



Full Length Research Article

Tree Health Management Strategy in Cianjur Urban Forest

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ABSTRACT

Urban forests have a high intensity of exposure from external factors such as air pollution and human activity disturbances. As a result, fallen trees and tree defects often occurred and can endanger the people around the city. This study aimed to assess tree health in Cianjur Urban Forest and formulate tree health management strategies. The tree health assessment used the Forest Health Monitoring (FHM) method. The management strategy was formulated using the Strengths, Weaknesses, Opportunities, and Threats (SWOT) Matrix and Quantitative Strategic Planning Matrix (QSPM). Tree sampling using FHM plots determined about 534 trees from 30 species. The results showed that Cianjur Urban Forest had high land productivity and biodiversity. The canopy condition was 86.41% in good condition. The results revealed that 92.70%, 5.34%, 1.31%, and 0.56% of the trees were in healthy, lightly, moderately, and heavily damaged conditions, respectively. The tree species that suffered the most damage was *Acacia denticulosa*. The most types of tree damage were leaf damage and rotten wood. Cianjur Urban Forest benefits the community as a place for natural tourism, sports, education, and expand job opportunities. However, the management of Cianjur Urban Forest has not been implemented effectively. There are three priority strategies to improve tree health management in Cianjur Urban Forest, i.e., conducting the assessment, evaluation, and action on damaged trees, community cooperation, institutional strengthening development programs, and optimizing collaboration and government commitment with managers.

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1. Introduction

Cities are places for all activity centers, such as residential areas, workplaces, education, trade, traffic centers, and other very intensive activities. These activities enhance urban development. The development in the urban environment increases with the increasing population and is supported by the need for land. This land requirement can lead to a decrease in the percentage of green areas in a city (Septriana et al. 2004). According to Budiman (2014), reduced green open space in big cities is influenced by cities' developments. In 2000-2013, the area of green open space in big cities decreased, such as DKI Jakarta were -0.17%, Bandung -0.33%, and Yogyakarta -0.03%. However, cities need sound environmental quality to balance the relationship

between humans and their ecosystem. Environmental conditions in urban areas are currently a major problem, such as increased pollution and air temperature (Lubis et al. 2012). One of the significant alternatives to urban environmental problem solving is through the urban forest development program.

Cianjur is a regency that is actively developing, especially in the infrastructure sector. This is stated in the Regional Regulation of Cianjur Regency Number 17 of 2012 about the 2011-2031 Regional Spatial Plan of Cianjur Regency and the Study Draft of the Regional Medium-Term Regulation of 2016-2021. These various developments in Cianjur have resulted in not achieving the target of 30% of the provision of green open space of the total urban area. The available green open space is only 14.9% of the entire urban area (Dinas Kehutanan dan Perkebunan Cianjur 2013). Therefore, the Cianjur Regency Government is developing more green open spaces, one of which is through the Cianjur Urban Forest development. The land in the Cianjur Urban Forest began to be planted from 2002 to 2003. In 2017, the Cianjur Regency Government began developing the Cianjur Urban Forest by developing the natural tourism of Cianjur Urban Forest, also known as "Hukoci" (Hutan Kota Cianjur).

The evaluation of vegetation in Cianjur Urban Forest has never been carried out. In addition, urban forests have a higher intensity of exposure to external factors than other forests, such as air pollution and disturbances to human activities. These are some of the causes of declining tree health in urban forests (Susilowati et al. 2018). It is essential because forest health is one of the criteria for achieving sustainable forest management (Abimanyu et al. 2019; Safe'i et al. 2019). The health of trees in urban forests is also essential to maintain visitors' safety and their surroundings. Forest health criteria were developed by Southeast Asian Regional Centre for Tropical Biology (SEAMEO BIOTROP), which adopted the Forest Health Monitoring (FHM) method (Stuckle et al. 2001). So, it is necessary to formulate a tree health management strategy in Cianjur Urban Forest to maintain its function as a buffer for the urban environment.

