Aggregation of Thai arborist judgments on urban tree hazard inventories used to determine tree health at single-tree level

S Kaewkhow¹ and M Srivanit¹²

¹ Faculty of Architecture and Planning, Thammasat University, Pathumthani, Thailand.
² Research Cluster in Livable Environment and Architectural Design Laboratory (LEAD-Lab)

E-mail: suppawad@gmail.com

Abstract. Tree risk assessment has evolved greatly in recent years, from ground-based visual hazard inspection methods. In this paper, we focus on Thai arborist judgment aggregations on the common optimization of urban tree hazard inventories by using the visual tree assessment (VTA) method to develop qualitative risk assessments for tree risk mitigation. The aim of this study was to develop a tree hazard inventory identifies at single-tree level based on 35 parameters with interviewing arborist experts. And then to assess parameters that are relevant to the VTA method, content validity analysis used as the basis for screening the optimal tree inventories. The results showed that VTA inventories as having 11 parameters and the definition was clarified on tree health assessment at single-tree level. Understanding the tree inventories and tree hazard level can promote management decisions that will improve public health and environmental quality in urban areas of Thailand.

1. Introduction

The VTA (Visual Tree Assessment) method has spread very rapidly world-wide and it is the basis of many cities, not least because it mainly involves visual monitoring at single-tree level, which is cost-effective and gentle on the tree. The VTA method has already been the basis of several judgements in whole or in part in such manner as it may see fit within their own city [1,2], particularly in the implementation as many large Thailand cities such as Bangkok Metropolitan Administration and Chiang Mai Municipality. The focus on information at single-tree level reflects the motives and goals of municipal authorities regarding urban forestry programs, where hazard management, traffic safety, arboricultural management, species choice, replanting decisions, and monitoring changes in the urban forest have been found to dominate [3]. However, there are several ways in which arborists might be engaged. Cities or municipal authorities in a matter may engage their own expert, and have increasingly started to perform tree inventories. In many instances, especially in urban landscape planning matters, the local authority will have engaged a number of professionals to produce the urban tree hazard reports required by council for a local environment application. These arborist specialists and their reports may end up in court if local council does not approve the tree hazard assessment and management. Thus, tree inventories at single-tree level have become valuable data sources for city authorities studying the environmental, social, and economic services provided by urban trees in Thailand. Moreover, the VTA method has limitations regarding the data parameters that can be collected at single-tree level and their measurement accuracy on tree health assessment, a fact that
needs to be taken into account. In this study, the aggregation of arborist judgments by the in-depth interview technique was employed in this research. Being professional arborists involves using the VTA skills to deliver an appropriate level of tree assessment knowledge and to ensure that tree inventory parameters is accurately for non-arborist expert must fulfill. Results from this study can be used to help support which variables communities should be concerned with as they develop their local urban tree risk management programme.

2. Research Methodology
In total, 35 parameters used to determine tree health at single-tree level were identified across several studies [1,4,5,6,7,8], and grouped into 11 types of data-based parameters (e.g. age of planting, tree location, crown size and density, damage to the tree, diameter at breast height, hazard status, interaction with infrastructure or buildings, planting site, maintenance needs and history, management information, species, tree appearance and use, and vitality and health condition) (see figure 1). Then, the in-depth interview technique was undertaken with the three Thai experts of arboriculture (a professional arborist and two lecturers from landscape architectural and forestry departments) in order to elicit which tree inventory parameters reflected the tree health at single-tree level (figure 2 and figure 3). In this study, evaluate content validity will be test using the Item Objective Congruence (IOC) Index (index vary from 0.00 to 1.00) developed by Rovinelli and Hambleton (1977) [9], as the basis for screening the tree inventory parameters quality. The qualified parameters should have the IOC equal to or greater than 0.67, are considered as high reliability of urban tree hazard inventory parameters. If the IOC values which are below 0.67, will be considered as low or poor reliability.

![Figure 1. A proposed framework for the study of tree hazard inventory identifies at single-tree level by using the visual tree assessment (VTA) method.](image)
Figure 2. (a) In-depth interview with Thai expert of arboriculture, and (b) a field visit to the Yang tree (*Dipterocarpus alatus* Roxb.) healthcare programs a long Chiang Mai – Lamphun route.

