



## **SETTING THE CRITERIA FOR URBAN TREE VANDALISM ASSESSMENT**

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### **Abstract**

An urban tree monitoring programme is a management procedure that determines the performance status of trees by conducting an inventory of the number of trees, their condition, their structure, and other quantitative or qualitative characteristics. The ability to successfully carry out a monitoring programme is highly dependent on precise data. At the same time, comprehensive and strategic urban tree policies require accurate baseline and trending data. Accordingly, there is a need for an improved assessment technique for tree monitoring. Due to the increasing number of tree vandalism incidents in urban areas, the immediate objective of this research was to determine the criteria for a precise tree vandalism assessment technique. A modified Delphi method was adopted to obtain the most reliable consensus among tree care experts through a series of questionnaires. Prior to conducting the Delphi survey, the initial tree vandalism criteria were identified through a preliminary survey conducted by means of the photo-elicitation technique. Experts provided the input for generating the criteria, and at the end of the second round of the Delphi survey, the experts reached a consensus on a set of criteria, which included 10 criteria related to aspects of specific motives and actions, 11 criteria related to aspects of ideologies and practices, and 11 other criteria related to the aspect of victim of circumstances. The selected criteria can be applied in a monitoring programme to assess the incidence of tree vandalism.

**Keywords:** Delphi Method, Tree Management, Tree Monitoring, Tree Vandalism

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## **INTRODUCTION**

An urban tree monitoring programme is believed to play an important role in guiding policymakers and tree managers in making decisions to improve planting programmes. A standard monitoring procedure should cover aspects of the structures, functions and health of urban trees. It has been suggested that urban tree monitoring efforts are more about the performance of urban trees in response to those policies or management strategies. In this case, site attributes (land use and type of site) and tree attributes (GPS coordinates, species, diameter at breast height, mortality status, and tree condition) are measured to counter-check against the aims and goals of the management (UTGL, 2015).

However, these approaches are becoming increasingly unreliable, where the social attributes are underestimated, especially in the context of tree vandalism. Researches tend to focus on physical attributes rather than social attributes. Despite these observations, the assessment technique for tree vandalism remains unclear. Hence, additional studies on the assessment of tree vandalism for tree monitoring programs are needed.

The objective of this research was to determine the criteria that can be used to assess the incidence of tree vandalism in urban areas. This research focused on a strategy to guide decision-makers and tree managers in making the right decisions with regard to the issue of tree vandalism. This approach will provide an effective monitoring program for urban tree management. The remainder of this paper is divided into three sections. After the introduction and the literature review, the second section clarifies the methodology, while the third section presents the results of the study. Finally, the fourth section provides the conclusions and suggestions for future research.

## **LITERATURE REVIEW**

Trees and vandalism are old issues that deserve new thought. Vandalism causes harmful consequences that affect the performance of trees in terms of their contribution to ecosystem services. Some scholars have explained that tree vandalism may reduce the number of safe and comfortable environmental spaces (Donovan & Prestemon, 2012; Hami, Suhardi, Manohar, & Malekizadeh, 2014; Hasan, Othman, & Ismail, 2018; Mohd Yunus & Md Saring, 2012), lower tree appraisal values (Grande-Ortiz, Ayuga-Téllez, & Contato-Carol, 2012) and increase environmental degradation (Roy, Byrne, & Pickering, 2012). Vandalism is synonymous with mechanical injuries that become the starting point for tree damage, thereby leading to tree failure (Moore, 2013). These phenomena are known as tree disservices, and they result in unexpected economic costs, physical damage to the infrastructure, and create fears or inconveniences due to poor health conditions (Lyytimäki, 2017). Hence, it is important to address the incidence of tree vandalism in order to mitigate tree disservices and sustain urban trees. Therefore, in this study, tree vandalism is defined as an act that may cause

damage to trees, and thus, have deleterious effects on the economy, society and environment. The economic, social and environmental deterioration will definitely have a negative impact on the well-being of humans, who depend on the benefits provided by trees in urban areas.