2. Materials and Methods

2.1. Study Area

This study research was conducted in Cianjur Urban Forest, located in Gelarmaju Village, Babakankaret, Cianjur District, Cianjur Regency. Geographically, this urban forest is located at coordinates 6° 79' 47.72" S and 107° 13' 57.67" E. Cianjur Urban Forest is located ± 3 km from the center of Cianjur City. Cianjur Urban Forest has an area of 11.3 ha. Cianjur Urban Forest has a height of ± 520 meters above sea level. The slope of the land ranges from 12% - 27%. The average rainfall per year ranges from 2,500 mm – 4,000 mm, with 150 rainy days per year. The temperature ranges from 18°C to 31°C. In general, Cianjur has a tropical climate, with a considerable wind effect, the wind speed in the Cianjur urban forest is 0.52 m/sec.

2.2. Data Collection and Analysis

2.2.1. Tree sampling

The sampling method for Forest Health Monitoring (FHM) used a cluster plot. The plot cluster consisted of 4 circular plots. The determination of the FHM plot used the purposive sampling method. The plot's center point is determined based on the location, representing all standing tree conditions in the urban forest. The criteria to determine the plot were land density,

the topography was relatively flat, and within the study area. The sampling intensity used was 10% (Fachrul 2007), which was 12 plots. Annular plots were made for measuring tree samples (Fig. 1). The parameters measured were the symptoms of damage and the circumference of the tree. The subplot was used for crown and sapling stage measurement (Cumming et al. 2008). The parameters measured were crown diameter, branch-free height, and tree height.

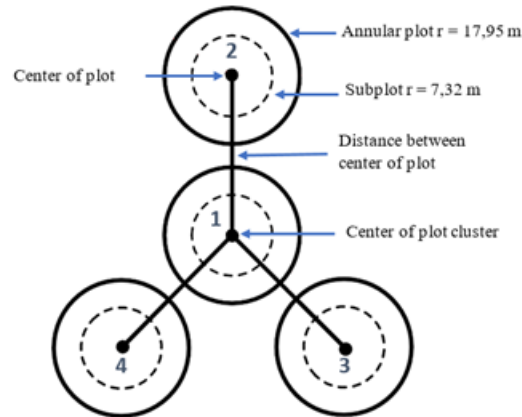


Fig. 1. Sampling plot design (Source: Pertiwi et al. 2019; Pratiwi and Safe'i 2018; Supriyanto and Iskandar 2016; USDA 1999).

2.2.2. Tree health assessment

Forest is classified as healthy when all components in the forest function optimally. Tree health in tropical forests can be assessed based on productivity, biodiversity, crown condition, and tree damage conditions (Stuckle et al. 2001; USDA 1999).

2.2.2.1. Productivity

Assessment of plant productivity is determined by the value of basal area (LBDS) (Cline 1995; Safe'i and Tsani 2016). LBDS interprets plant growth rates that are easily measured and have a high degree of accuracy and consistency (Philip 1994). LBDS (cm²) can be calculated using the following formula:

$$LBDS = \frac{1}{4} \pi d^2$$

where π is 3.14, d is the diameter at breast height (cm).

2.2.2.2. Biodiversity

Observation to determine the structure and composition of species in urban forests. The following is the biodiversity formula (Soerianegara and Indrawan 1982).

$$H' = - \sum p_i \ln p_i$$

$$P_i = \frac{\text{The number of trees of one species}}{\text{The number of trees in a plot}}$$

After the value of H' is calculated, the level of diversity will be determined on the condition that the criteria for the diversity index are as follows (Mawazin and Subiakto 2013):

$H' < 1$ = vegetation communities with less stable environmental conditions,

$H' > 2$ = vegetation communities with very stable environmental conditions.

2.2.3. Tree crown conditions

According to Putra (2004), a tree stand's vitality can be assessed based on the crown's condition. For each subplot, data were taken for the total tree height, branch-free height, and width (LT) or diameter of x and y canopy to assess crown condition. The LT and LCR conditions were then classified using Table 1. The LCR value in Table 1 was obtained through the proportion of crown length to tree height (Safe'i et al. 2013). The LT and LCR criteria can be used to determine tree crown condition (Table 2).

