0 (0.0)
FM	0 (0.0)	2 (13.3)	4 (26.7)	7 (46.7)	2 (13.3)
CC	2 (13.3)	1 (6.7)	4 (26.7)	8 (53.3)	0 (0.0)
FF	0 (0.0)	4 (26.7)	1 (6.7)	6 (40.0)	4 (26.7)
CF	0 (0.0)	0 (0.00)	1 (6.7)	0 (0.0)	14 (93.3)
AS	0 (0.0)	1 (6.7)	3 (20.0)	8 (53.3)	3 (20.0)
SM	0 (0.0)	0 (0.00)	1 (6.7)	6 (40.0)	8 (53.3)
TM	0 (0.0)	2 (13.3)	0 (0.0)	10 (66.7)	3 (20.0)
KH	0 (0.0)	0 (0.0)	0 (0.0)	7 (46.7)	8 (53.3)

Tree pit attributes (%)

Tree species	Open area	Single tree pit	Linear tree pit	Flower bed
BJ	1 (6.7)	2 (13.3)	8 (53.3)	5 (33.3)
LF	4 (26.7)	10 (66.7)	1 (6.7)	0 (0.0)
FM	11 (73.3)	2 (13.3)	0 (0.0)	2 (13.3)
CC	7 (46.7)	0 (0.0)	5 (33.3)	3 (20.0)
FF	7 (46.7)	1 (6.7)	6 (40.0)	1 (6.7)
CF	0 (0.0)	0 (0.0)	6 (40.0)	9 (60.0)
AS	9 (60.0)	3 (20.0)	0 (0.0)	2 (13.3)
SM	1 (6.7)	3 (20.0)	11 (73.3)	0 (0.0)
TM	3 (20.0)	4 (26.7)	5 (33.3)	3 (20.0)
KH	0 (0.0)	0 (0.0)	15 (100.0)	0 (0.0)

Note: Values in parentheses indicate percentages (%).

(Table 4), KH (100%) and SM (73.3%) were primarily found in linear tree pits; FM (73.3%) and AS (60%) were mostly located in open spaces; whereas CF (60%) was mainly planted in flower beds. These spatial patterns reflect species-specific planting strategies adapted to landscape designs and environmental constraints, offering valuable insights into factors influencing tree growth and health.

### Tree health assessment

The health assessment of 15 BJ individuals revealed an Average total deduction score of 27.1 points, with one tree exhibiting three critical risk factors. The primary health issues were associated with Trunk conditions and Habitat environment.

Regarding the trunk, significant deductions were noted in the categories of Biological Hazards—86.7% of the trees had parasitic

plants, and 40% exhibited trunk cavities—along with Trunk Structure and Types of Bark Damage. Structural defects and decay symptoms were commonly observed across these aspects.

In terms of Habitat environment, notable problems included Soil Quality, where 60% of trees were planted in compacted soils and 13.3% in areas with hard surfaces; Wind Exposure, with 60% of trees situated in wind-prone locations; and Drainage Conditions, with 46.7% showing inadequate drainage. Additionally, decay at the junction of roots and trunk was observed in 53.3% of the trees, indicating a potential structural risk.

Overall, the main threats to BJ health were biological hazards within the trunk, structural defects, and unfavorable habitat conditions (Table 5).

**Table 5. Health assessment items for 15 *Bischofia javanica* (BJ) trees and total deduction scores**

Aspect	Item	D (SD)	Proportions
I	1	0.40 (0.83)	73.3% normal; 20.0% with 5-25% abnormal leaf volume; 6.7% with 25-50% abnormal leaf volume
	2	1.00 (1.13)	40.0% uniform growth; 40.0% with crown loss rate of 5-25%; 20.0% with crown loss rate of 25-50%
	3	1.20 (1.52)	60.0% none; 40.0% with unhealthy branches of diameter 5-10 cm
	4	0.47 (0.52)	Average about 54.0%, with 53.3% having a live crown greater than 50%; 46.7% having a live crown between 25%-50%
II	5	2.47 (2.17)	6.7% none; 86.7% with parasitic plants; 20.0% with galls; 40.0% with tree holes; 6.7% with abnormal sap flow or ulcers; 13.3% with termite tunnels
	6	0.00 (0.00)	Average about 22.7, with 100.0% tree height to DBH ratio < 50
	7	0.60 (1.24)	80.0% with trunk tilt less than 15° ; 20.0% with trunk tilt between 15° and 30°
	8	1.20 (1.61)	33.3% none; 53.3% with codominant stems and angles greater than 30° ; 13.3% with codominant stems and angles less than 30°
	9	2.53 (2.77)	40.0% none; 40.0% with swollen branches; 13.3% with significant swollen branches having cavities; 6.7% with large cavities in the main trunk or main branches
	10	0.80 (1.01)	46.7% no damage; 40.0% with bark damage area less than 5-30% of circumference; 13.3% with bark damage area between 31-60% of circumference
	11	3.00 (4.39)	60.0% none; 33.3% with damage; 13.3% with internal bark; 26.7% with abnormal swelling; 6.7% with longitudinal cracks
12	0.33 (0.82)	80.0% none or well recovered; 13.3% weakened recovery or regeneration; 6.7% unable to regenerate, deformities, wounds unable to heal, discoloration occurs	
III	13	0.20 (0.41)	80.0% no basal sprouts; 20.0% with sprouts
	14	1.20 (1.53)	60.0% no covering soil; 40.0% with covering soil greater than 10 cm
	15	1.20 (1.86)	60.0% none; 13.3% slight; 13.3% moderately severe; 13.3% severe
	16	1.33 (1.95)	46.7% none; 33.3% slight; 20.0% partial
	17	3.0 (3.16)	46.7% none; 46.7% with decay area occupying less than 25% of the circumference at that point; 6.7% with decay area occupying more than 25% of the circumference at that point
	18	0.5 (0.52)	53.3% none; 46.7% with obvious damage or removal of roots
IV	19	0.67 (1.8)	86.7% sufficient area; 13.3% insufficient area
	20	1.20 (1.0)	40.0% not significantly affected by wind; 60.0% in wind-swept areas
	21	2.47 (1.7)	26.7% normal; 60.0% compacted; 13.3% hard paved surface
	22	1.33 (1.28)	40.0% good; 46.7% poor; 13.3% severe water accumulation
ATD		27.07	

Note: I: Crown condition, II: Trunk condition, III: Root condition, IV: Habitat environment, D: Average deduction, SD: Standard deviation; ATD: Average total deduction.

One critical factor in one of the BJ trees reached 3 items.

The health assessment of 15 LF individuals revealed an Average total deduction score of 24.8 points, indicating an overall fair condition. In the crown assessment, significant deductions were noted for the uniformity of branch growth and crown defect rate, with 46.7% of trees exhibiting uneven branch development and 20% exhibiting crown defects affecting 5-25% of the canopy, 26.7% showing crown defects affecting 25-50%, and 50% showing crown defects affecting more than 50%. Additionally, 60% of the trees had unhealthy branches ranging from 5 to 10 cm in diameter.

Regarding Trunk conditions, all individuals (100%) were affected by parasitic plants. Notable issues were observed in types of bark damage, with 33.3% of trees showing visible bark damage and 20% exhibiting endogenous bark. Furthermore, 20% of the trunks were tilted between 15 and 30 degrees, indicating potential structural instability.

Root-related problems primarily involved basal suckers, present in 60% of the trees, and root decay, which affected nearly 40% of individuals.

The Habitat environment also posed considerable challenges. Specifically, soil quality was poor for the majority of trees: 80% were planted in compacted soils and 20% in areas with hard surfaces. Wind exposure was a concern for 80% of the trees, and 53.3% were growing in spaces with insufficient soil volume for healthy root development. These environmental conditions highlight the need for urgent management and improvement (Table 6).

The health assessment of 15 FM individuals revealed an Average total deduction score of 30.8 points—the highest among all surveyed species—with two trees exhibiting three critical risk factors. Severe issues were identified in the trunk, particularly under

Biological Hazards: 100% of the trees had parasitic plants, 40% exhibited trunk cavities, and 13.3% showed signs of fungal infection. Additionally, 53.3% had bark damage, including endogenous bark and visible cracking. Several trunks also displayed tilting, raising further structural concerns.

Root-related problems were notably severe, with 66.7% of the trees affected by decay at the junction of roots and trunk, resulting in an average score of 4.7—indicating a high risk level. Some trees also showed evidence of mechanical root damage. In the crown, 20% of the trees had unhealthy branches larger than 10 cm in diameter, contributing to deductions in overall Crown condition.