Figure 3. A sample of basic tree risk assessment form used to determine tree health at single-tree level created by Bunchong Somboonchai, a professional arborist at Faculty of Architecture and Environmental Design, Maejo University.

3. Results and Discussion

The arborist experts tried to find the more specific parameters that could be described and covered by the tree inventories. The examination of the content validity by three experts have the evaluation of content validity score by IOC values ranged from 0.67 to 1.00. An eleven group of tree parameters are provided in Table 1 as a testing for interpretation purposes.

The IOC result shows that all inventory parameters (n=35) were a valid initial test with the overall reliability of 0.76 by mean IOC. The index value of 1 for tree appearance and use indicates (a list of valid parameters include cavities and windbreak width) that all experts agreed that the item is clearly measuring objective. The damage from insects and pests also has a high index of IOC value (IOC=0.86), indicating that the experts agree these parameters are clearly using to determine tree health at single-tree level (including damage to the tree, dieback, discolored leaves, mechanical damage, tree mortality, presence/absence of chlorosis, and presence of insects/disease). Only one of three experts believed that it is unclear whether the tree parameter (IOC=0.67) is the measure of age or year of planting, crown size and density, DBH, planting site, maintenance needs and history.

A five group of tree parameters were suggested by experts for improvement measures to determine tree health at single-tree level, as those parameters that had a similar content to other items, even though the IOC score of those items was more than 0.67. Moreover, to be useful in risk assessment and management, inventories must be regularly updated to include plantings, removals, and changes in tree condition. Obviously, this includes the collection of data that goes beyond what is needed to conduct a basic tree health at single-tree level. In contrast, the presence of an actively updated inventory was a key differentiation, which helped predict which programmes regularly conducted tree risk management [10].
Table 1. Index of items objectives congruence of types of tree data-based parameters

| Group of tree parameters | Inventories (n=35) | Mean of IOC | IOC* | Determine which valid/invalid parameters | Invalid (IOC < 0.67) |
|--------------------------|-------------------|-------------|------|-----------------------------------------|---------------------|
| Age or year of planting  | 1                 | 0.67        | 0.67 | Number of years after transplantation   | None                |
| Crown size, density     | 5                 | 0.67        | 0.67 | Crown size                               | None                |
|                         |                   |             | 0.67 | Canopy transparency                      |                     |
|                         |                   |             | 0.67 | Crown damage                            |                     |
|                         |                   |             | 0.67 | Crown density                           |                     |
|                         |                   |             | 0.67 | Crown dieback                           |                     |
| Damage, insects, and pests | 7            | 0.86        | 1.00 | Damage to the tree                      | None                |
|                         |                   |             | 0.67 | Dieback                                 |                     |
|                         |                   |             | 1.00 | Discolored leaves                       |                     |
|                         |                   |             | 1.00 | Mechanical damage                       |                     |
|                         |                   |             | 0.67 | Tree mortality                          |                     |
|                         |                   |             | 0.67 | Presence/absence of chlorosis           |                     |
|                         |                   |             | 1.00 | Presence of insects/disease             |                     |
| DBH (diameter at breast height) | 1            | 0.67        | 0.67 | Diameter at breast height                | None                |
| Hazard status           | 2                 | 0.84        | 0.67 | Existence of girdled roots              | None                |
|                         |                   |             | 1.00 | Tree part most likely to fail           |                     |
| Interaction with infrastructure or buildings | 5 | 0.74 | 1.00 | Proximity to building                   | None                |
|                         |                   |             | 0.67 | Building direction                      |                     |
|                         |                   |             | 0.67 | Conflict with infrastructure            |                     |
|                         |                   |             | 0.67 | Whether the sidewalk is raised          |                     |
|                         |                   |             | 0.67 | Tree position in relation to traffic    |                     |
| Location                | 6                 | 0.78        | 0.67 | Available planting spaces               | None                |
|                         |                   |             | 0.67 | Location                                |                     |
|                         |                   |             | 1.00 | Geographical location                   |                     |
|                         |                   |             | 1.00 | Local name                              |                     |
|                         |                   |             | 0.67 | Location of the trees                   |                     |
|                         |                   |             | 0.67 | Street name                             |                     |
| Planting site           | 3                 | 0.67        | 0.67 | Amount of impermeable cover             | None                |
| Maintenance needs and history | 1            | 0.67        | 0.67 | Pruning                                | None                |
| Size (except crown and DBH) | 2            | 0.84        | 0.67 | Number of trunks                        | None                |
|                         |                   |             | 1.00 | Height                                 |                     |
| Tree appearance and use | 2                 | 1.00        | 1.00 | Cavities                               | None                |
|                         |                   |             | 1.00 | Windbreak width                         |                     |