Table 1. LT and LCR classification (Putra 2004)

Parameter	Classification		
	Good (score = 3)	Medium (value = 2)	Bad (value = 1)
LCR	$\geq 40\%$	20-35%	5-15%
Crown width (LT)	≥ 10.1 m	2.5-10 m	≤ 2.4 m

Table 2. Crown condition assessment criteria

Crown Condition	Criteria
Good	If all values (LCR and LT) are good or a combination of good and moderate
Moderate	If all LCR and LT values are moderate or a combination of good and poor
Poor	If all LCR and LT values are poor, or a combination of moderate and poor

2.2.4. Tree Damage

Assessment of tree damage conditions is an indicator that can state a tree's health level (Pertiwi et al. 2019). The condition of tree damage was assessed using the FHM method. This method has been widely practiced in forests in America but is a relatively new technique applied in tropical areas, such as is Indonesia (Susilowati et al. 2018). Assessment of tree damage level is carried out through direct observation and identification using three indicators. The indicators are the location (L), type (T), and severity (K) of tree damage (Table 3 and Table 4). The severity of tree damage is assessed from a damage level of 0-90%. Damage of each tree is recorded for a maximum of three damages. If damage occurs in the same location, the most severe damage is recorded (Pertiwi et al. 2019). Then scoring for each code damage type, location, and severity of tree damage using Table 5.

Table 3. Code and description of tree damage location (T) (Putra 2004; Safe'i and Tsani 2016)

Code	Description
0	Healthy (no damage)
1	Roots (open) and stump (30 cm above the ground level)
2	Damage to roots and lower stems
3	Damage to lower stem (1/2 part lower stem between the stump and the base of the live canopy)
4	Lower and upper stems
5	Top stem (1/2 upper part between stump and base of live canopy)
6	Canopy stem (main stem in the live crown area, above the base of the canopy live)
7	Damage to the branch (> 2.54 cm at the branching point to the main stem or stem inside the canopy area)
8	Damage to buds and shoots (growth in recent years)
9	Leaf

Table 4. Code and description of type (T) and severity (K) of tree damage (Nuhamura and Kasno 2001; Putra 2004; Sagita 2015)

Code	Description	Severity Threshold Value (in class 10% -99%)
1	Cancer, gall (<i>puru</i>)	≥ 20% from the point of observation
2	Konk, fungi, and other indicators of rotten wood	None, except ≥ 20% at roots > 3 feet (0.91 m) from stem
3	Open wound	≥ 20% from the point of observation
4	Resinosis / gummosis	≥ 20% from the point of observation
5	Broken stem	None
6	Termite nests	≥ 20% from the point of observation
11	Stems or roots are broken less than 3 feet (0.91 m) from the stems	None
12	Brum on roots or stems	None
13	Roots are broken or dead > 3 feet (0.91 m) from stems	≥ 20% at the root
14	Scale insect	≥ 20%
20	Liana or parasitic plant on the leaf/crown or benalu	≥ 20%
21	Dieback	≥ 1% on canopy branches
22	Branches broken or dead	≥ 20% on twigs or shoots
23	Excessive branching or brum	≥ 20% on twigs or shoots
24	Damaged leaves, buds, or shoots	≥ 30% leaves cover canopy
25	Leaves change color	≥ 30% leaves cover canopy
31	Others	

Table 5. Scoring of code damage type, location, and severity of the tree (Sagita 2015)

Type Code	Score T	Location Code	Score L	Severity	Score K
1, 26	1.9	0	0	0 – 9 %	1.0
2	1.7	1	2	10-19%	1.1
3,4	1.5	2	2	20-29%	1.2
5	2	3	1.8	30-39%	1.3
6	1.5	4	1.8	40-49%	1.4
11	2.0	5	1.6	50-59%	1.5
12	1.6	6	1.2	60-69%	1.6
13, 20	1.5	7	1	70-79%	1.7
21	1.3	8	1	80-89%	1.8
14, 22, 23, 24, 25, 31	1.0	9	1	≥90%	1.9

Tree Damage Level Index (TDLI) was calculated using the formula below. Then determine the category of damage based on TDLI (Table 6).