There is a lack of urban tree monitoring guidelines or models that can guide decision-makers and urban tree managers specifically with regard to the subject of the incidence of tree vandalism. Thus, although urban trees are being managed with good strategies and implementation efforts, the issue of urban tree vandalism remains unresolved. The incidence of tree vandalism is increasing annually in most cities in the world (Hamzah, Othman, Mohd Hussain, & Simis, 2018; Mullaney, Lucke, & Trueman, 2015; Sieghardt et al., 2005). It occurs at all stages of urban tree management, either at the planning, implementation or maintenance stage. Implementing an urban tree monitoring program is recognized as a practical approach for interpreting the incidence of urban tree vandalism as it can explain in detail the factors of failure. However, existing urban tree monitoring programs do not look specifically into urban tree vandalism issues, especially in terms of the social factors, at all stages of tree management. Subsequently, the status of the incidence of tree vandalism, which may explain the significant criteria and activities, is unknown. As such, there is a lack of proper monitoring mechanisms in urban tree management to improve their strategies and implementation toward tree vandalism issues.

The references for an urban tree monitoring manual were mostly developed by the Urban Tree Growth and Longevity (UTGL) Working Group. The manual, known as the “Urban Tree Monitoring Protocols: Field Guide”, was published by the UTGL (2015). Its aim is to provide a standardized long-term data collection method for urban tree monitoring programs. It involves field collection procedures for five datasets of variables. The datasets include a: (1) Minimum Dataset - field crew information, location, site type, tree species, diameter at breast height, mortality status, and fine twig dieback; (2) Site Dataset - the characteristics of the site surrounding the trees, including the planting site, soils, and built environment; (3) Tree Dataset - tree growth, and health issues, including height, crown spread, maintenance tasks, and presence of pests and diseases; (4) Management Dataset - tree care practices by local organizations, including information institutions that plant and care for trees; and (5) Community Dataset - socioeconomic information of the community surrounding the trees, including income, housing value, and population density. Based on the datasets outlined in this manual, information relating to social attributes is lacking, and it is difficult to relate the data with the incidence of tree vandalism. To fill this gap, this research was undertaken to investigate the significant criteria that influence the incidence of tree vandalism. The criteria that were determined were then verified to assess the incidence of tree vandalism in urban areas. The results generated through this tree vandalism assessment are expected to provide

evidence to decision-makers and tree managers on the necessary collective efforts required to solve problems of tree vandalism in their management.

Researchers have conducted some studies on urban tree conditions that affect public preferences (Abd Kadir & Othman, 2012; Hamzah, Othman, & Mohd Hussain, 2017). These studies examined tree conditions that could influence the incidence of tree vandalism. It is common sense that people would reject trees that cause them problems. A study by Hamzah et al. (2017) found that the Kajang local authority received 935 public applications for the removal of trees in 2016. It can be concluded that this was due to the fear of the public of the risk to their safety that would be inflicted by dangerous tree conditions such as overgrown trees. Furthermore, a preliminary study in old Klang town carried out by Abd Kadir & Othman (2012) found that there are issues regarding the condition of urban trees that contribute to the inconvenience experienced by Klang citizens. Abd Kadir & Othman (2012) revealed that the issues had to do with overgrown trees, the conflict of urban trees versus overhead utility lines, minimum shading capability (poor tree canopy coverage), and aggressive urban tree roots that damaged sidewalks or paved areas. Those were among the tree conditions that were deemed a public inconvenience.

A growing number of studies have investigated the human misconduct behind the vandalisation of trees across urban areas. Previous studies noted that human misconduct led to the widespread vandalisation of urban trees across the city centre of Oakland (California), eleven cities in the north of England, Eastern Cape (South Africa), and Mexico City (Gilbertson & Bradshaw, 1985; Hernández Zaragoza et al., 2015; Nowak, McBride, & Beatty, 1990; Richardson & Shackleton, 2014). The authors almost exclusively cited differences in attitude toward urban trees as a major factor in the tree vandalism incidents, with a pessimistic, rather than an optimistic, attitude contributing to the higher incidence of tree vandalism. The issue of personal attitude and its relationship with the incidence of tree vandalism was briefly addressed by Long & Burke (2015) and Richardson & Shackleton (2014), where people who are bored, have a passion for delinquency, negative behaviour, and lack of appreciation for trees contribute to a high incidence of tree vandalism.