Regarding Habitat environment, 93.3% of the trees grew in compacted soil, and 33.3% experienced poor drainage and water accumulation.

Overall, the health condition of FM is concerning, with primary issues including root decay, biological hazards in the trunk, and bark damage—all exacerbated by a deteriorating soil environment (Table 7).

The health assessment of 15 CC individuals revealed an Average total deduction score of 27.7 points, indicating moderate health issues. In the crown assessment, a major concern was the condition of unhealthy branches, with 86.7% of trees exhibiting branches measuring 5–10 cm in diameter and 33.3% having unhealthy branches larger than 10 cm.

Regarding the trunk, notable issues included types of bark damage: 40% of the trees showed signs of bark damage, and 26.7% presented endogenous bark or swelling. Biological hazards were also widespread, with 93.3% of the trees hosting parasitic plants. Some individuals additionally exhibited trunk cavities or fungal infections.

**Table 6. Health Assessment for 15 Trees of *Liquidambar formosana* (LF)**

Aspect	Item	D (SD)	Proportions
I	1	0.1 (0.3)	94% normal; 6.7% with 5-25% abnormal leaf volume
	2	1.3 (1.6)	46.7% uniform growth; 20.0% with crown loss rate of 5-25%; 26.7% with crown loss rate of 25-50%; 6.7% with crown loss rate greater than 50%
	3	1.8 (1.5)	40.0% none; 60.0% with unhealthy branches of diameter 5-10 cm
	4	0.3 (0.5)	Average about 60.3%, with 73.3% having a live crown greater than 50%; 26.7% having a live crown between 25%-50%
II	5	1.1 (0.4)	100.0% with parasitic plants; 13.3% with tree holes
	6	0.1 (0.3)	Average about 33.4, with 93.3% tree height to DBH ratio < 50; 6.7% with 50 ≤ tree height to DBH ratio < 90
	7	1.1 (1.9)	73.3% with trunk tilt less than 15° ; 13.3% with trunk tilt between 15° and 30° ; 13.3% with trunk tilt greater than 30°
	8	0.8 (1.7)	73.3% none; 13.3% with codominant stems and angles greater than 30° ; 13.3% with codominant stems and angles less than 30°
	9	0.4 (1.1)	86.7% with swollen branches; 13.3% with significant swollen branches having cavities
	10	0.5 (0.8)	66.7% no damage; 26.7% with bark damage area less than 5-30% of circumference; 6.7% with bark damage area between 31-60% of circumference
	11	2.3 (3.8)	60.0% none; 33.3% with damage; 20.0% with internal bark; 6.7% with abnormal cracking; 13.3% with abnormal swelling
	12	0.2 (0.4)	80.0% none or well recovered; 20.0% weakened recovery or regeneration
III	13	2.0 (1.3)	20.0% no basal sprouts; 20.0% with sprouts; 60.0% with abundant sprouts
	14	0.4 (1.1)	86.7% no covering soil; 13.3% with covering soil greater than 10 cm
	15	0.4 (1.1)	86.7% none; 13.3% slightly severe
	16	0.1 (0.4)	86.7% none; 13.3% slight
	17	2.3 (3.2)	60.0% none; 33.3% with decay area occupying less than 25% of the circumference at that point; 6.7% with decay area occupying more than 25% of the circumference at that point
	18	0.1 (0.4)	86.7% none; 13.3% with obvious damage or removal of roots
IV	19	2.7 (2.6)	46.7% sufficient area; 53.3% insufficient area
	20	1.6 (0.8)	20.0% not significantly affected by wind; 80.0% in wind-swept areas
	21	3.4 (0.8)	80.0% compacted; 20.0% hard paved surface
	22	1.8 (1.1)	20.0% good; 60.0% poor; 20.0% severe water accumulation
ATD		24.8	

Note: I: Crown condition, II: Trunk condition, III: Root condition, IV: Habitat environment, D: Average deduction, SD: Standard deviation; ATD: Average total deduction.

**Table 7. Health Assessment for 15 Trees of *Ficus microcarpa* (FM)**

Aspect	Item	D (SD)	Proportions
I	1	0.8 (1.4)	60.0% normal; 26.7% with 5-25% abnormal leaf volume; 6.7% with 25-50% abnormal leaf volume; 6.7% with greater than 50% abnormal leaf volume
	2	1.5 (1.7)	46.7% uniform growth; 13.3% with crown loss rate of 5-25%; 33.3% with crown loss rate of 25-50%; 6.7% with crown loss rate greater than 50%
	3	2.2 (3.2)	40.0% none; 40.0% with unhealthy branches of diameter 5-10 cm; 20.0% with unhealthy branches greater than 10 cm
	4	0.6 (0.5)	Average about 52.78%, with 40.0% having a live crown greater than 50%; 60.0% having a live crown between 25%-50%
II	5	3.2 (3.9)	100.0% with parasitic plants; 13.3% with galls; 40.0% with tree holes; 6.7% with abnormal sap flow or ulcers; 13.3% with fungi (fruiting bodies)
	6	0.0 (0.0)	Average about 13.7, with 100.0% tree height to DBH ratio < 50
	7	1.5 (2.0)	60.0% with trunk tilt less than 15° ; 26.7% with trunk tilt between 15° and 30° ; 13.3% with trunk tilt greater than 30°
	8	1.3 (1.5)	20.0% none; 66.7% with codominant stems and angles greater than 30° ; 13.3% with codominant stems and angles less than 30°
	9	1.7 (2.0)	53.3% none; 33.3% with swollen branches; 13.3% with significant swollen branches having cavities
	10	1.0 (1.4)	40.0% no damage; 46.7% with bark damage area less than 5-30% of circumference; 6.7% with bark damage area between 31-60%; 6.7% with bark damage area greater than 61% of circumference
	11	3.5 (5.6)	46.7% none; 53.3% with damage; 13.3% with internal bark; 13.3% with abnormal cracking; 6.7% with abnormal swelling; 13.3% with longitudinal cracks
	12	0.7 (1.0)	53.3% none or well recovered; 33.3% with weakened recovery or regeneration; 13.3% unable to regenerate, deformities, wounds unable to heal, discoloration occurs
III	13	1.0 (1.3)	53.3% no basal sprouts; 20.0% with sprouts; 26.7% with abundant sprouts
	14	0.2 (0.8)	93.3% no covering soil; 6.7% with covering soil greater than 10 cm
	15	1.1 (1.3)	40.0% none; 33.3% slight; 26.7% moderately severe
	16	0.3 (0.5)	73.3% none; 26.7% slight
	17	4.7 (3.0)	20.0% none; 66.7% with decay area occupying less than 25% of the circumference at that point; 13.3% with decay area occupying more than 25% of the circumference at that point
	18	0.4 (0.5)	60.0% none; 40.0% with obvious damage or removal of roots
IV	19	0.0 (0.0)	100.0% sufficient area
	20	0.8 (1.0)	60.0% not significantly affected by wind; 40.0% in wind-swept areas
	21	2.8 (0.8)	6.7% normal; 93.3% compacted
	22	1.5 (1.4)	40.0% good; 26.7% poor; 33.3% severe water accumulation
ATD		30.8	

Note: I: Crown condition, II: Trunk condition, III: Root condition, IV: Habitat environment, D: Average deduction, SD: Standard deviation; ATD: Average total deduction.

One critical factor in two of the FM trees reached 3 items.

Root-related problems mainly involved basal suckers, present in 33.3% of the trees, and root damage, affecting 60% of individuals.

Concerning the Habitat environment, 93.3% of the trees were planted in compacted soils, 73.3% were situated in wind-exposed areas, and 40% experienced poor drainage and water accumulation.

Overall, the health of CC was compromised by unhealthy branches, trunk bark damage, and environmental stresses from degraded soil conditions, underscoring the need for targeted management and improvements (Table 8).

The health assessment of 15 FF individuals revealed an Average total deduction score of 29.4 points, indicating a below-average health condition. In the crown, notable issues included the condition of unhealthy branches, with 66.7% of trees exhibiting branches measuring 5-10 cm in diameter and 13.3% having branches larger than 10 cm. Additionally, crown defects were prevalent, with 40% of trees showing defects covering 5-25% of the crown and another 40% exhibiting defects affecting 25-50%.

The trunk exhibited the most severe deductions, particularly in types of bark damage, which received an average score of 5.5 due to the widespread presence of diverse and severe bark defects. Structural issues were also evident, with 20% of the trees displaying trunk lean angles less than 30°. Biological hazards, including parasitic plants (60%), trunk cavities (20%), and fungal infections (6.7%), further contributed to the high deduction scores.

