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The Tree Vandalism Model (Tvm): Quantifying urban tree vandalism status

Helmi Hamzah[1]*, Noriah Othman[2], Nur Huzeima Mohd Hussain[1]

[1] Department of Landscape Architecture, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA Perak Branch, Seri Iskandar Campus, 32610 Seri Iskandar, Malaysia
[2] Centre of Studies for Landscape Architecture, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA Selangor Branch, Puncak Alam Campus, 42300 Bandar Puncak Alam, Malaysia

helmi692@uitm.edu.my, noriaho@yahoo.com, nurhu154@uitm.edu.my
Tel: +6019 280 6604

Abstract
The Tree Vandalism Model (TVM) was developed to assist decision-makers and tree managers to quantify the status of tree vandalism incidence in the urban area. The model quantifies tree vandalism incident influenced by the shortcoming of tree conditions, tree vandalism incident derived from human error and tree vandalism incident due to lack of urban tree concern; which that interpret the number of tree vandalism throughout the area; the tree vandalism composite index value throughout the area; and a tree vandalism classification.

Keywords: Composite Index, Tree Vandalism, Urban Stresses, Urban Tree Care.

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1.0 Introduction

Few research discusses the effect and affects of affliction experienced by trees in urban areas. Many urban trees in most of the cities whether they are newly planted or mature exhibit serious deterioration (Koeser, Hauer, Norris, & Krouse, 2013; Nowak, Joe, & Beatty, 1990; Roman, Battles, & McBride, 2014) due to the urban stressors exposure especially in social factors (Hasan, Othman, & Ismail, 2017; Zaragoza Hernández et al., 2015). Tree vandalism expressed a social issue that dedicates a foundation for tree health decline and leads to mortality (Zaragoza Hernández et al., 2015). Usually more than half of the tree population will die as a result of serious pests and diseases infectious stems from vandalism injury (Nowak et al., 1990; Zaragoza Hernández et al., 2015). Hence, the thought of 'urban stresses' positioned an important of the criteria for tree vandalism incidence and establishing an appropriate urban tree monitoring model. In so doing, assessing the tree vandalism incident is one of the initial steps towards understanding the issues in developing appropriate prevention and remedial action plans (Richardson & Shackleton, 2014; Zaragoza Hernández et al., 2015). Understanding and quantifying the status of tree vandalism incidence is an important prerequisite in managing urban trees for optimal tree growth and longevity.

The Tree Vandalism Model (TVM) was developed through research on defining and determining an urban tree vandalism incident based on data obtained from tree care experts. This TVM can assist decision-makers and tree managers in evaluating the status of tree vandalism in urban areas. The model incorporates tree vandalism incidence data with criteria and categories weighting to measure the tree vandalism composite index. These models are structured by three (3) categories with thirty-two (32) verified tree vandalism criteria by the tree care experts.

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The categories and criteria consists of: (1) Specific motive and action (SMA): the anatomy of tree conditions which quantities vandalism act influenced by the tree conditions (including; location of tree, size of tree, tree health condition, tree growth rates, species of tree, the owner of the tree, tree characteristic, tree debris, tree value and age of tree) (Camacho-Cervantes, Schondube, Castillo, & MacGregor-Fors, 2014; Foster & Blaine, 1978; Friar, Gibson, & Vollebregt, 2012; Gilbertson & Bradshaw, 1985; Richardson & Shackleton, 2014); (2) Ideology and practices (IP): composition of the human misconduct that quantities vandalism act derived from human error (including; level of knowledge, rules and regulations, information of tree benefits, design and layout, tree care monitoring, tree maintenance approaches, tree maintenance status, religious and cultural beliefs, coordination and cooperation, demographic (age) and socio-economic status) (Long, 2003; Malek & Mariapan, 2009; Moore, 2013; OCHA, 2015; Pepper, 2008; Richardson & Shackleton, 2014); (3) Victim of circumstances (CC): configuration of the anthropogenic stresses, which quantities vandalism act due to lack of urban tree concern (including; conflict with other activities, infrastructure upgrading, priority of space usage, trees cause interference, tree for structure attachment, tree without protective structure, event and occasion, use of tree parts for other purposes, rate of human population, memorial display tree as protective structure) (Gwedla & Shackleton, 2015; Miller & Miller, 1991; Nowak, Kuroda, & Crane, 2004; Richardson & Shackleton, 2014; Trout & Brunt, 2014). This Tree Vandalism Model is applicable within the urban and rural areas in various scales and sizes. Comprehensively measuring the tree vandalism incident was evaluated critically in TVM.