The term “urban stresses” means that urban trees are constrained in their growth and performance due to threats from malicious, accidental and other anthropogenic activities (Osakabe, Kawaoka, Nishikubo, & Osakabe, 2012; Vogt, Watkins, Mincey, Patterson, & Fischer, 2015). Urban stresses give rise to poor tree conditions and disservices that impact all urban tree populations (Delshammar, Östberg, & Öxell, 2015; Lyytimäki, 2017). The studies detailed above outline the factors that affect “human misconduct” (e.g. poor workmanship approaches and ignorance of urban trees) in a dynamic urban environment, and its detrimental impact on urban tree populations. The nature of the dynamic

characteristics across an urban area would mean that urban trees are exposed to urban stresses, leading to deliberate or accidental incidents of vandalism.

Thus, the factors that influence the incidence of urban tree vandalism can be categorized into three criteria, namely, tree conditions, humans and the environment. The criteria of tree conditions refer to the characteristics of urban trees, while the human criteria refer to human misconduct, as well as safety and convenience. Finally, the environmental criteria refer to anthropogenic factors.

## **MATERIALS AND METHODS**

### **Research Design**

A two-round modified Delphi technique was used to solicit the independent opinions of experts in constructing a set of criteria for the assessment of tree vandalism. In this modified Delphi technique, the qualitative round (first round) was replaced by a preliminary survey (Stewart et al., 2017). The preliminary survey employed a photo-elicitation technique comprised of 35 damaged tree situations that were interpreted by the expert respondents as vandalism incidents. The initial criteria, which were generated from a preliminary survey, were then used to guide the development of statements for the Delphi questionnaire rounds. The final set of criteria developed at round two of the Delphi survey was then evaluated in terms of their ranking and importance, which were consistent with the budget allocation process (BAP) (Greco, Ishizaka, Tasiou, & Torrisi, 2019; Nardo, Saisana, Saltelli, & Tarantola, 2005).

### **Data Analysis**

Qualitative data from a preliminary survey were extracted through a coding analysis using the NVivo 11 program. All the interpretations of the experts were transcribed and imported into the program. Then, the main ideas in each answer were coded (Mayring, 2000). As many categories as needed were created to synthesize the information provided in the survey that had been mapped with the identified criteria for tree vandalism incidents. Next, similar categories were merged to find patterns.

A descriptive data analysis for the first and second rounds of the Delphi survey was undertaken using the Statistical Package for the Social Sciences (SPSS) version 25. The group mean was used to determine the consensus among the experts (Alvarez Etxeberria, Garayar, & Calvo Sánchez, 2015; Henning & Jordaan, 2016; Salazar-Elena, Sánchez, & Otamendi, 2016). The impact value of each criterion on the incidence of tree vandalism was calculated from the weightage ranking in round two of the Delphi survey.

### **Selection of Expert Respondents**

The expert respondents involved in this study (both in the preliminary and Delphi survey) were Malaysian tree care experts who were qualified as Certified

Arborists by the International Society of Arboriculture (I.S.A.). The preliminary survey questionnaires were handed to 92 Malaysian certified arborists in the form of a Google survey through email. Consistent with Sekaran & Bougie (2016), this survey adopted the rule of thumb for most researches, where the sample size should be larger than 30 samples and the minimum size of a sample should be 30% of the population.

A total of 60 potential experts, who had been identified for the Delphi survey, were informed and invited to participate in the research. However, only 47 respondents agreed to participate. A total of 30 responses were received for round one of the surveys. However, after the second round, 12 experts dropped out due to time constraints, leaving a remainder of 18 experts. This number was acceptable since it was consistent with the Delphi sample size of between 10 to 60 (Hasson, Keeney, & McKenna, 2000; Bogner, Littig, & Menz, 2009; Jeste et al., 2010). Local experts from various employment sectors related to urban tree management were engaged to elicit their ideas and responses. The group consisted of six main players; the researcher, academia, local authority, consultant, contractor, and federal government sectors. Specifically, all the potential respondents were selected based on at least one of the following criteria: (1) established academics who have either published their work in international journals or have lectured in the field of urban tree management; (2) established practitioners who have extensive experience in urban tree management; (3) officers from federal and local governments who have been involved in decision making or in managing urban tree planting programs; and (4) public from non-governmental organizations who have been involved in urban tree planting programs.