Root health concerns centered on decay at the junction of roots and trunk, with 13.3% of trees showing decay exceeding 25%, posing a potential hazard.

Regarding the Habitat environment,

all trees (100%) were planted in compacted soils, 73.3% were located in wind-exposed areas, and 66.7% experienced poor drainage conditions, indicating significant environmental stress.

Overall, the health issues in FF were primarily concentrated in trunk damage and structural weaknesses, which were severely exacerbated by adverse habitat conditions (Table 9).

The health assessment of 15 CF individuals revealed an Average total deduction score of 44.3 points—the highest among all surveyed species—with multiple trees exhibiting three to five critical risk factors, indicating extremely poor health. The most severe problems were concentrated in the trunk, where types of bark damage received an average score of 12.3; all trees (100%) showed various severe bark defects. Biological hazards were also prominent, with 73.3% of trees hosting parasitic plants, 33.3% affected by gummosis or ulcers, and 6.7% exhibiting fungal infections.

The roots presented critical weaknesses, particularly at the junction of roots and trunk, where decay had an average score of 8.7 and 73.3% of trees showed decay exceeding 25%, substantially increasing the risk of tree failure or toppling.

In the crown, leaf quantity was mostly abnormal, and the condition of unhealthy branches was notable, with 53.3% of trees having unhealthy branches measuring 5-10 cm in diameter and 26.8% having branches larger than 10 cm.

Although the Habitat environment provided sufficient planting area, 73.3% of the trees were growing in compacted soils, and 66.7% experienced poor drainage conditions.

Overall, the health condition of CF was critically poor, demanding immediate intervention and management (Table 10).

**Table 8. Health assessment for 15 trees of *Cinnamomum camphora* (CC)**

Aspect	Item	D (SD)	Proportions
I	1	0.7 (0.8)	46.7% normal; 46.7% with 5-25% abnormal leaf volume; 6.7% with 25-50% abnormal leaf volume
	2	1.1 (1.1)	33.3% uniform growth; 46.7% with crown loss rate of 5-25%; 20.0% with crown loss rate of 25-50%
	3	4.3 (2.9)	86.7% with unhealthy branches of diameter 5-10 cm; 33.3% with unhealthy branches greater than 10 cm
	4	0.7 (0.5)	Average about 49.1%, with 33.3% having a live crown greater than 50%; 66.7% having a live crown between 25%-50%
II	5	1.7 (2.9)	6.7% none; 93.3% with parasitic plants; 13.3% with tree holes; 6.7% with fungi (fruiting bodies)
	6	0.1 (0.3)	Average about 31.9, with 93.3% tree height to DBH ratio < 50; 6.7% with 50 ≤ tree height to DBH ratio < 90
	7	1.3 (1.9)	66.7% with trunk tilt less than 15° ; 20.0% with trunk tilt between 15° and 30° ; 13.3% with trunk tilt greater than 30°
	8	0.5 (0.5)	53.3% none; 46.7% with codominant stems and angles greater than 30°
	9	0.8 (1.4)	73.3% none; 26.7% with swollen branches
	10	0.5 (0.5)	46.7% no damage; 53.3% with bark damage area less than 5-30% of circumference
	11	3.4 (5.1)	53.3% none; 40.0% with damage; 26.7% with internal bark; 6.7% with abnormal cracking; 26.7% with abnormal swelling
	12	0.8 (1.2)	60.0% none or well recovered; 20.0% with weakened recovery or regeneration; 20.0% unable to regenerate, deformities, wounds unable to heal, discoloration occurs
III	13	1.3 (1.3)	40.0% no basal sprouts; 26.7% with sprouts; 33.3% with abundant sprouts
	14	0.0 (0.0)	100.0% no covering soil
	15	1.3 (1.8)	46.7% none; 26.7% slight; 13.3% moderately severe; 13.3% severe
	16	0.6 (1.3)	66.7% none; 26.7% slight; 6.7% partial
	17	2.0 (2.5)	6.0% none; 40.0% with decay area occupying less than 25% of the circumference at that point
	18	0.6 (0.5)	40.0% none; 60.0% with obvious damage or removal of roots
IV	19	0.0 (0.0)	100.0% sufficient area
	20	1.5 (0.9)	26.7% not significantly affected by wind; 73.3% in wind-swept areas
	21	2.8 (0.8)	6.7% normal; 93.3% compacted
	22	1.9 (1.3)	26.7% good; 33.3% poor; 40.0% severe water accumulation
ATD		27.7	

Note: I: Crown condition, II: Trunk condition, III: Root condition, IV: Habitat environment, D: Average deduction, SD: Standard deviation; ATD: Average total deduction.

**Table 9. Health assessment for 15 trees of *Fraxinus formosana* (FF)**

Aspect	Item	D (SD)	Proportions
I	1	0.8 (1.0)	46.7% normal; 40.0% with 5-25% abnormal leaf volume; 13.3% with 25-50% abnormal leaf volume
	2	1.6 (1.2)	20.0% uniform growth; 40.0% with crown loss rate of 5-25%; 40.0% with crown loss rate of 25-50%
	3	2.7 (2.1)	66.7% with unhealthy branches of diameter 5-10 cm; 13.3% with unhealthy branches greater than 10 cm
	4	0.7 (0.5)	Average about 49.1%, with 33.3% having a live crown greater than 50%; 66.7% having a live crown between 25%-50%
II	5	1.9 (3.1)	13.3% none; 60.0% with parasitic plants; 6.7% with galls; 20.0% with tree holes; 6.7% with abnormal sap flow or ulcers; 6.7% with fungi (fruiting bodies)
	6	0.6 (0.5)	Average about 57.2, with 40.0% tree height to DBH ratio < 50; 60.0% with 50 ≤ tree height to DBH ratio < 90
	7	1.5 (1.8)	53.3% with trunk tilt less than 15° ; 40.0% with trunk tilt between 15° and 30° ; 6.7% with trunk tilt greater than 30°
	8	1.7 (1.8)	13.3% none; 66.7% with codominant stems and angles greater than 30° ; 20.0% with codominant stems and angles less than 30°
	9	1.1 (1.9)	73.3% none; 13.3% with swollen branches; 13.3% with significantly swollen branches having cavities
	10	1.3 (1.3)	40.0% no damage; 26.7% with bark damage area less than 5-30% of circumference; 33.3% with bark damage area between 31-60% of circumference
	11	5.5 (5.5)	60.0% none; 13.3% with damage; 33.3% with internal bark; 6.7% with abnormal cracking; 13.3% with abnormal swelling; 26.7% with longitudinal cracks
	12	0.1 (0.3)	93.3% none or well recovered; 6.7% with weakened recovery or regeneration
III	13	0.1 (0.3)	93.3% no basal sprouts; 6.7% with sprouts
	14	0.4 (1.1)	86.7% no covering soil; 13.3% with covering soil greater than 10 cm
	15	0.4 (1.1)	86.7% none; 13.3% slightly severe
	16	0.5 (1.3)	73.3% none; 20.0% slight; 6.7% partial
	17	2.0 (3.7)	73.3% none; 13.3% with decay area occupying less than 25% of the circumference at that point; 13.3% with decay area occupying more than 25% of the circumference at that point
	18	0.1 (0.4)	86.7% none; 13.3% with obvious damage or removal of roots
IV	19	0.3 (1.3)	93.3% sufficient area; 6.7% insufficient area
	20	1.5 (0.0)	26.7% not significantly affected by wind; 73.3% in wind-swept areas
	21	3.0(0.0)	100.0% compacted
	22	1.7 (1.0)	20.0% good; 66.7% poor; 13.3% severe water accumulation
ATD		29.4	

Note: I: Crown condition, II: Trunk condition, III: Root condition, IV: Habitat environment, D: Average deduction, SD: Standard deviation; ATD: Average total deduction.

