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AN EXAMINATION OF THE RISKS OF HAZARDOUS TREES IN THE CONTEXT OF VANDALISM PREVENTION IN URBAN AREAS

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Abstract

It is essential to protect trees in urban areas, particularly those with defects and pose a hazard, to maintaining the longevity of the green infrastructure and the safety of the neighbourhoods. Defective trees (DTs) and hazardous trees (HTs) are often vandalised. Therefore, it is essential to understand the correlation between the vandalism index (VI) and hazard score (HS) of trees to implement strategies that effectively decrease risks and sustain the long-term health of urban green spaces. This present study aims to quantify the correlation between the HS and VI of trees, identify the unique effects of each element on the urban environment, and develop well-informed mitigation strategies. It also assesses the HSs of trees and quantifies their VIs to provide a comprehensive understanding of the risks associated with both factors in urban landscapes. The results of this present study indicate a positive correlation between the VI and HS of trees and identified tree size as an important element impacting their VI. Time constraints and accessibility, particularly when surveying broad areas, are some of the limitations of this present study as it used conventional methods of tree assessments. Nevertheless, tree managers can utilise its findings to make better management decisions as well as increase user comfort and security in urban settings. Furthermore, implementing these findings will enhance and beautify public areas as well as increase public safety.

***Keywords**:* Green Infrastructure Safety, Hazardous Trees, Tree Vandalism, Urban Tree Risks

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INTRODUCTION

Increased awareness of the risks associated with hazardous trees (HTs) in urban areas, highlighting the damage they might cause to people and property, has led to the need for immediate action to mitigate the related hazards. It is widely accepted that defective trees (DTs) and HTs are closely related. Numerous tree assessments, particularly in tropical regions, confirm this assertion (Chuon et al., 2011; Mojiol, 2018; Sreetheran et al., 2011; Tomao et al., 2015). More specifically, Hamzah et al. (2018) reported that tree vandalism (TV) is the primary cause of DTs and HTs. Despite the risks posed by TV to HTs, not much research has been done on the topic, and it is still not entirely obvious how urban HTs are related to TV. Further investigation is required to fully comprehend these connections. This study is aimed at defining the various effects that each element has on the urban environment, with the objective of quantifying the correlation between TV and urban HTs for mitigation strategies. The study delves into both the hazard score (HS) and vandalism index (VI) of trees and seeks to unravel the dynamics and correlations between these variables. The context and issues of HTs and TV incidences are introduced at the beginning of the article. It then explores the literature that is currently available on HTs and TV. The third section of this article offers comprehensive details on the materials and methods used for the purpose of the study. Proceeding to the fourth section, the paper highlights and evaluates the outcomes of the study. Lastly, it makes suggestions for more research on the subject and provides a summary of the findings.

LITERATURE REVIEW

Hazardous Trees (HTs)

The features that distinguish HTs are a decline, deterioration, or other conditions that impair the stability of the trees and raise the risk of failure. These flaws can show up as cavities, cracks, or damaged root systems, among other things (Li et al., 2022; Tomao et al., 2015; Van Haaften et al., 2015). These trees are very dangerous because they can fail and cause harm to people, property, or even result in fatalities (Fernandes et al., 2018). The identification and classification of hazardous trees (HTs) require extensive evaluations by arborists or tree care specialists using methods like visual inspections, sophisticated diagnostic tools, and risk assessment methodologies (Chau et al., 2020; He et al., 2022). Comprehending the unique characteristics that render a tree potentially dangerous is imperative for efficient management of urban forests, safeguarding the public, and devising focused mitigation approaches.

Hazardous tree (HT) mitigation requires a thorough strategy that takes into account reactive as well as preventive measures. Regular tree inspections, good maintenance techniques, and the removal of high-risk trees before they become a serious hazard, are examples of proactive measures (Davies et al., 2017). Emergency response plans, the immediate removal of identified HTs, and community awareness initiatives to inform the public about potential risks are examples of reactive strategies (Fors et al., 2018; Pradipta et al., 2018). To create a safer and more resilient urban environment, arborists, local authorities, and community members must work together to effectively manage HTs.