Note: *summary of three professional arborist experts' judgments regarding tree parameters of VTA.

4. Conclusions
Because there are no statistical tests for assessing significance of the measure, a substantive procedure is recommended for setting criterion levels. For example, an index value of 0.67 would occur if two
thirds of the decisions had perfect agreement that a parameter is measuring what it has been defined to measure and one thirds of the professional arborist experts were unsure if the item is measuring each of the objectives. The study recommended inspection of the objective averages for more detailed diagnostic purposes. An IOC value of 0.67 when two of three experts have perfect agreement on the objective being measured may be acceptable as other parameters. However, the IOC indicated that having just some form of inventory was not sufficient as the more ambiguous tree inventory parameter was used to determine tree health at single-tree level for urban tree conditions in Thailand.

Findings from this study identify the current state of urban tree risk management in the local or municipal authorities in Thailand, as well as the tree inventories which either cause or are associated with tree hazard assessment and management, and an investment in the collection and analysis of relevant urban tree data, to make informed decisions in their urban areas. Ideally, a municipal programme designed to address tree risk management should be developed in a proactive manner, before an incident involving a tree-related failure occurs. Once implemented, the programme should help to reduce the risk associated with personal injury or property damage.

5. References
[1] Schipperijn J, Pillmann W, Tyrvainen L, Mäkinen K and O’Sullivan R 2005 Information for urban forest planning and management Urban forests and trees Springer The Netherlands 399–417
[2] Nielsen AB, Östberg J and Delshammar T 2014 Review of Urban Tree Inventory Methods Used to Collect Data at Single-Tree Level Arboriculture & Urban Forestry 40(2) 96–111
[3] Keller JKK and Konijnendijk CC 2012 Short communication: A comparative analysis of municipal urban tree inventories of selected major cities in North America and Europe Arboriculture & Urban Forestry 38 (1) 24–30
[4] Matheny N and Clark J 1994 A photographic guide to the evaluation of hazard trees in urban areas (2nd ed.) Champaign IL International Society of Arboriculture.
[5] Fink S 2009 Hazard tree identification by visual tree assessment (VTA): Scientifically solid and practically approved Arboricultural Journal 32 139–155
[6] Norris M 2007 Tree risk assessments – what works – what does not – can we tell? A review of a range of existing tree risk assessment methods In ISAAC Conference Proceedings Perth p 29
[7] Paine LA 1971 Accident hazard evaluation and control decisions on forested recreation sites (Res. Paper PSW-68) Berkeley CA: Pacific Southwest Forest & Range Experiment Station Forest Service U.S. Department of Agriculture
[8] Östberg J, Wiström B and Randrup TB 2018 The state and use of municipal tree inventories in Swedish municipalities – results from a national survey Urban Ecosystems 21 467–477
[9] Rovinelli RJ and Hambleton RK 1977 On the use of content specialists in the assessment of criterion-referenced test item validity Dutch Journal of Educational Research 2 49-60
[10] Koese AK, Hauer RJ, Miesbauer JW and Peterson W 2016 Municipal tree risk assessment in the United States: Findings from a comprehensive survey of urban forest management Arboricultural Journal 38(4) 218-229

Acknowledgments
This study was supported by Thammasat University Research Fund, Contact No. TUGT 2/2562. The authors would like to express a heartfelt thanks to the involved professional arborists include Taradon Tunduan, Bunchong Somboonchai and Dr.Ponthep Meunpong, for their participation and contribution in the investigation. We especially want to thanks Khwanchanok Deepathana and the team of the LEAD-Lab for assisting this research project.