**Table 10. Health assessment for 15 trees of *Cassia fistula* (CF)**

Aspect	Item	D (SD)	Proportions
I	1	1.7 (1.5)	20.0% normal; 40.0% with 5-25% abnormal leaf volume; 33.3% with 25-50% abnormal leaf volume; 6.7% with more than 50% abnormal leaf volume
	2	1.3 (1.5)	40.0% uniform growth; 33.3% with crown loss rate of 5-25%; 20.0% with crown loss rate of 25-50%; 6.7% with crown loss rate greater than 50%
	3	2.9 (2.7)	20.0% none; 53.3% with unhealthy branches of diameter 5-10 cm; 26.7% with unhealthy branches greater than 10 cm
	4	1.1 (0.6)	Average about 40.80%, with 6.7% having a live crown greater than 50%; 86.7% having a live crown between 25%-50%; 6.7% with crown loss rate greater than 50%
II	5	3.3 (4.2)	13.3% none; 73.3% with parasitic plants; 20.0% with tree holes; 33.3% with abnormal sap flow or ulcers; 6.7% with fungi (fruiting bodies)
	6	0.3 (0.5)	Average about 46.2, with 73.3% tree height to DBH ratio < 50; 26.7% with 50 ≤ tree height to DBH ratio < 90
	7	1.5 (2.0)	60.0% with trunk tilt less than 15° ; 26.7% with trunk tilt between 15° and 30° ; 13.3% with trunk tilt greater than 30°
	8	0.3 (0.5)	66.7% none; 33.3% with codominant stems and angles greater than 30°
	9	1.6 (1.6)	46.7% none; 53.3% with swollen branches
	10	1.5 (0.9)	73.3% with bark damage area less than 5-30% of circumference; 26.7% with bark damage area between 31-60% of circumference
	11	12.3 (6.4)	100.0% damaged; 13.3% with internal bark; 26.7% with abnormal cracking; 13.3% with abnormal swelling; 20.0% with horizontal cracks; 66.7% with longitudinal cracks
	12	1.8 (2.0)	40.0% none or well recovered; 20.0% with weakened recovery or regeneration; 20.0% unable to regenerate, deformities, wounds unable to heal, discoloration occurs; 20.0% with wound diameter between 10 cm and 20 cm, unable to heal leading to decay
III	13	0.2 (0.8)	93.3% no basal sprouts; 6.7% with abundant sprouts
	14	0.0 (0.0)	100.0% no covering soil
	15	0.1 (0.4)	86.7% none; 13.3% slight
	16	0.8 (2.6)	80.0% none; 13.3% slight; 6.7% severe
	17	8.7 (3.0)	6.7% none; 13.3% with decay area occupying less than 25% of the circumference at that point; 73.3% with decay area occupying more than 25% of the circumference at that point; 6.7% with fungi (fruiting bodies)
	18	0.4 (0.5)	60.0% none; 40.0% with obvious damage or removal of roots
IV	19	0.0 (0.0)	100.0% sufficient area
	20	0.9 (1.0)	53.3% not significantly affected by wind; 46.7% in wind-swept areas
	21	2.2 (1.4)	26.7% normal; 73.3% compacted
	22	1.3 (1.0)	33.3% good; 66.7% poor
ATD		44.3	

Note: I: Crown condition, II: Trunk condition, III: Root condition, IV: Habitat environment, D: Average deduction, SD: Standard deviation; ATD: Average total deduction.

Two of the *Cassia fistula* trees had three critical factors; two had four factors; and one had five factors.

The health assessment of 15 AS individuals revealed an Average total deduction score of 29.5 points, indicating moderate health issues. In the trunk, prominent problems included types of bark damage, with 53.3% of the trees exhibiting bark damage and 53.3% showing endogenous bark. Structural concerns were also significant, as 53.3% of the trees displayed trunk lean angles less than 30°, suggesting a high-risk condition. All trees were infested with parasitic plants.

The Habitat environment was a major contributing factor, with severe issues in soil quality—93.3% of trees were growing in compacted soil—and drainage conditions, which were poor for all trees (100%). Additionally, 66.7% of the trees were located in wind-prone areas.

In the crown, a general prevalence of reduced leaf quantity and unhealthy branches was observed. Root health also required attention, with 40% of trees exhibiting slight issues and 26.7% showing moderately severe problems in Root condition. Furthermore, nearly 60% of the trees showed decay at the junction of roots and trunk.

Overall, the health of AS was compromised by trunk damage, poor structural stability, and adverse environmental pressures, underscoring the need for enhanced monitoring and management (Table 11).

The health assessment of 15 SM individuals revealed an Average total deduction score of 50.5 points—the highest among all surveyed species—with multiple trees exhibiting three to four critical risk factors, indicating extremely poor health. The most severe problems were concentrated in the trunk, where types of bark damage received an average score of 16.6; 93.3% of the trees exhibited various severe bark defects causing extensive damage.

Biological hazards were also significant,

with 73.3% of the trees hosting parasitic plants and 40% showing fungal infections. Issues with trunk structure were prevalent, with 73.3% of trees having lean angles greater than 30°, and some exhibiting decay and cracks.

Root health presented a critical weakness, particularly decay at the junction of roots and trunk, which had an average score of 8.0 and was observed in 73.3% of trees with decay exceeding 25%, posing a very high risk of failure or toppling.

Regarding the Habitat environment, 93.3% of the trees were located in wind-exposed areas, 80% were growing in compacted soils, 13.3% were planted on hard surfaces, and 66.7% experienced poor drainage conditions, indicating substantial environmental stress.

Overall, the health condition of SM was critical and demanded immediate intervention (Table 12).

The health assessment of 15 TM individuals revealed an Average total deduction score of 33.7 points, indicating poor health. Significant issues were observed in the trunk, with types of bark damage receiving an average score of 6.3, reflecting widespread severe defects. Biological hazards were prevalent, with 86.7% of trees hosting parasitic plants and 20% exhibiting trunk cavities. Additionally, trunk tilting was notable, with 40% of the trees leaning between 15 and 30 degrees, and 13.3% tilted over 30 degrees.

Root conditions also raised concerns, as 40% of the trees showed abnormal growth of lateral roots, and 60% exhibited decay at the junction of roots and trunk, both requiring attention.

The Habitat environment posed significant stress, with all trees (100%) growing in compacted soil and 86.7% experiencing poor drainage conditions.

**Table 11. Health assessment for 15 trees of *Alstonia scholaris* (AS)**

Aspect	Item	D (SD)	Proportions
I	1	1.4 (1.6)	40.0% normal; 26.7% with 5-25% abnormal leaf volume; 26.7% with 25-50% abnormal leaf volume; 6.7% with more than 50% abnormal leaf volume
	2	0.8 (1.2)	60.0% uniform growth; 20.0% with crown loss rate of 5-25%; 20.0% with crown loss rate of 25-50%
	3	2.7 (1.2)	13.3% none; 80.0% with unhealthy branches of diameter 5-10 cm; 6.7% with unhealthy branches greater than 10 cm
	4	0.7 (0.8)	Average about 49.8%, with 46.7% having a live crown greater than 50%; 46.7% having a live crown between 25%-50%; 6.7% with crown loss rate greater than 50%
II	5	1.4 (1.3)	100.0% with parasitic plants; 66.7% with galls; 6.7% with abnormal sap flow or ulcers
	6	0.2 (0.4)	Average about 36.7, with 80.0% tree height to DBH ratio < 50; 20.0% with 50 ≤ tree height to DBH ratio < 90
	7	0.5 (1.5)	86.7% with trunk tilt less than 15° ; 6.7% with trunk tilt between 15° and 30° ; 6.7% with trunk tilt greater than 30°
	8	2.7 (2.6)	46.7% none; 53.3% with codominant stems and angles less than 30°
	9	0.0 (0.0)	100.0% none
	10	0.5 (0.8)	66.7% no damage; 26.7% with bark damage area less than 5-30% of circumference; 6.7% with bark damage area between 31-60% of circumference
	11	5.5 (6.5)	26.7% none; 53.3% damaged; 53.3% with internal bark; 6.7% with abnormal swelling; 6.7% with horizontal cracks; 13.3% with longitudinal cracks
	12	0.3 (0.8)	86.7% none or well recovered; 6.7% with weakened recovery or regeneration; 6.7% unable to regenerate, deformities, wounds unable to heal, discoloration occurs
III	13	0.0 (0.0)	100.0% no basal sprouts
	14	0.0 (0.0)	100.0% no covering soil
	15	1.5 (1.5)	26.7% none; 40.0% slight; 26.7% moderate; 6.7% severe
	16	0.4 (1.3)	86.7% none; 6.7% slight; 6.7% partial
	17	3.3 (3.1)	40.0% none; 53.3% with decay area occupying less than 25% of the circumference at that point; 6.7% with decay area occupying more than 25% of the circumference at that point
	18	0.5 (0.5)	53.3% none; 46.7% with obvious damage or removal of roots
IV	19	0.7 (1.8)	86.7% sufficient area; 13.3% insufficient area
	20	1.3 (1.0)	33.3% not significantly affected by wind; 66.7% in wind-swept areas
	21	3.1 (0.5)	93.3% compacted; 6.7% hard surface
	22	2.0 (0.0)	100.0% poor
ATD		29.5	

Note: I: Crown condition, II: Trunk condition, III: Root condition, IV: Habitat environment, D: Average deduction, SD: Standard deviation; ATD: Average total deduction.