Hazardous trees (HTs) can emerge when people navigate a more complex social environment because of intentional or unintentional TV, which occurs when someone intentionally damages the structural integrity of a tree (Hamzah & Mohd Hussain, 2021; Kirkpatrick et al., 2013). As a result, defects and weaknesses start to show through, endangering not only the stability of the tree but also the safety of nearby humans and wildlife (Abdullah et al., 2018; Hamzah et al., 2023). As such, a thorough comprehension of TV incidences is imperative, especially when it comes to potential HTs. This understanding is crucial for creating preventive strategies, raising community awareness, and devising plans to lessen the many risks connected to the purposeful damage of trees.

Tree Vandalism (TV) Incidents

TV incidents involve intentional or unintentional acts that injure trees, frequently leading to damage to tree parts (Hamzah et al., 2020; Moore, 2013; Nik Mohamed Sukri et al., 2017). This destructive behaviour can take many different forms, such as cutting, carving, or using toxic materials, all of which directly endanger the health of the targeted trees (Figure 1). Tree vandalism (TV) occurs for a variety of reasons; such as acts of frustration, self-expression, or deliberate harm caused by disregard for the environment (Cummins, 2017; Raskin, 2015; Richardson & Shackleton, 2014). To prevent TV, maintain urban green spaces, and promote a sense of community responsibility towards the environment, it is imperative to comprehend the dynamics of such incidences.

Multiple studies have found a positive correlation between the condition of trees and urban TV incidences. Hamzah et al. (2018) identified tree maturity, safety, and HTs as relevant factors. Hamzah, Othman, and Mohd Hussain (2020) used expert consensus to confirm that trees are far more vulnerable to TV when they are in poor condition, such as overgrown and neglected. These requirements need to be addressed and strengthened to promote the health and defence of urban trees against vandalism.

Figure 1: A sample of urban trees that are being vandalised.
Source: Author's inventory

Beyond its immediate aesthetic impact, TV has long-term ecological consequences as well as detrimental effects on the health of urban ecosystems. Damaged trees are more prone to diseases, pests, and environmental stressors, which shorten their lifespan and general health (Cavender & Donnelly, 2019). Furthermore, the ecosystem services offered by mature trees, such as temperature regulation, air purification, and wildlife habitat, are disrupted by their disappearance (Amir et al., 2022). Community involvement, public awareness campaigns, and cooperation between local government and environmental organisations are all part of the efforts to combat TV and foster an appreciation for trees and their vital role in maintaining urban environments.

Understanding the correlation between HTs and TV is crucial for an all-encompassing approach to urban management. The correlation between HTs and intentional injury emphasises the need for a thoughtful strategy for both public safety and tree care. Arborists, urban planners, and community leaders can create focused strategies to identify and reduce the intentional and unintentional factors that lead to HTs by investigating the patterns and motivations behind TV. Maintaining the integrity of urban green spaces can be done more comprehensively and successfully by incorporating this knowledge into larger programmes that support tree health and protect urban ecosystems.

RESEARCH METHODOLOGY

The correlation between HTs and TV incidences was measured quantitatively in this study. The subject of the analysis was the quantitative data that had been gathered in less than a month in 2023. The HS and VI of trees were assessed using two forms of data collection.

Data was gathered from Malaysia's Kuala Kangsar Urban Park, which is situated in the centre of Kuala Kangsar, the royal town of Perak, close to the Perak River. Covering an area of around 11 hectares, it is the only urban park in Malaysia serving both commercial and recreational purposes. The approximate geographic coordinates of the park are 3° 46′ 30" N and 100° 56′ 39" E. This urban park was selected as the study area due to its feasibility and appropriateness for examining the primary goal. The main author's familiarity with the city and its neighbourhoods, together with his excellent rapport with tree organisations and the local government, were invaluable in gathering inventory and tree evaluation data for the study.

This study used the most practical tree-hazard assessment method established by the International Society of Arboriculture (ISA). The method recommended by the ISA was essential for identifying and assessing potential HTs in the park (Koeser & Smiley, 2017; Smiley et al., 2017). By employing this method, it was possible to conduct a thorough and standard evaluation, with assurance of the reliability and accuracy of the gathered information. The utilisation of this globally acknowledged methodology enhanced the credibility of the study and permitted significant comparisons to be made with similar research undertakings across the globe.

The tree vandalism model (TVM) by Hamzah et al. (2021) was used to assess TV incidences. The model measures the number of TV incidences across the area, the VI of the trees throughout the area, and the classification of TV incidences. It also accounts for TV incidences resulting from human error, inadequate tree conditions, and a lack of concern for urban trees.