$$TDLI = T \text{ Value} \times L \text{ Value} \times K \text{ Value}$$

Table 6. Tree damage categories based on TDLI

TDLI score	Category
≤ 5	Healthy
6 - 10	Light damage
11 - 15	Moderate Damage
≥ 16	Heavy Damage

2.2.5. Social and Management Data Collection

Data were collected using questionnaires and interviews with people living close to the urban forest, visitors, and managers of the Cianjur Urban Forest, i.e., Cianjur Environmental Service (DLH) and the Cianjur Tourism, Youth, and Sports Agency (DISPARPORA). Perception questionnaires about the benefits of Cianjur Urban Forest for the community were prepared using a Likert scale. The method of selecting respondents was done by using purposive random sampling. The criteria for selecting respondents are people who know and have visited the Cianjur Urban Forest. The sample of respondents to be selected was 50 respondents.

2.2.6. Formulation of Management Strategies

Tree health assessment, social, and management condition is needed for the formulation of management strategies. These three aspects were then used to determine the internal and external factors, which are the critical factors in tree health management in Cianjur Urban Forest. According to the strategic management model (David 2011), these factors are essential aspects of strategy formulation. Strategy formulation consists of three stages: the data input stage, the data matching stage, and the decision-making stage (David 2011).

- a. The input stage uses the IFE (Internal Factor Evaluation) and EFE (External Factor Evaluation), i.e., entering the key factors and providing weight and rating. The weight and rating are given by experts, who are the managers of Cianjur Urban Forest from Cianjur Environmental Service (DLH) and the Cianjur Tourism, Youth, and Sports Agency (DISPARPORA). According to David (2011), the weighting of each factor uses a scale ranging from 1.0 (most important) to 0.0 (not important), and the total weight of all factors does not exceed a total of 1.0. The weights indicate the importance of each factor to tree health management. The ranking of each factor uses intervals from 1–4, where 4 is very good, 3 is good, 2 is average, and 1 is poor. Each weight and rank for each factor is multiplied by the score for each factor. These scores are then added together to calculate the total average of internal and external factors that will be included in the Internal-External (IE) Matrix.
- b. The matching stage is to devise opportunities, threats, strengths, and weaknesses in the key factors that have been determined. At this stage, the SWOT (Strength-Weakness-Opportunities-Threats) Matrix is used. The IE Matrix is used to produce several strategic options. SWOT analysis is based on the logic to maximize the strengths and opportunities and simultaneously minimize the weaknesses and threats.
- c. The decision-making stage to determine which strategic priority should be selected uses the Quantitative Strategic Planning Matrix (QSPM). The QSPM provides the most optimal strategy to be implemented based on a strategy that is most influenced by key factors. The QSPM is calculated by Total Attractiveness Score (TAS). This scoring is also conducted by experts, i.e., DLH and DISPARPORA. Each key factor is matched with each strategy on the SWOT analysis, then given attractiveness score with intervals 1–4. The highest TAS is the most important strategic priority option.

3. Results and Discussion

3.1. Tree Health

3.1.1. Forest productivity

The average LBDS of trees in Cianjur Urban Forest is 25.72 m²/ha, with an average tree diameter of 23.06 cm. The vegetation density in Cianjur Urban Forest for the sapling stage is 76 trees/ha, the pole stage is 144 trees/ha, and the tree stage is 219 trees/ha. [Sagita \(2015\)](#) reported the highest average LBDS in Garut Urban Forest Garut of 14.72 m²/ha with an average diameter of 44.86 cm. Based on this comparison, it can be stated that the basal area of trees in Cianjur Urban Forest is classified as very high, which means that Cianjur Urban Forest has good plant productivity. LBDS also interprets the productivity of a tree over time ([Sagita 2015](#)). This is because plant growth can be influenced by environmental factors, such as disturbance factors (diseases, pests, and weeds), climatic factors (rainfall, wind, and temperature), and essential factors (sunlight, water, and nutrients). When the LBDS value is high, it indicates that plant growth is not inhibited by these disorders ([Widyastuti 2018](#)).