**Table 12. Health Assessment for 15 Trees of *Sapindus mukorossi* (SM)**

Aspect	Item	D (SD)	Proportions
I	1	0.8 (0.8)	33.3% normal; 60.0% with 5-25% abnormal leaf volume; 6.7% with 25-50% abnormal leaf volume
	2	0.5 (1.1)	73.3% uniform growth; 13.3% with crown loss rate of 5-25%; 13.3% with crown loss rate of 25-50%
	3	0.8 (1.4)	73.3% none; 26.7% with unhealthy branches of diameter 5-10 cm
	4	1.0 (0.7)	Average about 38.6%, with 13.3% having a live crown greater than 50%; 80.0% having a live crown between 25%-50%; 6.7% with crown loss rate greater than 50%
II	5	5.3 (5.3)	20.0% none; 73.3% with parasitic plants; 6.7% with galls; 13.3% with tree holes; 6.7% with termite tunnels; 40.0% with fungi (fruiting bodies)
	6	0.5 (0.5)	Average about 49.7, with 53.3% tree height to DBH ratio < 50; 46.7% with 50 ≤ tree height to DBH ratio < 90
	7	0.9 (1.7)	73.3% with trunk tilt less than 15°; 20.0% with trunk tilt between 15° and 30°; 6.7% with trunk tilt greater than 30°
	8	2.1 (2.6)	6.7% none; 73.3% with codominant stems and angles greater than 30°; 13.3% with codominant stems and angles less than 30°; 6.7% with codominant stems with decay or cracks
	9	1.9 (2.7)	53.3% none; 40.0% with swollen branches; 6.7% with large cavities in the trunk or main branches
	10	0.9 (1.2)	33.3% no damage; 60.0% with bark damage area less than 5-30% of circumference; 6.7% with bark damage area greater than 61% of circumference
	11	16.6 (6.1)	93.3% damaged; 86.7% with internal bark; 20.0% with abnormal cracking; 20.0% with abnormal swelling; 73.3% with horizontal cracks; 20.0% with longitudinal cracks
	12	0.7 (2.6)	93.3% none or well recovered; 6.7% with wounds greater than 20 cm in diameter that cannot heal, leading to decay
III	13	0.0 (0.0)	100.0% no basal sprouts
	14	0.0 (0.0)	100.0% no covering soil
	15	2.1 (1.6)	13.3% none; 40.0% slight; 33.3% moderate; 13.3% severe
	16	0.3 (0.5)	66.7% none; 33.3% slight
	17	8.0 (3.7)	13.3% none; 13.3% with decay area occupying less than 25% of the circumference at that point; 73.3% with decay area occupying more than 25% of the circumference at that point
	18	0.7 (0.5)	26.7% none; 73.3% with obvious damage or removal of roots
IV	19	1.0 (2.1)	80.0% sufficient area; 20.0% insufficient area
	20	1.9 (0.5)	6.7% not significantly affected by wind; 93.3% in wind-swept areas
	21	3.1 (1.1)	6.7% normal; 80.0% compacted; 13.3% hard surface
	22	1.5 (1.0)	26.7% good; 66.7% poor; 6.7% with severe water accumulation
ATD		50.5	

Note: I: Crown condition, II: Trunk condition, III: Root condition, IV: Habitat environment, D: Average deduction, SD: Standard deviation; ATD: Average total deduction.

Four of the SM trees had three critical factors; four had four critical factors.

The crown exhibited a high prevalence of unhealthy branches and defects.

Overall, the health of TM was adversely affected by trunk damage, tilting, root abnormalities, and poor habitat conditions, indicating a high risk of structural instability and decline (Table 13).

The health assessment of 15 KH individuals revealed an Average total deduction score of 27.6 points, indicating moderate health issues. Major problems in the trunk included biological hazards, with 93.3% of trees hosting parasitic plants, 46.7% exhibiting trunk cavities, and 13.3% showing signs of fungal infections. Additionally, trunk tilting was significant, with 40% of trees leaning between 15 and 30 degrees, and 20% tilted over 30 degrees. Structural concerns were also prominent, as 46.7% of trees showed trunk lean angles less than 30 degrees.

Regarding the Habitat environment, all trees (100%) were growing in compacted soil, and 86.7% were located in wind-exposed areas, indicating high environmental stress.

Crown defects and unhealthy branches were common, and the live crown ratio averaged 29.6%, the lowest among all surveyed species. In the roots, 40% of the trees exhibited decay at the junction of roots and trunk, and 60% showed root damage, both requiring attention.

Overall, the health of KH was influenced by multiple factors, underscoring the need for targeted pruning, structural support, and soil improvement (Table 14).

Table 15 summarizes the average and total deduction scores across four assessed aspects—crown, trunk, roots, and Habitat environment—for the ten surveyed tree species. SM had the highest total score of 50.5 points, followed by CF with 44.3 points and TM with 33.7 points, indicating the poorest health

conditions among these species. LF recorded the lowest Average total deduction of 24.80 points, reflecting relatively better health.

For trunk deductions were highest for SM (28.8 points) and CF (22.6 points), indicating severe problems related to trunk pests, decay, or structural damage. Root deductions were also highest for SM (11.1 points) and CF (10.2 points), demonstrating extremely high health risks within their root systems.

Crown deductions were greatest for CF (7.0 points), CC (6.7 points), and FF (5.7 points), indicating poor branch structure and health.

Regarding the Habitat environment, LF (9.5 points), SM (7.5 points), and AS (7.1 points) had the highest deductions, reflecting common issues such as soil compaction, wind exposure, and poor drainage.

The comprehensive assessment indicates that SM and CF exhibit the poorest health and should be prioritized for monitoring and management interventions. In contrast, LF, BJ, KH demonstrated overall better health conditions, although some specific areas still require attention and enhanced management.

### **Tree health and safety assessment proportions (%)**

Table 16 categorizes the health of ten tree species into four levels: Good, Fair, Poor, and Grade A (Major Hazard). BJ, LF and CC had the highest proportions of “Good” health individuals at 66.7%. In contrast, SM had no trees rated as “Good,” with 67.7% rated as “Poor” and 6.7% as Grade A, showing the worst health condition. CF, TM, and KH also had some individuals classified as Grade A.

The notes to Table 16 also highlight severe defects in Grade A trees, such as extensive trunk decay in CF, irreparable structural damage with deep cracks in SM

**Table 13. Health assessment for 15 trees of *Terminalia mantalyi* (TM)**

Aspect	Item	D (SD)	Proportions
I	1	0.5 (0.8)	66.7% normal; 26.7% with 5-25% abnormal leaf volume
	2	1.0 (1.1)	40.0% uniform growth; 40.0% with crown loss rate of 5-25%; 20.0% with crown loss rate of 25-50%
	3	2.1 (2.2)	33.3% none; 60.0% with unhealthy branches of diameter 5-10 cm; 6.7% with unhealthy branches greater than 10 cm
	4	0.9 (1.0)	Average about 46.00%, with 40.0% having a live crown greater than 50%; 46.7% having a live crown between 25%-50%; 13.3% with crown loss rate greater than 50%
II	5	2.1 (2.1)	13.3% none; 86.7% with parasitic plants; 6.7% with galls; 20.0% with tree holes; 13.3% with abnormal sap flow or ulcers; 6.7% with termite tunnels
	6	0.1 (0.4)	Average about 37.9, with 86.7% tree height to DBH ratio < 50; 13.3% with 50 ≤ tree height to DBH ratio < 90
	7	1.9 (1.9)	46.7% with trunk tilt less than 15° ; 40.0% with trunk tilt between 15° and 30° ; 13.3% with trunk tilt greater than 30°
	8	1.3 (2.3)	73.3% none; 26.7% with codominant stems and angles less than 30°
	9	1.6 (2.9)	66.7% none; 20.0% with swollen branches; 6.7% with obvious swelling and cavities; 6.7% with large cavities in the trunk or main branches
	10	0.6 (0.5)	40.0% no damage; 60.0% with bark damage area less than 5-30% of circumference
	11	6.3 (5.8)	13.3% none; 66.7% damaged; 26.7% with internal bark; 13.3% with abnormal cracking; 20.0% with abnormal swelling; 13.3% with horizontal cracks; 13.3% with longitudinal cracks
	12	0.4 (1.1)	86.7% none or well recovered; 13.3% unable to regenerate or showing deformities, with wounds that cannot heal and discoloration occurring
III	13	0.0 (0.0)	100.0% no basal sprouts
	14	0.4 (1.1)	86.7% no covering soil; 13.3% with covering soil greater than 10 cm
	15	1.4 (1.6)	40.0% none; 26.7% slight; 26.7% moderate; 6.7% severe
	16	2.8 (3.6)	46.7% none; 13.3% slight; 26.7% partial; 13.3% severe
	17	3.7 (3.0)	33.3% none; 60.0% with decay area occupying less than 25% of the circumference at that point; 6.7% with decay area occupying more than 25% of the circumference at that point
	18	0.7 (1.3)	60.0% none; 33.3% with obvious damage or removal of roots; 6.7% with damage or removal greater than 25%
	IV	19	0.0 (0.0)
20		0.9 (1.0)	53.3% not significantly affected by wind; 46.7% in wind-swept areas
21		3.0 (0.0)	100.0% compacted
22		1.9 (0.6)	6.7% good; 86.7% poor; 6.7% with severe water accumulation
ATD		33.7	