### **Administration of the Delphi Survey**

In the Delphi procedure, several measures were taken to ensure the validity of the course of action. A formal letter of invitation was sent out via email to each of the 60 potential respondents identified earlier in the sample selection process. The letter of invitation included an explanation on the purpose of the research, a request for participation as an expert, and a feedback notification as to whether the potential respondent agreed or disagreed with this request. Within two weeks after the invitation letter was sent through email, a total of 47 experts gave their consent to participate. The questionnaire for round one of the survey was sent to the 47 experts who had agreed to participate. A total of 30 responses were received for this round of the survey. The questionnaire for the final (second) round of the survey was sent to all 30 experts who had previously participated in round one of the Delphi survey. In return, a total of 18 completed responses were received from these experts.

A Delphi survey approach was used for the data collection to determine the criteria for the incidence of tree vandalism and to establish the weighted

criteria for a tree vandalism assessment. The questionnaire was designed to be consistent with the suggestion by Neuman (2014) that they include introductory remarks on instructions for clarification and questions to measure each variable. A Delphi draft questionnaire should be subjected to a pilot survey to check possible ambiguities that might affect the intended meaning (Bryman, 2012). Thus, the questionnaire was tested in a pilot study to ascertain its reliability before being used with a larger sample of respondents.

The Delphi survey questionnaire was designed individually for each round because different rounds served different purposes. The questionnaire in round one was to identify the relevant criteria for the incidence of tree vandalism and to ascertain the content validity of the criteria according to their categories based on expert perceptions. Meanwhile, round two of the survey was to revalidate and finalize the relevant criteria, which had yet to achieve group consensus (Brennan Ramirez et al., 2006). The survey in round two was also to examine the level of importance of each criterion for urban tree care monitoring. For the measurement of social desirability, a four-point Likert scale was used for round one, and a five-point Likert scale was used for round two of the Delphi survey (Asún, Rdz-Navarro, & Alvarado, 2016). The questionnaires and feedback were sent and received through email. Table 1 shows the processes for the preliminary and Delphi surveys of this study.

**Table 1:** Analysis Process for Preliminary and Delphi Surveys

Items	Preliminary Survey	Delphi Survey		Results
		Round 1	Round 2	
Database	Photo elicitation	<ul style="list-style-type: none"> <li>• Literature review</li> <li>• Results of preliminary survey</li> </ul>	Results from round 1	Comprehensive criteria of the incidence of tree vandalism (Final).
Number of experts Selected	92	60	30	
Number of experts that Responded	37	30	18	
Data analysis	Coding analysis	Mean analysis & Amendment	Mean analysis	
Findings	Tree vandalism categories	Tree vandalism criteria	Revised & Finalized	

## RESULTS AND DISCUSSION

### Demography of Respondents

Out of the 92 questionnaires that were distributed to the experts, only 37 were completed in the preliminary survey. The sample comprised 27 male and 10

female respondents. Their ages varied between 25 to 60 years, with the majority of them being from 45 to 60 years old. The respondents were predominantly Malays (26), followed by Chinese (7) and Indians (4). Almost 30 of the respondents had more than 5 years of experience as Certified Arborists, and about half of them (19) were involved as private tree care practitioners, while the rest were government servants. This indicated that the respondents in this study possessed in-depth knowledge of the topics. Table 2 presents the characteristics of the experts in the preliminary survey.

**Table 2:** Characteristic of Expert Respondents in Preliminary Survey

Sector	N	Gender		Race/Ethnic			Experience (Arborist)	
		Male	Female	Malay	Chinese	Indian	< 5 Years	5 Years ^
1. Academic	4	3	1	4	0	0	1	3
2. Researcher	4	4	0	3	0	1	0	4
3. Local Authority	9	7	2	7	0	2	1	8
4. Consultant	17	12	5	9	7	1	4	13
5. Contractor	2	1	1	2	0	0	1	1
6. Federal Government	1	0	1	1	0	0	0	1
<b>Total</b>	<b>37</b>	<b>27</b>	<b>10</b>	<b>26</b>	<b>7</b>	<b>4</b>	<b>7</b>	<b>30</b>

Meanwhile, in round one of the Delphi survey, a total of 30 responses were received, thereby giving a response rate of 63.8%. Of the total number of respondents, 10.0% (3) were researchers, 13.3% (4) were academics, 20.0% (6) were from local authorities, 43.3% (13) were consultants, 6.7% (2) were contractors, and the remaining 6.7% (2) were from the federal government. In terms of their experience, 14 or 46.7% of them had been involved in the field of urban tree management for more than 20 years, another 5 experts (16.7%) had between 15 to 20 years of experience, while the rest had between 5 to 14 years of experience. This implied that the majority of the experts had wide experience in their fields. Table 3 describes the background and experience of the experts who participated in round one of the Delphi survey.