3.1.2. Biodiversity

The Shannon-Wiener diversity index (H') is an appropriate index for calculating species diversity level ([Suratissa and Rathnayake 2016](#)). The H' of species in the Cianjur Urban Forest is classified as high (H' > 2), with the H' value of 2.73. This shows that the vegetation and environmental conditions in this forest is very stable. The biodiversity of vegetation can be used as an indicator for assessing health in a forest. This is because biodiversity is very easily influenced by the environment, interactions among living organisms, and interactions between living organisms and their environment. Changes in biodiversity can be caused by positive or negative responses from these interactions. These responses can be observed in the form of development, growth, death of living organisms or species, and migration ([Safe'i et al. 2018](#)).

3.1.3. Tree crown conditions

Visual Crown Rating (VCR) is divided into good, moderate, and poor conditions. Based on the results of the assessment, as many as 86.41% (86 trees) of tree crowns were in good condition, 9.71% (10 trees) were in moderate condition, and 3.88% (4 trees) of tree crowns were in poor condition (**Fig. 2**). VCR describes the condition of the crown, where the higher value means the better crown condition. According to [Putra \(2004\)](#), the tree stand's vitality can be assessed based on the tree crown and tree damage condition. The crown condition is an important parameter to be assessed because it is the place for photosynthesis. The photosynthesis results are distributed for the growth of the plant ([Cavalli and Finger 2017](#)). The canopy also reflects a close relationship with tree health because it has a function in maintaining the balance of energy regulation from sunlight, distributing rainwater, and retaining moisture in the forest.

Cianjur Urban Forest has a dominant proportion of 93.68% green area, and the rest is built-up land for natural tourism support facilities. Based on the measurement results, the vegetation density in Cianjur Urban Forest for the sapling stage is 76 trees/ha, the pole stage is 144 trees/ha, and the tree stage is 219 trees/ha. According to [Rusmana and Susanti \(2015\)](#), the optimal number of trees/ha at the sapling stage is 400 trees/ha, 100 trees/ha for the pole stage, and 25 trees/ha at the tree stage. Based on this, the number of trees per hectare for poles and trees level in the Cianjur

Urban Forest exceeds the optimal limit, so that it allows for competition for canopy in getting sunlight. The condition and development of the tree canopy are influenced by the spacing and competition of the surrounding trees. Thus density determines the growing space for the tree to develop the crown. Dominant trees with the characteristics of larger tree sizes, wider crowns, and many roots have the higher competitiveness than non-dominant trees in absorbing environmental factors such as light, water, and nutrients (Sharma et al. 2016).

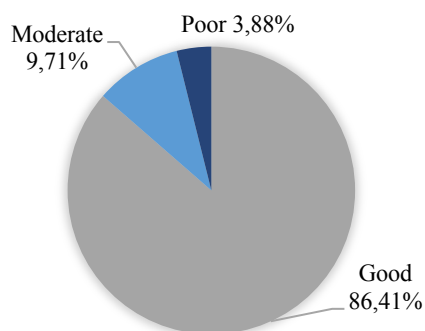


Figure 2. The Visual Crown Rating (VCR) of Cianjur Urban Forest canopy.

3.1.4. Tree damage

Assessment of tree damage conditions is an indicator that can state a tree's health level (Pertiwi et al. 2019). The results of the assessment of damage level to trees showed that there were 92.70% (495 trees) classified as healthy, 5.34% classified as lightly damaged, 1.31% moderately damaged, and 0.56% (3 trees) heavily damaged (Fig. 3). The 3 trees in the heavily damaged category are two *Acacia denticulosa* trees and one *Enterolobium cyclocarpum* tree. The results of field identification found several factors that could cause tree damage to several plants in the Cianjur Urban Forest. These factors include the presence of lightning and wind attacks, the suitability of growing place with tree growth requirements, tree density, shade factors, competition for nutrients, human activity, and the presence of fungal infections.