The study employed descriptive statistics to provide an overview and display of the primary elements of the dataset, while a Pearson's correlation analysis was utilised to evaluate the direction and strength of the correlations between the variables. The research methodology flowchart employed in this study is shown in Figure 2.

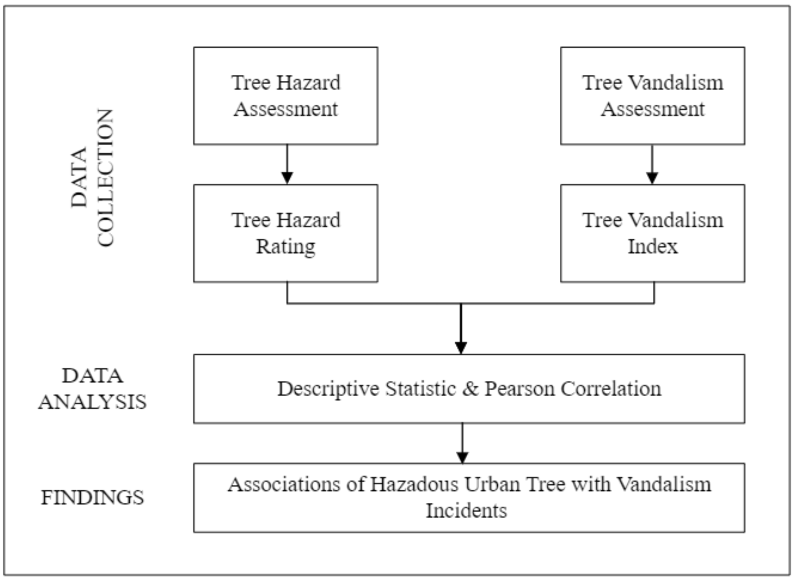

Figure 2: A flowchart of the methodology of this present study.
Source: Author's illustration

RESULT AND DISCUSSION

This present study identified 348 trees in the designated study area, representing a wide variety of 21 different tree species (Table 1). The distribution of the tree species showed that 31.32% of the trees were *Plumeria rubra*, followed by *Polyalthia longifolia* (10.63%), while for each of the remaining tree species, the distribution was less than 7%. The HSs and VIs of the trees, as presented in Table 2, indicated that 47.70% of the trees had low hazard scores, 37.36% had moderate hazard scores, 14.37% had high hazard scores, and 0.57% had extreme hazard scores. The trees with moderate HSs had the highest VI (362.45 points), followed by those with high HSs (306.41 points). Conversely, the trees with extreme HSs had the lowest VI (18.5 index points). The results of the correlation analysis showed that there was a positive correlation (r = 0.216) between the VI and HS, which explains why TV incidences are significantly influenced by tree conditions. Figure 3 presents a sample of trees in poor condition that were exposed to TV. This was consistent with the finding of Hamzah et al. (2018) that unhealthy and overgrown trees are more vulnerable to TV. This explains why trees in poor condition have high defect indices in Kota Kinabalu town (Mojiol, 2018) and in the Titiwangsa Recreational Park (Norainiratna et al., 2013). The reason for this susceptibility is the correlation between poor tree conditions and a high HS.

Table 1: The species distribution of the trees in the studied area.