2.0 Data Requirements

The TVM could be run by using the tree vandalism incidence data consisting of 32 criteria from the three categories; specific motive and action (SMA):10 criteria, ideology and practices (IP):11 criteria, and victim of circumstances (CC):11 criteria. The quantity of vandalism incident data is required to be represented in the respective measurement units (e.g., 65 units of signage attached on tree stem, 15 kids snapped tree brunches, 10 kg nails nailed on tree stem and 8m^3 root zone excavation). All data should be organized according to the three (3) abovementioned categories. The sign of tree damaged as a form of unsatisfied with the tree conditions that are committed intentionally and planned to modify tree conditions classified in the SMA category. (e.g., overgrown tree canopy removal and ring-barking to the old tree). Meanwhile, a tree damaged occurs in a form of traditional regulation breaking without malicious intent, influenced by human error such as poor skill and lack of an awareness spirit (e.g., build a structure under the tree canopy and widening the road on root zone) classified in IP category. Finally, any damaged tree in intentionally or unintentionally due to anthropogenic activities to achieve the other goals without concern about the tree (e.g., burning rubbish at tree stem and signage attachment at tree stem) are classified in CC category.

3.0 Analysis

This model calculates each vandalism incident of criteria normalized score (*a*), criteria weighting (*b*), and criteria aggregate (*c*) to generate an index of tree vandalism throughout the area (Baptista, 2014; Greco, Ishizaka, Tasiou, & Torrisi, 2019):

Equation 3.1

$$\sum_{k,t} a_k b_k c_t$$

k = 1,2,3… 32 and *t* = 1,2,3

where *k* = criteria, *t* = category, *a* = criteria normalized score of assessment area, *b* = criteria weighting, and *c* = category aggregate

3.1 Criteria Normalized

In identifying tree vandalism incidents involves the subjective criteria, the Min-Max Normalization technique used in normalizing all criteria score (Mazziotta & Pareto, 2013). These techniques are made to compare the criteria score due to differences in measurement units. This procedure refers to linear transforming on the original range of data that fit the data in a pre-defined boundary with a pre-defined boundary (Patro & Sahu, 2015). The transformation that has the identical range (0 - 1) normalizes criteria score are as follows:

Equation 3.2

$$\mathrm{A}' = \left(\frac{A - \min value of\ A}{\max value of\ A - \min value of\ A} \right) * (D - C) + C$$

Where, A' contains Min-Max Normalized data one, the pre-defined boundary is [C - 0, D - 1].

3.2 Criteria Weighting and Categories Aggregate

The model uses criteria weightage and category aggregate (Table 3.1) which has been established through the budget allocation process (BAP) method (Greco et al., 2019; Nardo, Saisana, Saltelli, & Tarantola, 2005) to ascertain the impact value of each criterion and category on tree vandalism incidence. A total of 18 experts in tree care management have been involved in these processes.

Table 3.1: Criteria Weightages Used in Tree Vandalism Model

Criteria (*k*)	Criteria Weighting (*b*)	Category Aggregate (*c*)
Specific Motive And Action		33.89
1. Location of tree	3.61	
2. Size of tree	3.17	
3. Tree health condition	3.11	
4. Tree growth rates	3.11	
5. Species of tree	2.78	
6. The owner of the tree	2.72	
7. Tree characteristic	2.72	
8. Tree debris	2.61	
9. Tree value	2.06	
10. Age of tree	1.94	
Ideology And Practices		32.78
1. Level of knowledge	3.67	
2. Rule and regulations	3.67	
3. Information on tree benefits	3.22	
4. Design and layout	3.11	
5. Tree care monitoring	3.06	
6. Tree maintenance approaches	3.06	
7. Tree maintenance status	2.94	
8. Religious and cultural beliefs	2.72	
9. Coordination and cooperation	2.67	
10. Demographic (age)	2.33	
11. Socio-economic status	1.83	
Victim Of Circumstances		33.33
1. Conflict with other activities	3.78	
2. Infrastructure upgrading/extension & urbanization/development	3.78	
3. A priority of space usage	3.72	
4. Trees cause interference/obstruction	3.67	
5. A tree for structure attachment	3.67	
6. Tree as a protective structure	2.39	
7. Event and occasion	3.00	
8. Use of tree parts for other purposes	2.67	
9. Rate of the human population	2.39	
10. Memorial display	2.39	
11. A tree without a protective structure	3.06	