Note: I: Crown condition, II: Trunk condition, III: Root condition, IV: Habitat environment, D: Average deduction, SD: Standard deviation; ATD: Average total deduction.

**Table 14. Health assessment for 15 trees of *Koelreuteria henryi* (KH)**

Aspect	Item	D (SD)	Proportions
I	1	0.2 (0.4)	80.0% normal; 20.0% with 5-25% abnormal leaf volume
	2	1.3 (1.5)	33.3% uniform growth; 40.0% with crown loss rate of 5-25%; 20.0% with crown loss rate of 25-50%; 6.7% with crown loss rate greater than 50%
	3	1.9 (1.9)	46.7% none; 40.0% with unhealthy branches of diameter 5-10 cm; 13.3% with unhealthy branches greater than 10 cm
	4	0.9 (0.3)	Average about 29.6%, with 6.7% having a live crown greater than 50%; 93.3% having a live crown between 25%-50%
II	5	3.1 (4.0)	6.7% none; 93.3% with parasitic plants; 46.7% with tree holes; 6.7% with abnormal sap flow or ulcers; 13.3% with fungi (fruiting bodies)
	6	0.1 (0.4)	Average about 37.1, with 86.7% tree height to DBH ratio < 50; 13.3% with 50 ≤ tree height to DBH ratio < 90
	7	2.2 (2.0)	40.0% with trunk tilt less than 15° ; 40.0% with trunk tilt between 15° and 30° ; 20.0% with trunk tilt greater than 30°
	8	2.7 (2.3)	20.0% none; 33.3% with codominant stems and angles greater than 30° ; 46.7% with codominant stems and angles less than 30°
	9	0.2 (0.8)	93.3% none; 6.7% with swollen branches
	10	0.3 (0.5)	73.3% no damage; 26.7% with bark damage area less than 5-30% of circumference
	11	2.5 (3.4)	66.7% none; 20.0% with internal bark; 33.3% with abnormal cracking; 6.7% with longitudinal cracks
	12	0.5 (1.3)	80.0% none or well recovered; 13.3% with weakened recovery or regeneration; 6.7% with wounds of diameter 10 cm ≤ wounds < 20 cm that cannot heal, causing decay
III	13	0.1 (0.3)	93.3% no basal sprouts; 6.7% with sprouts present
	14	0.0 (0.0)	100.0% no covering soil
	15	1.3 (1.5)	40.0% none; 33.3% slight; 20.0% moderate; 6.7% severe
	16	1.00 (1.69)	53.3% none; 33.3% slight; 13.3% partial
	17	2.7 (3.7)	60.0% none; 26.7% with decay area occupying less than 25% of the circumference at that point; 13.3% with decay area occupying more than 25% of the circumference at that point
	18	0.9 (1.2)	33.3% none; 60.0% with obvious damage or removal of roots; 6.7% with damage or removal greater than 25%
IV	19	0.0 (0.0)	100.0% sufficient area
	20	1.7 (0.7)	13.3% not significantly affected by wind; 86.7% in wind-swept areas
	21	3.0 (0.0)	100.0% compacted
	22	1.1 (1.0)	46.7% good; 53.3% poor
ATD		27.6	

Note: I: Crown condition, II: Trunk condition, III: Root condition, IV: Habitat environment, D: Average deduction, SD: Standard deviation; ATD: Average total deduction.

**Table 15. Average total deduction for Tree Species in Crown, Trunk, Root, and Habitat environment**

Tree species	Crown condition	Trunk condition	Root condition	Habitat environment	Average total deduction
BJ	3.1	10.9	7.4	5.7	27.1
LF	3.5	6.5	5.4	9.5	24.8
FM	5.1	12.9	7.7	5.1	30.8
CC	6.7	9.1	5.8	6.1	27.7
FF	5.7	13.5	3.5	6.5	29.3
CF	7.0	22.6	10.2	4.5	44.3
AS	5.6	11.1	5.7	7.1	29.5
SM	3.1	28.8	11.1	7.5	50.5
TM	4.5	14.4	8.9	5.9	33.7
KH	4.3	11.5	5.9	5.8	27.6

**Table 16. Health assessment proportions (%) of 10 tree species**

Tree species	Good (%)	Average (%)	Poor (%)	Grade A
BJ	10 (66.7)	3 (20.0)	2 (13.3)	0 (0.0)
LF	10 (66.7)	5 (33.3)	0 (0.0)	0 (0.0)
FM	9 (60.0)	2 (13.3)	4 (26.7)	0 (0.0)
CC	10 (66.7)	5 (33.3)	0 (0.0)	0 (0.0)
FF	8 (53.3)	6 (40.0)	1 (6.7)	0 (0.0)
CF	1 (6.7)	8 (53.3)	5 (33.3)	1 (6.7)
AS	8 (53.3)	5 (33.3)	2 (13.3)	0 (0.0)
SM	0 (0.0)	4 (26.7)	10 (67.7)	1 (6.7)
TM	6 (40.0)	6 (40.0)	2 (13.3)	1 (6.7)
KH	7 (46.7)	6 (40.0)	1 (6.7)	1 (6.7)

**Notes:**

Percentages are shown in parentheses.

Criteria for severe hazards include: Class A (Severe Hazard)

CF: One tree has a trunk decay area exceeding 50% of the cross-sectional area.

SM: One tree has a co-dominant stem with a crack deep enough to match the diameter of the stem, structural damage, and trunk decay area exceeding 50%.

TM: One tree has a cavity depth exceeding 2/3 of the cross-sectional diameter and an opening of more than 1/3.

KH: One tree has a cavity depth exceeding 2/3 of the cross-sectional diameter and an opening of more than 1/3.

and deep trunk cavities in both TM and KH. These conditions indicate critical health problems in Grade A trees and management authorities are urged to prioritize high-risk species and individuals.

No species are rated as “Low risk” in Table 17 for environmental safety. BJ, LF, FF, SM, and KH were 100% “High risk.” CF and FM had over 87% high risk, while AS and TM were at 80%. Only CC had the lowest high-risk proportion (67.7%), but it was still substantial.

Table 18’s comprehensive safety assessment identified SM, CF, TM, and KH as primary intervention targets, each with 6.7% A Grade individuals. SM had the highest proportion of Grade B (66.7%) and no low-risk trees. Species like BJ, CC, LF, and FM showed higher proportions of low risk (Grade D).

In summary, Grade A trees and those with high Grade B proportions should be prioritized to protect campus safety.

**Table 17. Environmental public safety risk assessment proportions (%) of the 10 tree species**

Tree species	Low (%)	Medium (%)	High (%)
BJ	-	-	15 (100.0)
LF	-	-	15 (100.0)
FM	-	2 (13.3)	13 (87.7)
CC	-	4 (26.7)	11 (67.7)
FF	-	1 (6.7)	14 (93.3)
CF	-	2 (13.3)	13 (87.7)
AS	-	3 (20.0)	12 (80.0)
SM	-	-	15 (100.0)
TM	-	3 (20.0)	12 (80.0)
KH	-	-	15 (100.0)

Note: Percentages are shown in parentheses.