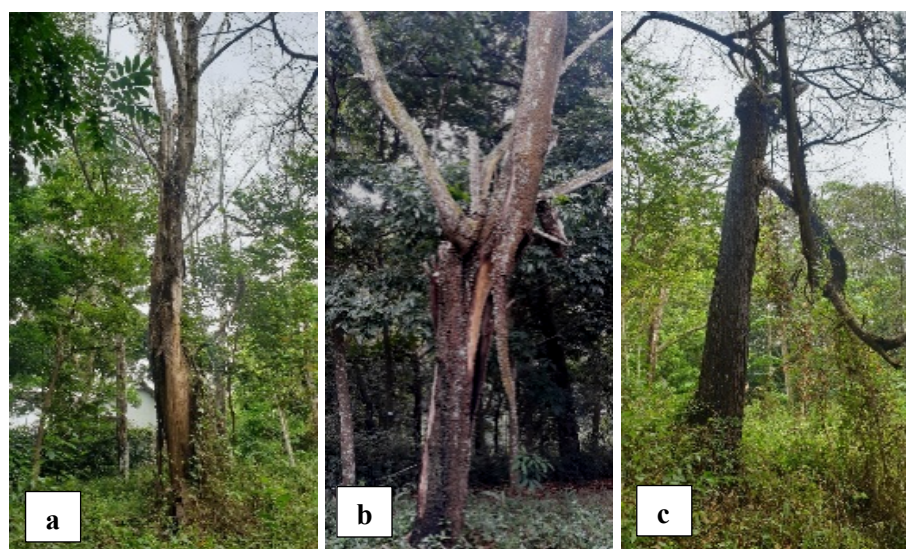


Fig. 3. Heavily damaged trees in Cianjur Urban Forest: broken stem and damaged leaves of *A. Denticulosa* (a, b), rotten wood, damaged leaves, and broken branches of *S. Mahagoni* (c).

Tree damage is usually caused by biotic disturbances such as disease, insects, and abiotic factors such as wind, rain, and lightning (Pertiwi et al. 2019). There are 15 types of tree damage in Cianjur Urban Forest from the 17 types of tree damage (Manglod 1997; Safe'i and Tsani 2016). The most common types of tree damage were leaf or shoot damage reaching 23.95%, rotten wood reaching 19.77%, change in leaf color 19.49%, cancer or gall 11.79% of the total type of damage (Fig. 4). The least types of damage that attacked the trees at Cianjur Urban Forest were broken stems (0.38%) and resinosis or gummosis (0.76%).

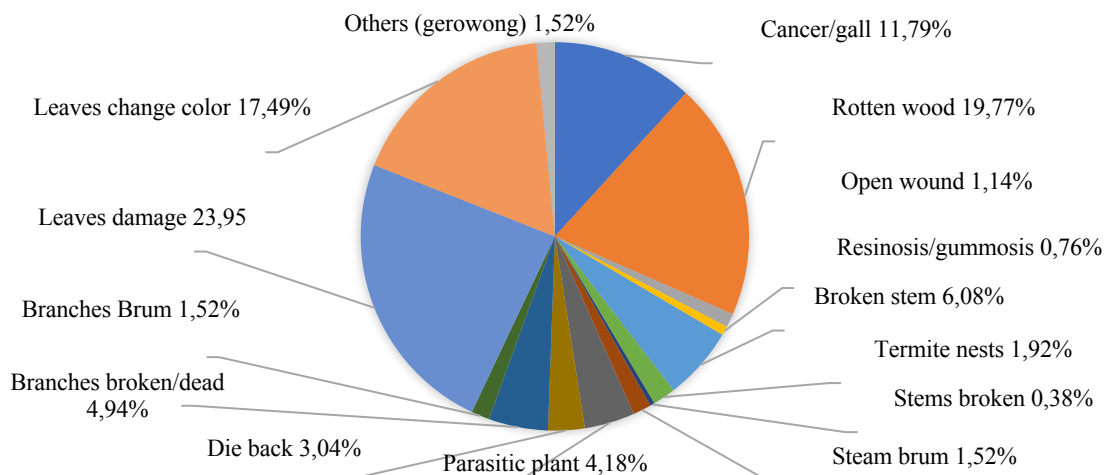


Figure 4. The distribution of the damage type to trees in Cianjur Urban Forest.