**Table 3:** Profile of Expert Participants in Delphi Survey

Sector	>20yrs	15-20yrs	5-14yrs	Total	%
1. Researcher	1	1	1	3	10.0
2. Academic	1	0	3	4	13.3



3. Local Authority	4	0	2	6	20.0
4. Consultant	7	4	2	13	43.3
5. Contractor	0	0	2	2	6.7
6. Federal Government	1	0	1	2	6.7
<b>Total</b>	<b>14</b>	<b>5</b>	<b>11</b>	<b>30</b>	<b>100</b>
<b>%</b>	<b>46.7</b>	<b>16.7</b>	<b>36.6</b>	<b>100</b>	

Round two of the survey received a total of 18 responses (Table 4). Of the total number of respondents in round two, 11.1% (2) were researchers, 11.1% (2) were academics, 22.2% (4) were experts from local authorities, 44.5% (8) were consultants and 11.1% (2) were contractors. Unfortunately, there was no respondent from the federal government.

**Table 4:** Expert Participants in Round Two of the Delphi Survey

<b>Sector</b>	<b>Experts</b>	<b>%</b>
1. Researcher	2	11.1
2. Academic	2	11.1
3. Local Authority	4	22.2
4. Consultant	8	44.5
5. Contractor	2	11.1
6. Federal Government	0	0.0
<b>Total</b>	<b>18</b>	<b>100</b>

### **Preliminary Survey**

A descriptive analysis was executed in a systematic manner through the process of coding, sorting and synthesizing the respective meanings of the criteria for the incidence of tree vandalism. The following three categories, as stated in the theory of planned behaviour (Ajzen, 1985), were focused on: (a) the attitude of those who commit tree vandalism, (b) the perception of social pressure or subjective norms in tree vandalism behaviours, and (c) the ability to perform tree vandalism. In the first cycle of the coding process, 63 coding aspects that had been noted by the experts were sorted and synthesized by merging the repeated codes or codes that represented the same meaning. These were summarized to only 22 coding aspects and synthesized to the respective three categories; 5 codes in the Attitude category, 8 codes in the Subjective Norms category, and 9 codes in the Ability category. The coding process for identifying the criteria for the incidence of tree vandalism is reported below in Table 5.

**Table 5:** Coding Process for Identifying the Criteria for the Incidence of Tree Vandalism

First Cycle Coding	No. of Respondents	Sorting	Categorizing & Synthesizing
<i>Attitude</i>			
1. No Attitude.	7	1. Lack of Awareness	Specific Motive & Action
2. Awareness.	7		
3. Curving.	1		
4. Irresponsible.	11		
5. Beauty.	4	2. Preferences & Acceptance	
6. Painting.	6	3. Safety & Security Priority	
7. Safety.	2	4. Tree Hates	
8. Convenience.	1	5. Uncomfortable	
9. Kill the Tree.	27		
10. Unhappy.	1		
11. Not Comfortable	1		
12. Privacy	1		
<i>Subjective Norm</i>			
13. Collaboration Failure.	2	1. Collaboration Failure	Ideology & Practices
14. Poor Collaboration.	1	2. Common Practices	
15. Canopy Removal.	1	3. Design Failure	
16. Design Failure.	6	4. Enforcement Failure	
17. No Enforcement.	1	5. Ignore the Tree	
18. Enforcement Failure.	4	6. Management Failure	
19. Ignore the Tree.	6	7. Practices Failure	
20. Don't Like Tree.	34		
21. Management Failure.	5		
22. No Tree Protection.	1		
23. No Monitoring	1		
24. Maintenance Failure.	13		
25. Practices Failure	3		
26. Topping.	3		
27. Usual Practices.	1		
28. Wrong Approaches	4		
29. Wrong Practices.	16		
30. Bad Practices.	14		
31. Careless.	4		

