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Assessment of urban tree condition using VTA at Urban Green Space of Mataram University Rectorate

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Abstract. Urban green spaces, including those in the University of Mataram, is all urban land covered by vegetation of any kind, which has aesthetic and recreation values and are important components in improving the ecosystem function. Many trees at the University of Mataram Rectorate Area have aesthetical and ecological values. These trees have not been subjected to health assessment, while various stressors may have impacted the trees in the past. There is no available previous assessment information regarding the tree's health condition. The purpose of this study is to conduct a Visual Tree Assessment (VTA) to evaluate the 62 trees' health condition at the Mataram University Rectorate Area. The target trees were ≥ 20 cm diameter at breast height (dbh) and poles (10-19 cm dbh). The assessment was carried out using the VTA method to the condition of the common defects of the tree. The results show that based on the condition of the common defects of the tree, it was found that 22% of the trees had dead trees, top, and branches; 21% had parasite or mistletoe; 19% had stem or branch decay; 13% had weak branch union; 10% had poor tree architecture; 6% had cracks; 4% had termite attack; 3% had cankers, and 2% trees had root problems. Based on the hazard category of targeted trees, 79,03% of the trees are in Low hazard conditions (sound), 19,35% were in Moderately hazardous conditions, and only 1,61% were in Highly hazardous conditions. This assessment should be continued with an in-depth investigation. Monitoring and evaluation of tree health assessment should be done at least once a year. It is very important to gather up-to-date information on health conditions in the trees. The evaluation results integrated into GIS will be used as a tree health database that can be updated continuously. This data is expected to reduce the risk of damage that can be caused by the trees.

1. Introduction

Urban green spaces are all urban land covered by vegetation of any kind which has aesthetic and recreation values and are important components in improving the ecosystem function such as cleaning the air, modifying temperature extremes, noise reduction, and affecting micro-climate [1,2,3]. Trees in urban areas also provide the habitat for fauna in the city, such as avifauna [4], arthropods [5], reptiles [6], and mammals [7,8,9]. To optimize the function of urban trees, they must have a healthy and vigorous appearance. However, the urban trees have to face various stressors that cause negative impacts, such as destruction of roots by trenching, mechanical bruising and wounding, soil compaction, broken or partially attached branch, an open cavity in trunk or branch, dead or dying



branches, and decay and rot present in old wounds. Assessment of the tree health in the city is usually conducted by the city manager and the property manager.

One of the tree health assessments is the Visual tree assessment (VTA) method. This method is the simplest, easy to do, and nondestructive for healthy trees. This is a series of inspection activities on all parts of the tree to determine the health condition of the tree based on its biological and physical-mechanical characteristics based on arboricultural knowledge [10].

Inspections can be carried out at any time of the year with the aim of detecting, assessing, and documenting the presence of trees that have the potential to fall or break branches or die (hazard trees), then provide recommendations for the appropriate actions to be given to these trees. In the VTA, the observation and assessment of biological characteristics include the fitness of the trunk and branches, the condition of leaves and twigs, the presence of pests and diseases, especially pathogenic fungi, and the architecture of branches and tree branches [11,12]. This observation is carried out using a camera and binoculars, especially on parts of the tree that are not visible to the naked eye, such as branches, twigs, and leaves. Meanwhile, the mechanical characteristics include damage that occurs based on changes in the condition of the stems, wounds, holes, the slope of the stems, breaks or cracks of stems and branches (cracks), as well as conditions of mechanical damage to the roots.

At Mataram University Rectorate Area, 62 trees have aesthetical and ecological values. To the best of our knowledge, these trees have not been subjected to health assessment, while various stressors may have impacted the trees in the past. There is no available previous assessment information regarding the tree health condition as clearly indicated by decay, cracks, or other stressed condition. The purpose of this study is to conduct the VTA to evaluate the tree health condition at the Mataram University Rectorate Area.

2. Materials and methods

The assessment was made on 62 trees in the Mataram University rectorate area. The target trees were ≥ 20 cm diameter at breast height (dbh) and poles (10-19 cm dbh). The assessment was carried out using the VTA method to the condition of the common defects of a tree, which is (1) dead trees, top, and branches (2) cankers, (3) stem or branch decay, (4) weak branch union, (5) cracks, (6) root problems, (7) termite attack, (8) parasite or mistletoe, and (9) poor tree architecture. Data collected through the VTA method is then analyzed to conclude the hazard level of targeted trees into three categories, as presented in table 1. This analysis was developed based on Tree Risk Assessment Methods, which refers to the Three General Evaluation Forms (Andrew International Society of Arboriculture (ISA) Tree Hazard Evaluation Method [10]; United States Department of Agriculture (USDA) Forest Service Community Tree Risk Evaluation Method [13]; and ISA Tree Risk Assessment Best Management Practice (BMP) Method [14,15].