Tree damage occurred to *Gmelina arborea*, *Ceiba pentandra*, *P. imbricatus*, *E. cyclocarpum*, *A. denticulosa*, *H. brasiliensis*, *F. lyrata*, and *M. eminii*. Tree damages in *G. arborea*, *C. pentandra*, and *E. cyclocarpum* were indicated by leaf fall, which is a form of adaptation and self-defense against the environment (Kijkar 2004; Orwa et al. 2009). These types will shed their leaves during the dry season to reduce evaporation. Damage to shoots or leaves on other species can be caused by disease. Disease attack *Pestalotiopsis* sp. can make yellow leaves and brown spots, and leaf fall occurs. In addition, lack of N nutrient also causes leaf damage such as spotting on leaves, yellowing of the leaves, and then falling (Wasis and Anggraini 2017).

The type of rotten wood damage in Cianjur Urban Forest occurred as much as 19.77%. The damage is indicated by the presence of punky wood. This rotten wood indicates that there is wood tissue that becomes soft (damaged wood tissue), wood degraded, and has high water content (Nuhamara and Kasno 2001). Rotting of these woods can make the trees more vulnerable to fall and die, and endangering visitors (Abimanyu et al. 2019). Rotting on trees can be preceded by open wounds as a medium for fungus entry and develop in wood (Abimanyu et al. 2018; Pertiwi et al. 2019). According to Nuhamara and Hadi (1999), open wounds on the stem or branches allow wood rot fungus to penetrate the heartwood. As a result, the wood tissue is damaged, and the wood is rotting.

Rotten wood occurred in 47% of *A. denticulosa* and 41% of *S. mahagoni*. These two types are the species that compose the most vegetation in the Cianjur Urban Forest. *A. denticulosa* was the species that suffered the most damage. Nuhamara and Hadi (1999) stated that acacia tree species are susceptible to rotting the heartwood, which usually begins with a wound on the tree and becomes infected. Meanwhile, *A. denticulosa* has growing requirements that are not matched with environmental parameters. *A. denticulosa* has a requirement to grow at an altitude of 0-300

m above sea level and an average rainfall of 1,000–2,100 mm/year. Meanwhile, Cianjur Urban Forest has an altitude \pm 520 m and rainfall of 2,500–4,000 mm/year; hence tree cannot grow well in that condition. Acacia species are susceptible to pests and diseases (Hidayati and Nurrohmah 2015; Sulendra et al. 2017), especially by fungi, one of which is the most common caused by *Ganoderma* sp. that causes plants to wither, not develop, and rot on the stems (Hidayati and Nurrohmah 2015). Rotten wood on mahogany stems can be caused by the fungi *Rhizopus arrhizus* and *Myrothecium verrucaria*. Infection of *R. arrhizus* on the stem is characterized by white patches on the bark getting bigger and thicker. Meanwhile, an infection sign of *M. verrucaria* fungi is the stem's color turning blackish-brown and damaging its epidermal layer (Darmuh et al. 2018).

The location of tree damage in Cianjur Urban Forest was identified as scattered in 7 parts. The most damage was 21% on the top of the stem and 19% on the buds or shoots. The stem is the support for the canopy. Physiologically, the stem's role is vital for transporting nutrients (Safe'i and Tsani 2016). Damage to the stem can affect the nutrients and water distribution by plants, which could disrupt the photosynthesis process (Supriyanto and Iskandar 2016).

3.1.5. Social aspects

The Decree of the Regent of Cianjur Number 522.12/Kep.10d-Pe/2010 concerning Cianjur Urban Forest explains that the Cianjur Urban Forest functions as a hydrological and ecological area, natural tourism, education, research, counseling, and germplasm protection. As a hydrological area, Cianjur Urban Forest is a water catchment area used to irrigate paddy fields downstream and around the area. As an ecological function, Cianjur Urban Forest is a place to live at least 35 species of fauna and 91 species of flora. Based on the questionnaires and interviews with respondents, the advantages of Cianjur Urban Forest are for sports, learning about nature, natural tourism, and creating jobs. In the Decree of the Regent of Cianjur, Cianjur Urban Forest functions as an education area and an object of natural tourism. Cianjur Urban Forest's function develops into a place for the community to open businesses and exercise. The Cianjur Urban Forest also maintains environmental air quality around the city. Based on the calculation results, Cianjur Urban Forest contributes to the absorption of CO₂ from urban air with an estimated carbon stored of 53.87 ton/ha. Based on the results of field observations and questionnaires to respondents, it was revealed that Cianjur Urban Forest had many broken branches or twigs and lots of shrubs or weeds, as shown in **Fig. 5**. Respondents stated that the Cianjur Urban Forest needs to be reorganized as a natural tourist destination, such as improving and repairing facilities and infrastructure, cleaning the land, and arranging and maintaining the trees.