First Cycle Coding	No. of Respondents	Sorting	Categorizing & Synthesizing
32. Wrong Pruning Method.	1		
33. Poor Practices.	2		
34. Religious Purposes.	13	8. Religious Purposes	
35. Patriotic.	2		
<b>Ability</b>			
36. Conflict with Others Activities.	6	1. Conflict with Other Activities	Victim of Circumstances
37. Burning & Dumping Rubbish.	12		
38. Other Purposes.	12		
39. Improper Usage.	6		
40. Construction Work.	16	2. Construction Work	
41. Construct Structure.	11		
42. Conflict with Infrastructure.	4		
43. Machinery.	5		
44. Construct Materials.	8		
45. Earthwork.	16		
46. Grade Change.	14		
47. Root Zone Disturbance.	10		
48. Illegal Activities.	11	3. Illegal Activities	
49. Incidentally.	1	4. Lack of Knowledge	
50. No Knowledge.	31		
51. Not Aware.	4		
52. Obstruction.	22	5. Obstruction	
53. Disturbance.	1		
54. Opportunities.	8	6. Opportunities	
55. Priority of Space Usage.	1	7. Priority of Space Usage	
56. Space Conflict.	4		
57. Electrical Fixtures.	9	8. Structure Attachment	
58. Signage Attachment.	13		
59. Structure Attachment.	21		
60. Nailing.	8		

First Cycle Coding	No. of Respondents	Sorting	Categorizing & Synthesizing
61. Structure Attachment.	2	9. Supporting Element	
62. Supporting Element.	6		
63. Tying.	11		

The codes were then categorized according to their overall meaning. The attitudes of the vandals for a specific motive and action influenced their intention to vandalise trees. Therefore, the tree vandalism criteria stemmed from the attitudes of the vandals that had been categorized according to specific motives and actions. Meanwhile, for the subjective norms, the ideologies and practices of the vandals influenced their performance of tree vandalism. Thus, the tree vandalism criteria stemmed from the subjective norms or social pressures that had been categorized as ideologies and practices. Finally, the tree vandalism incidents also occurred in a victim-of-circumstances situation. Therefore, the tree vandalism criteria also stemmed from the abilities that had been categorized as a victim of circumstances.

The criteria for the tree vandalism categories derived from the preliminary survey were then mapped with the previous research to align with the three factors that influence the incidence of urban tree vandalism, namely, the criteria of tree conditions, humans and the environment. These generated the initial criteria, which were finalized through the two rounds of the Delphi survey (Table 6), thereby yielding 21 initial criteria in three categories for the incidence of tree vandalism.

**Table 6:** Mapping the Criteria for Tree Vandalism Categories with the Previous Research

Categories in Tree Vandalism	Criteria for Tree Vandalism Incidents	Sources (Author, Year and Country)
<b>1. Specific Motive and Action</b>	1. Species of the Tree	Camacho Cervantes, Schondube, Castillo, & MacGregor-Fors (2014); Mexico
	2. Age of tree.	Richardson & Shackleton (2014); Eastern Cape, South Africa
	3. Size of the tree.	Fernandes, Da Silva, Teixeira, & Costa (2018); Portugal
	4. Location of the tree.	Moore (2013); Melbourne, Australia
	5. The owner of the tree.	Raskin (2015); California, United States of America

Categories in Tree Vandalism	Criteria for Tree Vandalism Incidents	Sources (Author, Year and Country)
	6. Tree characteristic.	Camacho Cervantes et al. (2014); Mexico
	7. Tree health condition.	Kirkpatrick, Davison, & Daniels (2012); Australia
	8. Tree growth rates.	Camacho Cervantes et al. (2014); Mexico
<b>2. Ideology and Practices</b>	1. Religious and cultural beliefs.	Sharma & Pegu (2011), India
	2. Level of knowledge.	Richardson & Shackleton (2014); Eastern Cape, South Africa
	3. Socio-economic status.	Nowak et al. (1990); California, United States of America
	4. Rule and regulations.	Roos (1992); Washington, United States of America
	5. Design and layout.	Kirkpatrick et al. (2012); Australia
	6. Tree maintenance approaches.	Moore (2013); Melbourne, Australia
	7. Tree maintenance status.	Hernández Zaragoza et al. (2015); Mexico
<b>3. Victim of Circumstances</b>	1. Tree for structure attachment.	Travelia & Arifin (2018); Tangerang, Indonesia
	2. Trees cause interference/obstruction.	Gwedla & Shackleton (2015); South Africa
	3. Conflict with other activities.	Kirkpatrick et al. (2012); Australia
	4. Priority of space usage.	Bhati & Pearce (2016); Singapore
	5. Use of tree parts for other purposes.	Richardson & Shackleton (2014); Eastern Cape, South Africa
	6. Tree without a protective structure.	Richardson & Shackleton (2014); Eastern Cape, South Africa