Table 1. Hazard category of targeted trees.

Hazard Category	Status	Defect level based on VTA (IMD ^{a,b} %)
1	Highly hazard condition	> 70
2	Moderately hazard condition	50 – 70
3	Low hazard condition	< 50

^a IMD = Intensity of Major Tree Defect

^b Defect type which has can threaten the biomechanical credibility and vigorous of particular tree parts, for example, severe decay (rot), severe subterranean termite attack, large open cavity, etc.

3. Results and discussion

VTA is important to determine anomalies such as wood decay, evidence of insect activity, physical damage, cavities, cracks, seams, bulges, buttresses, and other irregularities, including the status of the tree (apparently healthy, leaning, branch death, etc.) as part of a (VTA). It is important to access the signs and symptoms of defects in each targeted tree trunk, branches, leaves, crown, root, and micro-

environmental condition. As roots are located below the ground and not visible, their condition was estimated based on above-ground features like root girdling, top dying, and exposure with cuts or injures.

There are 62 target trees from 11 species examined in this study. The target trees have aesthetical and ecological values. Dominant species found were the Flamboyan (35.48%), followed by the Palm raja (24.19%), Cemara glodokan (14.54%) and Tanjung (11.29%) (table 2). The inspection was carried out by VTA and also supported by photographic documentation.

Table 2. Tree species identification in the study.

No.	Local name	Scientific name ^a	Percentage (%)
1	Flamboyan	<i>Delonix regia (Bojer ex Hook.) Raf.</i>	37,10
2	Palm raja	<i>Roystonea Regia (Kunth) O.F.Cook</i>	24,19
3	Cemara glodokan	<i>Monoon longifolium (Sonn.) B.Xue & R.M.K.Saunders</i>	14,52
4	Tanjung	<i>Mimusops elengi L.</i>	11,29
5	Angsana	<i>Pterocarpus indicus Willd.</i>	3,23
6	Beringin	<i>Ficus benjamina L.</i>	1,61
7	Beringin karet merah	<i>Ficus elastica Roxb. ex Hornem.</i>	1,61
8	Cemara pensil	<i>Cupressus sempervirens L.</i>	1,61
9	Jamblang	<i>Syzygium cumini (L.) Skeels</i>	1,61
10	Ketapang	<i>Terminalia catappa L.</i>	1,61
11	Mahoni	<i>Swietenia mahagoni (L.) Jacq.</i>	1,61

^a Source: <http://www.plantsoftheworldonline.org>

The diameter of each tree's main trunk and branch was measured and recorded (figure 1). The distribution of target trees with a diameter of 20-39 cm was 32 trees (51,61%), followed by trees with a diameter of 40-59 cm was 16 trees (25,81%), trees with a diameter of 60-79 cm were 3 trees (4,84%), and trees with a diameter of 80-100 cm was 2 trees (3,23%). Besides that, there are also 9 poles (14,52%) in this evaluation as an initial test before becoming a tree.

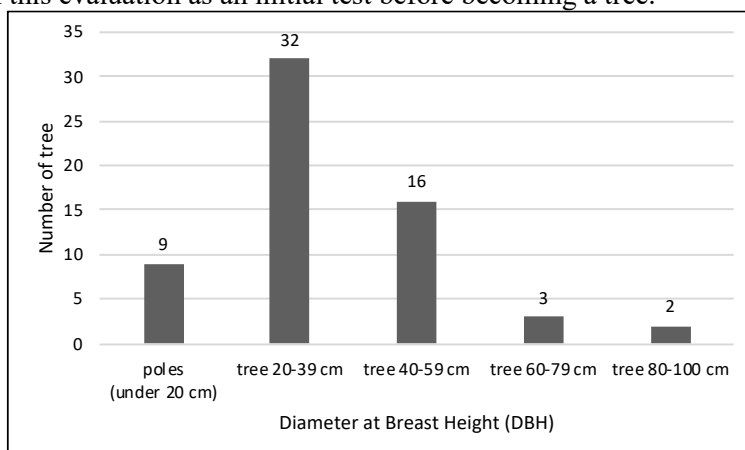


Figure 1. The distribution of the Diameter at Breast Height (DBH) of the target trees.