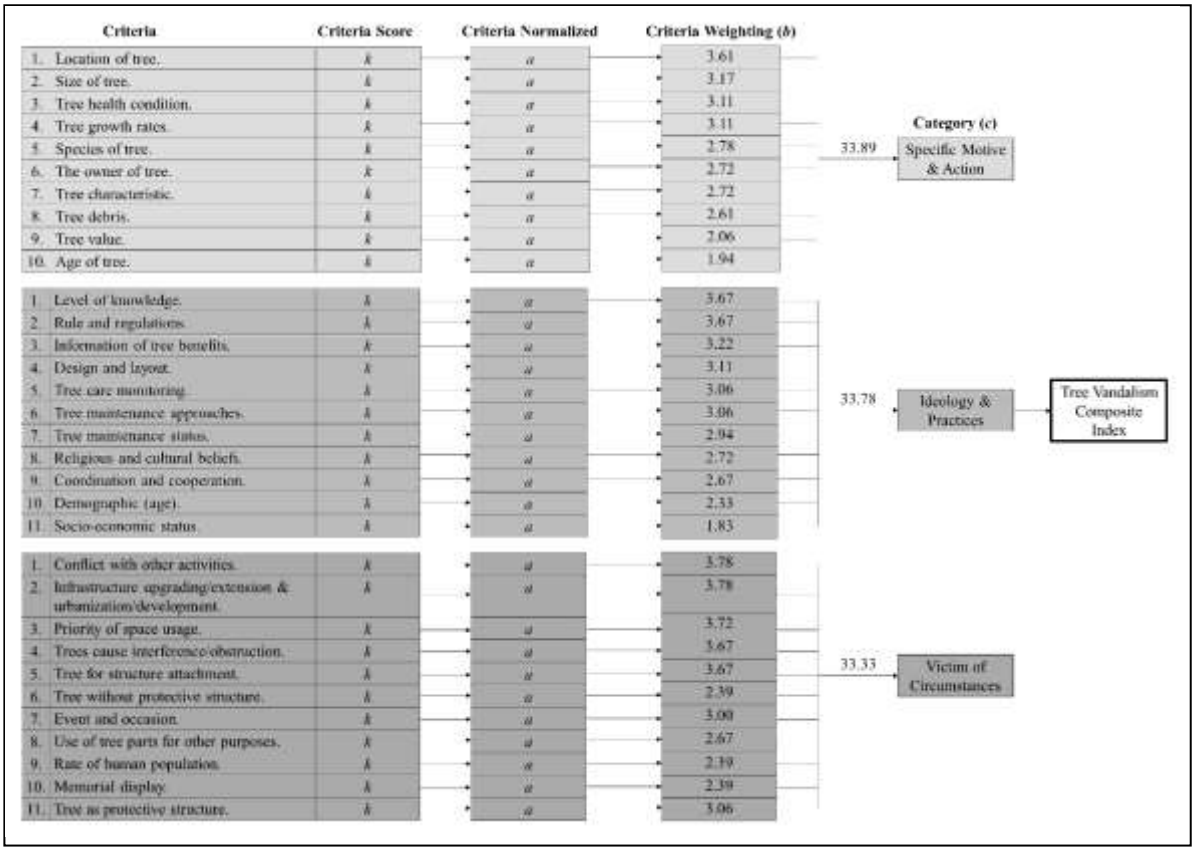

Figure 3.1: The Tree Vandalism Model Framework

Hence, the value of tree vandalism index can be generated through multiplied each normalized criteria score and criteria weighting with category aggregate (Equation). By this equation, each rated criteria of tree vandalism gained index incidence value of its own. Figure 3.1 shows the framework that used the criteria normalized score, identified items weighting, and category aggregate to measure the tree vandalism composite index.

3.3 Tree Vandalism Classification

The classification of tree vandalism status determined by a typical scale used by most analysts, assessors, and evaluators for measuring a stage or the occurrence of a matter (Welle, Birkmann, Rhyner, Witting, & Wolfertz, 2012; Baptista, 2014; Balica, Wright, & van der Meulen, 2012). The value of tree vandalism composite index indicator developed base on maximum criteria normalized score. The classification based on generated tree vandalism composite index value within five index dimensions (table 3.2); 'very low', 'low', 'medium', 'high' and 'very high'. Each dimension assigned a color code that offers the distinct advantage of revealing geospatial relationships and patterns when mapping the index results.

Table 3.2: The Classification of Tree Vandalism Incidence

Explanation			Classification
The score of Tree Vandalism Composite Index	**Percentage of Tree Vandalism Index**	**Indicator**	
2,523 to 3,152	81% - 100%	Achieve tree vandalism incidence radius 81% - 100%, having a severe level of tree vandalism incidence	**Very High**
1,892 to 2,522	61% - 80%	Reach tree vandalism incidence radius 61% - 80%, having a high level of tree vandalism incidence	**High**
1,262 to 1,891	41% - 60%	Reach tree vandalism incidence radius 41% - 60%, having a medium level of tree vandalism incidence	**Medium**
631 to 1,261	21% - 40%	Reach tree vandalism incidence radius 21% - 40%, having a medium level of tree vandalism incidence	**Low**
< 630	< 20%	Reach tree vandalism incidence under < 20%, having a low level of tree vandalism incidence	**Very Low**

4.0 Conclusion

TVM uses all tree vandalism incidence data based on the value of each criterion involved and translates it to their status by classification indicator. TVM helps to provide policymakers and tree managers with useful guidance to assess and determine the tree vandalism status of the urban area. It facilitates monitored tree vandalism incidence over time concerning the classification of tree vandalism status as an indicator to monitor changes in the status of tree vandalism, and, whether it heads towards a better status or otherwise. Thus, the results generated from TVM are expected to provide evidence and awareness for policymakers and tree managers towards managing the urban tree.

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