### Round One of Delphi Survey: Identifying the Relevant Criteria

A list of 21 criteria from three categories was included in round one of the Delphi survey. Upon completion of this round, a descriptive analysis was conducted to identify the criteria that the group of experts considered as being relevant for the incidence of tree vandalism. Table 7 shows the results for all the 21 criteria in the three tree vandalism categories (specific motives and actions, ideologies and practices, and victim of circumstances) and their respective mean scores. The group mean scores for relevance ranged from the lowest, 2.30 (age of tree: specific motives and actions category, and socio-economic status: ideologies and

practices category) to the highest, 3.67 (tree for structural attachment and conflict with other activities: victim of circumstances). Based on the group mean agreement of relevance ( $\geq 2.01$  group mean value), the results indicated that all the 21 criteria examined in this survey achieved consensus among the experts, and, thus, were selected as relevant criteria for the incidence of tree vandalism.

**Table 7:** Results of Round One of Delphi Survey

Item (N=21)	Mean
<b><i>Specific motive and action category (8 criteria)</i></b>	
1. Species of the tree.	2.47
2. Age of the tree.	2.30
3. Size of the tree.	2.57
4. Location of the tree.	3.57
5. The owner of the tree.	2.90
6. Tree characteristic.	2.67
7. Tree health condition.	2.83
8. Tree growth rates.	2.63
<b><i>Ideology and practices category (7 criteria)</i></b>	
9. Religious and cultural beliefs.	3.00
10. Level of knowledge.	3.37
11. Socio-economic status.	2.30
12. Rule and regulations.	3.37
13. Design and layout.	3.13
14. Tree maintenance approaches.	3.00
15. Tree maintenance status.	3.07
<b><i>Victim of circumstances category (6 criteria)</i></b>	
16. Tree for structure attachment.	3.67
17. Trees cause interference/obstruction.	3.63
18. Conflict with other activities.	3.67
19. Priority of space usage.	3.60
20. Use of tree parts for other purposes.	2.90
21. Tree without a protective structure.	2.97
Note: 0 – 1 = Strongly disagree, 1.01 – 2.0 = Disagree, 2.01 – 3.0 = Agree, 3.01 – 4.0 = Strongly agree	

The experts were encouraged to modify or delete any criteria that they believed were duplicates of other criteria, and also to suggest new criteria that they believed were important but had not been included in the list so as to increase the richness of the data. Out of the 30 respondents, 16 experts took the opportunity to suggest some new criteria. There were no suggestions for the existing criteria to be modified or deleted; however, the experts took the opportunity to suggest 11 new relevant criteria which they believed were important to consider but were not included in the existing list of criteria. Table

8 shows a shortlist of these new criteria derived from a pool of suggestions from these experts. There were an additional two criteria for the specific motives and actions category, four criteria for the ideologies and practices category, while five new criteria were added to the victim of circumstances category.

**Table 8:** Additional New Criteria Suggested by Experts

New criteria	Category
1. Tree debris.	Specific motive and action
2. Tree value.	
3. Coordination and cooperation.	Ideology and practices
4. Demographic (age).	
5. Tree care monitoring.	
6. Information on Tree Benefits.	
7. Infrastructure upgrading/extension & urbanization/development.	Victim of circumstances
8. Event and occasion.	
9. Rate of the human population.	
10. Memorial display.	
11. Tree as a protective structure.	

### Round Two of Delphi Survey: Identifying the Important Criteria

Following the identification of the relevant criteria in round one, round two was conducted to confirm these relevant criteria and examine their level of importance for a tree vandalism assessment. A list of 32 criteria was sent out to all the 30 experts who had completed the previous round of the Delphi survey. The results indicated that the group mean value of importance ranged from the lowest: 1.83 (socio-economic status: ideologies and practices category) to the highest, 3.78 (conflict with other activities and infrastructure upgrading/extension & urbanization/development both in the victim of circumstances category). All the 32 criteria from all three categories achieved consensus ( $\geq 1.01$  group mean value) (Table 9).