3.1. Tree defect

The percentage of common defects found in target trees is presented in figure 2. The results of this research show that based on nine types of defects (tree defects) or important deterioration of trees, there were 31 cases of dead branching (22%), 30 cases of parasite or mistletoe (21%), 27 cases of stem or branch decay (19%), 19 cases of weak branch union (13%), 15 cases of poor tree architecture

(10%), 9 cases of cracks (6%), 6 cases of termite attack (4%), 4 cases of cankers (3%) and 3 cases of root problems (2%). From these data, it can be seen that one target tree can experience more than one sign or symptom of deterioration.

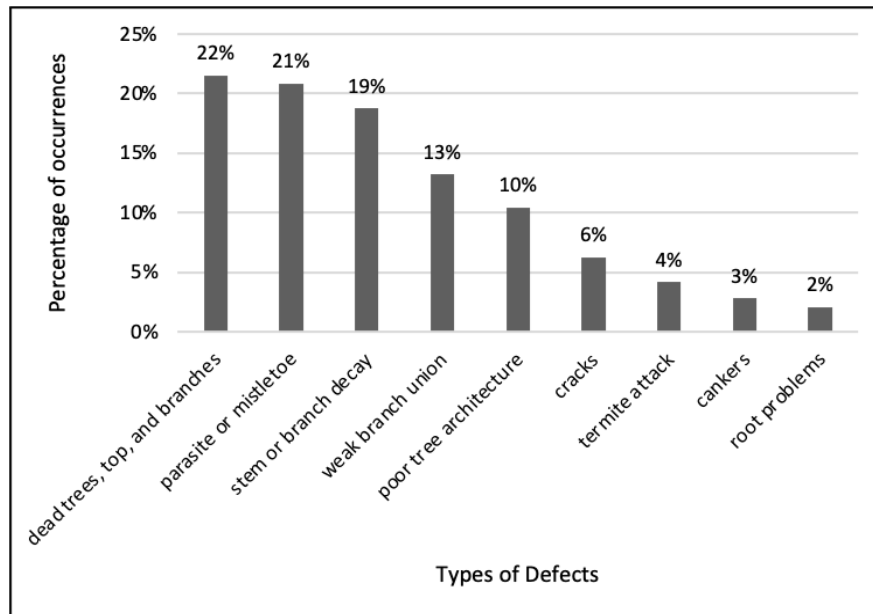


Figure 2. The percentage of common defects found in target trees.

Dead trees, tops, and branches are the most frequent problem found on the tree (figure 3a). It is suspected to be caused by sapwood decay and lichens, especially those seen on tree trunks and branches (figure 3c). This will be very dangerous because dead trees, tops, and branches will become a breeding ground for several species of wood destroyer [16,17]. Standing dead trees, top, and branches, especially coarse woody debris (CWD), is a preferred habitat for fungi, lichens, and insects and provides animals nesting places [18]. Particularly for fungal pathogens on stems by heavy weathering conditions, it is suspected to indicate high humidity depending on location and tree type [19]. However, there is only one dead tree (figure 3a), which is caused by *Ganoderma* root rot (figure 3f). This kind of fungus is one of the lethal diseases on the flamboyant tree [20]. *Ganoderma* is known to cause severe loss and is more prominent in humid regions and semi-arid locations [21].

In addition, a serious canker was also found on the main lateral branch (figure 3b). Swollen branches become soft and brittle, which is generally caused by a fungus [22]. Termites attack was detected on the tree's main trunk, indicated by existing termite tunnels (figure 3g). However, based on the morphological performance of the termite specimens, we identified that the termite was subterranean termite *Macrotermes gilvus* Hagen (Isoptera: Termitidae). This species is known as the most widely distributed termite species in Indonesia [23]. In addition, other defects like weak branch union, poor tree architecture, cracks, and bottle butt were found on the tree (figure 3).

3.2. Hazard category

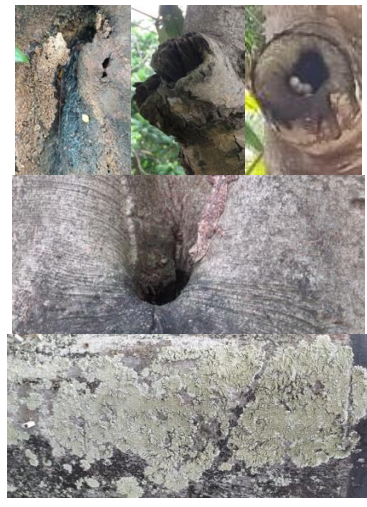
Hazard category of targeted trees based on VTA analysis presented in table 3. There was 1 Flamboyant tree with highly hazardous conditions based on hazard category. This tree should be removed because it has experienced rotting of the roots and. This recommendation can be considered in light of the consequences of falling trees on public safety. Fallen trees can eventually injure or cause death [15]. In addition, 12 other trees with moderately hazardous conditions must also be followed up immediately to reduce the potential for more serious damage. At the same time, the other 49 trees must be cared for to keep them in low hazard condition.