**Table 18. Comprehensive safety assessment proportions (%) of 10 Tree Species**

Tree species	Grade A	Grade B	Grade C	Grade D
BJ	0.0%	13.3%	20.0%	66.7%
LF	0.0%	0.0%	33.3%	66.7%
FM	0.0%	26.7%	13.3%	60.0%
CC	0.0%	0.0%	33.3%	66.7%
FF	0.0%	6.7%	40.0%	53.3%
CF	6.7%	20.0%	66.7%	6.7%
AS	0.0%	6.7%	40.0%	53.3%
SM	6.7%	66.7%	26.7%	0.0%
TM	6.7%	13.3%	40.0%	40.0%
KH	6.7%	6.7%	40.0%	46.7%

## DISCUSSION

### Methods of visual tree assessment

This study conducted a comprehensive health and public safety assessment of 150 trees from 10 common species on the campus of National Ilan University, systematically identifying interspecific differences in physiological health and external risk conditions. By integrating the assessment results with risk classification, the research provides a scientific basis to inform future green space management and campus planting strategies.

According to previous research, three visual risk assessment methods—THREATS

(Tree Hazard Rating and Evaluation Tool System), QTRA (Quantified Tree Risk Assessment), and ISA BMP (International Society of Arboriculture Best Management)—showed no significant differences in overall results among assessors; however, differences were noted in the components of “likelihood of impact” and “risk rating.” Until a method better adapted to local conditions is developed, the ISA BMP method remains the preferred choice, as it provides detailed analysis of defects and residual risk (Ameneiros 2022). Nonetheless, the choice of method should align with practical needs: the U.S. Department of Agriculture Forest Service method is suitable for rapid assessments (approximately 10 minutes per tree), while

ISA BMP is more appropriate for detailed assessments of critical trees (approximately 20-25 minutes per tree), and the traditional ISA framework offers a balanced intermediate option.

It is recommended that digital tools and professional training be integrated with the characteristics of local tree species (Koeser et al. 2013). In this study, the assessors were not certified arborists but had received training; consequently, uncertainties occasionally arose during the inspection process. However, as the number of inspections increased, the assessors' experience and proficiency improved. To enhance the reliability of evaluations, future applications should incorporate repeat inspections and verification by two or more assessors to ensure consistency and improve overall accuracy.

This study further recommends refining the Taipei City tree safety assessment form based on accumulated field experience to better address local risk conditions. First, the risks of environmental safety and tree health should not be combined into a single tree safety assessment form, as "safety" and "health" are distinct concepts, and conflating them may lead to misunderstandings among the general public. Secondly, the judgment criteria in the "Significant Hazard (A-level)" category and the "Environmental Public Safety Risk Level" are somewhat vague, which may result in misclassification; therefore it is suggested to refine these judgment standards. Additionally, while the current "total deduction method" used in tree health assessments is suitable for general use, it is less reasonable and flexible compared to the ISA's basic tree risk assessment framework. Consideration should therefore be given to adjusting the assessment methods to improve diagnostic accuracy. Finally, the scoring standards in

"Tree Health Assessment" should be more explicitly grounded in literature to clarify the relationship between score quantification and health status. Together, these improvements would improve both the accuracy and practical utility of the assessment process while underscoring that different visual tree assessment methods have specific applicability.

### **Health differences among tree species**

Significant health differences among tree species were found (Table 15). SM and CF exhibited the poorest health, with total deduction scores of 50.3 and 44.3 respectively, far exceeding other species, implying poor adaptation or exposure to long-term stressors. Conversely, LF showed good adaptability with a lower total deduction of 24.8. Deduction types varied by species; for example, TM's problems were related to planting hole size and crown lean (Liao et al. 2021), while Taichung City street trees displayed various hazardous defects (Chen 2018).

From reviewing Table 16 regarding the assessment ratios of the ten tree species that, in cases where human damage affected tree health and A grades were not considered, the tree species with poorer health included SM, CF, and FM. Due to the poor growth vitality of these species, it was recommended to avoid selecting them for planting in the future. In this study, trunk decay and root damage in trees were found to be key structural defects affecting tree health. The main causes of these issues are attributed to human mechanical injuries, such as pruning, mechanical weeding, or construction activities. The proportion of damage caused by these factors is approximately 30-70%. Therefore, it is essential to avoid these human-induced factors.

This study identified the trunk and roots as key contributors to high deductions, particularly in SM and CF, identifying structural defects including trunk decay and root damage as major health determinants. This aligns with prior research that emphasizes trunk and root integrity as core health and risk indicators (Pokorny 2003, Lin et al. 2012, Martinez and Coelho-Duarte 2023). Martinez and Coelho-Duarte (2023) also introduced “conflicts with infrastructure” and “structural support” as additional indicators, totaling nine. Future management should focus on early monitoring and intervention targeting these critical areas. In addition, each tree species demonstrated its own specific set of recurring health defects, suggesting that inspectors should pay special attention to these species-specific vulnerabilities during assessment.

#### **Hazardous defects and health grades**

As shown in Table 16, the health ratings of most species clustered around “Good” and “Fair,” but some individuals were classified as “Poor” or “Grade A Major Hazard.” SM had no individuals rated “Good,” with 67.7% rated “Poor” and 6.7% rated Grade A, indicating urgent intervention needed. Similarly, CF, TM, and KH each had individuals rated Grade A, frequently showing structural instability such as severe decay, deep cracks, large cavities, and irreparable damage. One SM individual exhibited three major hazard characteristics, marking the highest risk and public safety threat.

In this study, the high deduction scores recorded for the trunks and roots of certain tree species were primarily attributed to unfavorable growing environments, poor soil in planting pits, human damage, and inappropriate species selection. To address these issues and reduce associated risk

levels, strategies should not only target the underlying causes, but also refer to the recommended handling methods in the tree safety assessment framework, including continuous inspection and monitoring, mitigation measures (such as pruning, support, pest and disease control, habitat improvement), transplantation, removal, and inviting experts to conduct on-site assessments and provide recommendations.

It is essential to note that the A Grade classification corresponds to seven specific high-risk conditions, including severe trunk decay, major cavities, large branch failure potential, and others, which should serve as key warning indicators during evaluations (Pokorny 2003, Lin et al. 2012). Case studies across Taiwan illustrate these risks: in Taitung City, crown dieback, external decay, and planting hole size were identified as indicators (Chen 2019), while the major defects in Taichung City street trees were primarily linked to improper pruning and insufficient planting space (Chien 2018). These findings indicate that even generally healthy species may harbor high-risk individuals, necessitating detailed management. Similar observations in other studies highlight the need for urgent actions on the 2.1% to 7.8% of trees classified as high-risk (Chiou and Lin 2024, Li et al. 2021).

#### **Environmental public safety risk assessment**

Regarding public safety risks (Table 17), no species had individuals rated “Low risk,” showing medium to high environmental risks campus-wide. Notably, BJ, LF, SM, and KH had 100% individuals rated “High risk.” Even species with acceptable health presented high environmental risks due to external factors. This result confirms that a comprehensive risk assessment must integrate a tree’s health with its environmental context. This highlights that

risk is linked not only to tree health but also to planting locations and surroundings. Trees near sidewalks, busy areas, roads, or wind-prone zones carry elevated risk regardless of health status. Risk assessment should thus consider physiological indicators alongside environmental variables such as hazard zones and receptor sensitivity, including metrics like “Likelihood of Failure,” “Likelihood of Impact,” “Consequence,” and “Risk rating” (Dunster et al. 2017, Coelho-Duarte et al. 2021). Despite methodological differences, the need for detailed multifactorial risk management is clear.

The results of this study indicate that the environmental public safety risk of campus trees is relatively high, suggesting that the planting and growing environment of trees on campus is unfavorable to their growth. The main reason for this is the high frequency of activities by students, faculty, and the public in these areas. Therefore, effective tree safety management requires a comprehensive, multifactorial approach that considers both the tree’s health and its surrounding environment. To avoid and improve these issues, the following measures can be considered: enhancing the growing environment, installing protective fences, guiding traffic, transplanting trees, and strengthening tree management.

### **Comprehensive tree safety risk levels**

By integrating health and environmental risk data (Table 18), a practical risk matrix was established. SM ranked worst, with no low-risk individuals, 66.7% high risk, and some major hazards, making it the top priority for interventions such as pruning or removal. CF, TM, and KH also had major hazard individuals and should be secondary priorities. Conversely, FM, CC, FF, and AS had more low-risk individuals, allowing

management through regular monitoring and targeted improvements. This confirms the utility of the “Risk matrix” approach (Ameneiros et al. 2022), which helps campus managers allocate limited resources efficiently to maximize public safety while preserving green space quality.