The analysis to determine the level of importance of each criterion was conducted based on the ranking order of the mean values (Gosavi, 2015), as shown in Table 9. The results indicated that the 'location of the tree' was the most important criterion (ranking no. 1), and the 'age of the tree' was the least important (ranking no. 10) for the specific motives and actions category. The 'level of knowledge' was the most important criterion (ranking no. 1), while the 'socio-economic status' was the least important (ranking no. 11) in the category of ideologies and practices. Meanwhile, the 'conflict with other activities' was the most important criterion (ranking no. 1), and the 'tree as a protective structure' was the least important (ranking no. 11) for the victim of circumstances category.

**Table 9:** Delphi Round Two Results

Item (N=32)	Mean	Variance	Ranking
<b><i>Specific motive and action (10 criteria)</i></b>			
1. Species of tree	2.78	0.54	<b>5</b>
2. Age of tree	1.94	0.53	<b>10</b>
3. Size of tree	3.17	0.85	<b>2</b>
4. Location of tree	3.61	0.37	<b>1</b>
5. The owner of the tree	2.72	0.57	<b>6</b>
6. Tree characteristic	2.72	0.80	<b>7</b>
7. Tree health condition	3.11	0.58	<b>3</b>
8. Tree growth rates	3.11	0.81	<b>4</b>
9. Tree debris	2.61	0.37	<b>8</b>
10. Tree value	2.06	0.64	<b>9</b>
<b><i>Ideology and practices (11 criteria)</i></b>			
11. Religious and cultural beliefs	2.72	0.80	<b>8</b>
12. Level of knowledge	3.67	0.24	<b>1</b>
13. Socio-economic status	1.83	1.44	<b>11</b>
14. Rule and regulations	3.67	0.35	<b>2</b>
15. Design and layout	3.11	0.58	<b>4</b>
16. Tree maintenance approaches	3.06	1.00	<b>6</b>
17. Tree maintenance status	2.94	0.64	<b>7</b>
18. Coordination and cooperation	2.67	1.41	<b>9</b>
19. Demographic (age)	2.33	0.82	<b>10</b>
20. Tree care monitoring	3.06	0.88	<b>5</b>
21. Information on tree benefits	3.22	0.65	<b>3</b>
<b><i>Victim of circumstances (11 criteria)</i></b>			
22. Tree for structure attachment	3.67	0.35	<b>5</b>
23. Trees cause interference/obstruction	3.67	0.24	<b>4</b>
24. Conflict with other activities	3.78	0.18	<b>1</b>
25. Priority of space usage	3.72	0.21	<b>3</b>
26. Use of tree parts for other purposes	2.67	0.71	<b>8</b>
27. Tree without protective structure	3.06	0.64	<b>6</b>
28. Infrastructure upgrading/extension & urbanization/development	3.78	0.18	<b>2</b>
29. Event and occasion	3.00	0.71	<b>7</b>
30. Rate of the human population	2.39	0.72	<b>9</b>
31. Memorial display	2.39	0.84	<b>10</b>
32. Tree as a protective structure	2.39	0.96	<b>11</b>
Note: Mean 0 – 1.0 = Not important, 1.01 – 2.0 = Least important, 2.01 – 3.0 = Average important, 3.01 – 4.0 = Absolutely important.			



## CONCLUSION

The research generated 32 important criteria for use in assessing the incidence of tree vandalism for urban tree care monitoring. The set of criteria determined in this study provides the necessary guidance to identify the incidence of tree vandalism in urban areas. More importantly, it provides accurate data for policymakers and tree managers to make effective decisions concerning tree vandalism issues.

This research has shown that the photographic method known as the photo-elicitation technique is able to provide richness to the qualitative data required from experts for an initial investigation into tree vandalism. This research has also demonstrated the value of the Delphi survey as a potential tool for generating important tree vandalism criteria, and in helping to generate the criteria ranking. Undoubtedly, since the criteria for a tree vandalism assessment have been determined in this research, further studies are needed to develop the indicators to represent the status of tree vandalism.

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