(a) dead trees, top or branches



(b) cankers



(c) stem or branch decay



(d) weak branch union



(e) cracks



(f) root problems



(g) termite attack



(h) parasite or mistletoe



(i) poor tree architecture

Figure 3. The common defects found in target trees.

The decay part of the main trunk and the branch should be removed and followed by fungicide application [24]. The open cavities must be protected to avoid the presence of decay. These cavities can be filled using polyurethane foam [25]. The termite colony should be eliminated by applicated a termite bait [26]. To make a symmetric canopy, the branch that leaned cross over the covered tree site should be removed by proper pruning. Trees that had been properly pruned will better withstand the wind than trees that had been improperly pruned or not pruned at all [27]. The assessment needs to be followed up with routine tree health assessment using sonic tomography and micro-drilling resistance to assure the entire condition of the tree [28].

Table 3. Hazard category of targeted trees based on VTA analysis.

Hazard Category	Status	Number of tree(s)	Percentage (%)
1	Highly hazard condition: tree with high IMD level (see table 1); light of the consequences of falling tree; dead tree; e.g. severe decay (rot), severe subterranean termite attack, large open cavity, etc. (defect > 70%)	1	1,61
2	Moderately hazard condition: a tree with multiple IMD (see table 1); must be followed up immediately to reduce the potential for more serious damage; e.g., cankers, cracks, etc. (defect 50 – 70%)	12	19,35
3	Low hazard condition: trees with minor damage; e.g. parasite, dead branches, etc (defect < 50)	49	79,03

3.3. Integration of research data into Geographical Information Systems (GIS)

The integrated display of the evaluation data from the VTA of 62 target trees is presented in the data entered in the Google Earth program. Figure 4 shows the general appearance of the geographic position of the target trees with various health conditions based on the results of the evaluation.

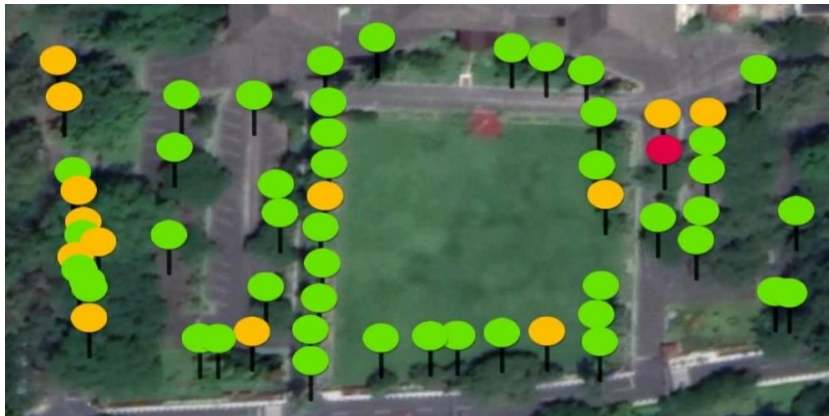


Figure 4. Display of the distribution of target trees on Google Earth based on the results of the evaluation of tree conditions: green symbol indicates Low hazard condition, the yellow symbol indicates Moderately hazard condition, and red symbol indicates Highly hazard condition.

4. Conclusion

The results show that based on the condition of the common defects of the tree, it was found that 22% of the trees had dead trees, top, and branches; 21% had parasite or mistletoe; 19% had stem or branch decay; 13% had weak branch union; 10% had poor tree architecture; 6% had cracks; 4% had termite attack; 3% had cankers; and 2% trees had root problems. The high number of trees that suffer from

dead trees, top, and branches must be considered to reduce the damage since these parts can fall which can endanger public safety. Based on the hazard category of targeted trees, 79,03% of the trees were in Low hazard condition (sound), 19,35% were in Moderately hazard condition, and only 1,61% were in Highly hazard condition. However, this assessment should be continued with an in-depth investigation. Monitoring and evaluation of tree health assessment should be done at least once a year. It is very important to gather up-to-date information on health conditions in the trees. The evaluation results integrated into GIS will be used as a tree health database that can be updated continuously. This data is expected to reduce the risk of damage that can be caused by the trees.

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