In terms of tree management, it is recommended to establish a regular health inspection system to assess the health status and risks of the trees, allowing for early detection of issues. Additionally, efforts should be made to improve the soil and water conditions around the trees to provide an environment suitable for their growth. To minimize the impact of human activity on the trees, protective fences or measures can be set up around them. Furthermore, signage and guidance should be placed near trees to reduce traffic interference and damage. For trees exhibiting poor growth conditions, consideration should be given to relocating them to more suitable locations. To ensure the daily care and maintenance of trees, a tree management team should be established to handle tasks such as pruning and fertilization. Moreover, it is important to enhance awareness of tree protection among faculty, students, and the campus community, emphasizing the significance of tree management. Finally, establishing a database of campus trees to record and track each tree’s health status, inspection history, and management measures will facilitate subsequent management and decision-making.

### **CONCLUSIONS**

This study applied the Taipei City Tree Safety Assessment Form to evaluate the health status and public safety risk of 150 trees in 10 species on the campus of

National Ilan University. The results revealed significant variation in health conditions and risk levels among species, providing empirical evidence for future green space management and resource allocation.

*Sapindus mukorossii* (SM) and *Cassia fistula* (CF) exhibited the poorest health, with severe issues particularly in trunk and root structures. *Sapindus mukorossii* had the lowest overall health scores and one Grade A major hazard individual, indicating urgent risk. Furthermore, most campus trees faced high environmental public safety risks, resulting in the majority of individuals being classified as “High risk,” highlighting the critical influence of environmental factors on risk levels.

By integrating health and environmental assessments, four tree species—*Cassia fistula* (CF), *Sapindus mukorossii* (SM), *Terminalia mantalyi* (TM), and *Koelreuteria henryi* (KH)—were identified as priority targets due to the presence of Grade A hazard individuals. Among them, *Sapindus mukorossii* also had a high proportion of Grade B (high risk) individuals, requiring continued management attention. These findings support the development of a clear risk map to guide resource allocation and targeted maintenance strategies. While the Taipei City Tree Safety Assessment Form proved practical for identifying potential risks in this study, its long-term applicability would benefit from continuous refinement based on accumulated data, local experience, and changing site-specific conditions.

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研究報告

## 國立宜蘭大學校園樹木健康與風險之目視檢測評估

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### 摘要

#### 背景

樹木是城市和校園綠地的重要組成部分，提供生態和環境效益，提升人類福祉與生活品質。然而，樹木在生長過程中受到自然環境和人類活動的影響，面臨害蟲侵擾、疾病、機械損傷及不良棲息條件等威脅，可能導致安全隱患。特別是在行人流量大的大學校園，樹木的結構安全對於保障人身安全和防止財產損失至關重要。因此，建立科學系統的風險評估與管理機制對於校園綠色基礎設施的可持續發展至關重要。

本研究採用了視覺樹木評估(Visual Tree Assessment, VTA)方法，對國立宜蘭大學校園樹木進行健康與安全狀況的評估，旨在識別高風險樹木並探討影響樹木衰退的關鍵因素。研究結果將為未來類似環境的樹木管理提供參考，並提出有效的維護策略，以提升校園安全和樹木健康管理標準。

#### 材料及方法

本研究旨在評估宜蘭大學校園內10種常見樹木的健康狀況與公共安全風險，採用系統性的目視樹木評估法(VTA)，依據「臺北市樹木安全評估表」進行資料收集與分析。調查對象為校園內150株樹木，涵蓋茄苳(*Bischofia javanica* Blume)、楓香(*Liquidambar formosana* Hance)、榕樹(*Ficus microcarpa* L.f.)等10種樹種，調查期間為2024年12月至2025年6月。

健康度評估依據22項評估項目，涵蓋樹冠、樹幹、根部及棲地環境。每項目根據缺陷程度設有扣分標準，並針對關鍵因子進行高風險判斷。健康度分級為「好」、「普通」、

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「差」及「重大危害(A級)」，而環境公共安全風險度則分為「低」、「中」和「高」。最終，綜合健康度與風險度，利用安全評估矩陣將樹木風險分為四個等級，以協助校園管理單位制定應對策略。

## 結果

本研究分析了宜蘭大學校園內10種樹木的生長特性，發現不同樹種之間的生長形態差異顯著。其中，榕樹擁有最大的胸徑和冠幅，顯得粗壯，而黑板樹(*Alstonia scholaris* (L.) R.Br.)則是最高的樹種，但冠幅較窄。光蠟樹(*Fraxinus griffithii* C.B.Clarke)的胸徑最小，顯示其相對纖細。樹木的種植位置主要集中在人行道和分隔島，這些分佈反映了環境因素對樹木健康的影響。

健康度評估顯示，茄苳的主要問題在於樹幹狀況和棲地環境；楓香的樹冠和樹幹均存在不健康枝條的問題；榕樹的根部問題最為嚴重，特別是根領腐朽；阿勃勒(*Cassia fistula* L.)的健康狀況極差，樹幹和根部問題突出，急需處理。無患子(*Sapindus mukorossii* Gaertn.)的健康狀況也不佳，顯示出嚴重的樹幹損傷及根部腐朽問題；小葉欖仁(*Terminalia boivinii* Tul.)和臺灣欖樹(*Koelreuteria henryi* Dümmer)的健康狀況相對較差，面臨多重環境壓力。

在健康度評估中，部分樹種的健康狀況良好，但無患子和阿勃勒的健康狀況最差，顯示出結構問題的嚴重性。環境公共安全風險普遍偏高，許多樹種均被評為高風險。整體而言，應優先處理健康狀況不佳的樹木，以保障校園的公共安全。

## 討論

本研究對國立宜蘭大學校園內150棵樹木進行了全面的健康與公共安全評估，揭示了不同樹種在生理健康和外部風險條件上的差異。調查結果與風險分類的結合為未來的綠地管理和種植策略提供了堅實的基礎。根據先前研究，三種視覺風險評估方法(THREATS、QTRA和ISA BMP)在評估結果上無顯著差異，但在“影響可能性”和“風險評級”方面存在差異。ISA BMP方法因其詳細的缺陷分析和殘餘風險評估而更為推薦。

研究發現樹種之間存在顯著的健康差異，某些樹種表現出較差的健康狀態，顯示出適應性不足或長期受到壓力的跡象。樹幹和根部被認為是健康評估的關鍵因素，結構缺陷如樹幹腐爛和根部損傷被確認為主要健康決定因素。這表明未來的管理應專注於早期監測和干預。

大多數樹種的健康評級集中在“良好”和“一般”之間，但部分樹木被評為“差”或“A級重大危險”。這些樹木的結構不穩定性，如嚴重腐爛和深裂，顯示出急需干預的需求。A級分類對應七種高風險條件，這些應成為評估中的重要警示指標。

在公共安全風險方面，沒有樹種被評為“低風險”，顯示出校園範圍內的中高環境風

險。健康狀況良好的樹木因周邊環境因素仍可能存在高風險，強調風險不僅與樹木健康有關，還與種植位置和環境有關。

通過整合健康和環境風險數據，建立了實用的風險矩陣。某些樹木被評為高風險且存在重大危險，應優先進行修剪或移除。相對而言，其他樹木則有較多的低風險個體，可以通過定期監測和針對性改善進行管理。這確認了“風險矩陣”方法的有效性，有助於校園管理者有效分配資源，以最大化公共安全並保持綠地質量。

## 結論

本研究採用臺北市樹木安全評估表，對國立宜蘭大學校園內的樹木進行全面性的健康與公共安全風險評估。評估內容涵蓋樹冠、樹幹、根部與周邊環境四大面向，並透過量化計分方式，辨識各樹種的健康狀況與風險模式。結果顯示，不同樹種間存在明顯差異，顯示樹木檢測時應重視各樹種常見的健康缺陷類型。其中，七項「A級(重大危害)」健康缺陷指標，屬於高風險項目，應特別留意。環境安全評估結果亦顯示，若生長環境條件不良，將顯著提高樹木風險，強調應審慎規劃種植環境與樹穴設計。整體而言，結合健康與環境條件之評估，有助於確立高風險樹木之管理優先順序。本研究證實臺北市樹木安全評估表具備實用性，惟建議未來可結合實務經驗與田野數據持續修正，以提升其長期適用性。

**關鍵詞：**樹木健康、樹木安全、樹木管理、風險評估、目視檢測評估

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