No.	Species	Diameter Breast High (DBH) (m)	Overall Height (OH) (m)	Quantity	Percentage (%)
1	*Alstonia scholaris*	0.35 to 0.45	18 to 28	21	6.03
2	*Bauhinia purpurea*	0.32 to 0.34	16 to 13	2	0.57
3	*Casuarina equisetifolia*	0.32 to 0.54	19 to 26	17	4.89
4	*Ficus benjamina*	0.30 to 0.39	12 to 18	14	4.02
5	*Gymnostoma nobile*	0.28	12	1	0.29
6	*Hopea odorata*	0.33 to 0.45	21 to 26	12	3.45
7	*Hura crepitans*	0.23 to 0.48	10 to 17	18	5.17
8	*Khaya senegalensis*	0.48 to 0.62	17 to 24	5	1.44
9	*Lagerstroemia floribunda*	0.12 to 0.47	12 to 23	24	6.90
10	*Melaleuca cajuputi*	0.32	16	1	0.29
11	*Mimusops elengi*	0.32 to 0.41	12 to 16	10	2.87
12	*Murraya paniculata*	0.08	3.5	1	0.29
13	*Peltophorum pterocarpum*	0.08 to 0.44	4 to 19	16	4.60
14	*Pisonia grandis*	0.32 to 0.34	11 to 17	7	2.01
15	*Plumeria rubra*	0.01 to 0.09	2 to 5	109	31.32
16	*Polyalthia longifolia*	0.31 to 0.40	17 to 26	37	10.63
17	*Samanea saman*	0.32 to 3.80	12 to 26	7	2.01
18	*Syzygium grande*	0.32 to 0.37	13 to 17	10	2.87
19	*Syzygium myrtifolium*	0.21 to 0.34	11 to 16	20	5.75
20	*Tabebuia rosea*	0.23 to 0.42	8 to 21	8	2.30
21	*Terminalia mantaly*	0.30 to 0.33	15 to 21	8	2.30
	Total			**348**	**100.00**

Source: Author's inventory

Figure 3: The overgrown and HTs vandalised in the studied area.
Source: Author's Inventory

Table 2: The results of the tree HS and VI assessment.

HS	Quantity	Percentage (%)	VI
Low	166	47.70	70.49
Moderate	130	37.36	362.45
High	50	14.37	306.41
Extreme	2	0.57	18.65

*r = 0.216

Source: Author's inventory

According to the correlation analysis, the HS, VI, overall height (OH), and diameter breast height (DBH) of the trees were positively correlated with one another (Table 3). Nonetheless, there was a strong correlation (r = 0.5, < 0.7) between the VI as well as OH and HS. On the other hand, there was a moderate correlation (r = 0.3, < 0.5) between the HS as well as the DBH and VI. The results demonstrated that the size of a tree was a significant factor in the incidences of TV. This was consistent with the studies by Hamzah et al. (2023) and Hamzah et al. (2022), which highlighted how human activities damage tree structures because of the structural and size-appropriateness of trees for supporting other structures. However, Richardson and Shackleton (2014) found that smaller, younger trees are more susceptible to TV than larger ones, which contradicts the findings of this present study. This discrepancy has to be investigated and explained in more detail by further research.

Table 3: The correlation matrix of tree DBH, OH, HS, and VI.

	OH	***DBH***	***VI***	***HS***
OH	1			
DBH	0.5672	1		
VI	0.5672	1	1	
HS	0.6699	0.3809	0.3809	1

Source: Author's analysis

CONCLUSION

The findings of the present study clarified the dynamics of tree management, wherein the positive correlation between VI and HS was an important finding. According to this correlation, the HS of a tree rises in tandem with the number of TV incidences. This study highlighted a wider influence on the safety and wellbeing of trees, with ramifications that go beyond the specific act of TV. To create comprehensive strategies that not only prevent TV but also improve the general resilience and health of urban tree populations, it is imperative that this positive correlation be recognised and addressed.

The study found that the size of the tree was another important component that was crucial in determining the occurrence of TV. It appears that larger trees are more likely to be vandalised, suggesting possible causes like visibility or symbolic significance. Understanding how tree size affects TV incidences can help urban planning and arboriculture practices. It can also direct efforts to protect larger trees in public areas and encourage a reassessment of TV prevention tactics by considering tree size. This double understanding of the correlation between VI and HS, as well as the influence of tree size, adds significant information to the larger conversation on urban forestry and sustainable tree management.

In addition, the conclusions of this study provide tree managers with useful advice on how to emphasise user comfort and safety in landscapes while making design decisions. Tree managers will be better able to customise their efforts to reduce hazards and improve overall safety if they are aware of the positive correlation between the VI and HS, as well as the importance of tree size in TV incidences. By putting these findings into practice, public spaces will become more functional and enjoyable by fostering the development of both visually beautiful landscapes and secure conditions for people.

The limitations of conventional methods for the gathering of data for tree assessments are acknowledged in this work. Two of the restrictions include time constraints and accessibility to survey large areas. The use of unmanned aerial vehicles (UAVs) can improve accessibility and enable large areas to be surveyed more quickly and efficiently. By overcoming the drawbacks of conventional techniques, UAVs can provide a more flexible and efficient method of gathering data for better research results.

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