3.1.6. Management

The administration of Urban Forests as described in Government Regulation No. 63 of 2002 includes activities of development, determination, and management. The Cianjur Urban Forest management rights are owned by the Cianjur Regency Environmental Service (DLH). Based on an interview with the Environmental Agency, since management was taken over from the Forestry and Plantation Service of Cianjur Regency (Dishutbun) to DLH in 2017, there has been no management, especially management to the vegetation. This is because there are limited funds provided related to the management of the Cianjur Urban Forest. In the Decree of the Regent of Cianjur Number 522.12/Kep.10d-Pe/2010, the urban forest management is still the right of Dishutbun, and there has been no renewal.

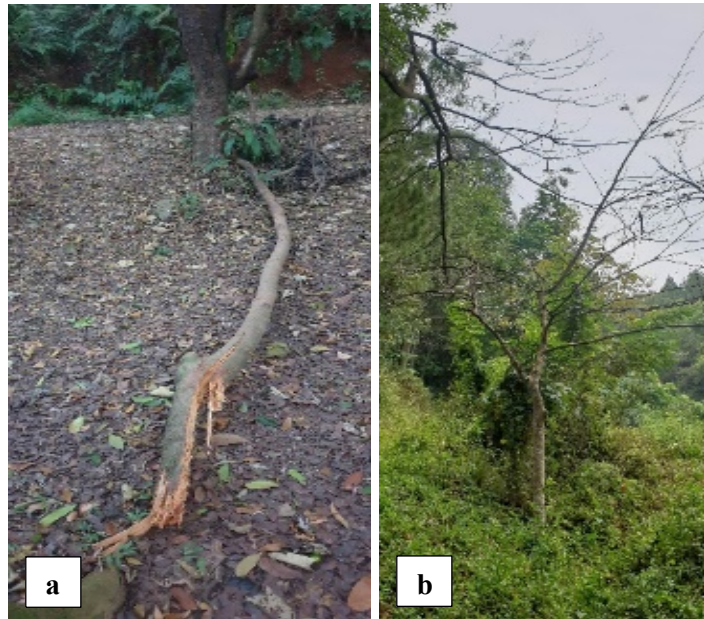


Fig. 5. (a) Broken branches of *S. mahagoni* and (b) weeds in Cianjur Urban Forest.

Before the management rights were given to DLH, the maintenance of vegetation in the Cianjur Urban Forest was implemented. The maintenance carried out includes replanting plants that fail to grow, cutting the weeds, and pruning the branches. In 2017, the Cianjur Regency Tourism, Youth, and Sports Agency (DISPARPORA) built natural tourism destinations in Cianjur Urban Forest named "Taman Wisata Hukoci". Cianjur Urban Forest was built with various kinds of facilities for natural tourism. However, tourism activities have stopped about 4 months after opening due to a lack of funds. The conditions of supporting facilities for natural tourism need to be repaired, such as damaged garden lights caused by lightning strikes, lack of water source for the toilet, and broken facilities. Cianjur Urban Forest Manager must install lightning rods due to the existence of an Extra High Voltage Air Line (SUTET) tower that caused several facilities and trees to be damaged due to the lightning strikes.

In the institutional aspect, in 2017 DISPARPORA, with the head of Babakankaret formed a community organizer named "Kompepar" as an informal organization. Kompepar members come from people living around the Cianjur Urban Forest area. Kompepar was formed to grow awareness of natural tourism so that a sense of responsibility can arise and participate in tourism development and activities. Kompepar can improve services to tourist visitors, maintain cleanliness, and expand job opportunities for the people living around urban forest, and create a harmonious relationship between DLH, DISPARPORA, and other parties. However, after formed, Kompepar did not make work programs and meeting agendas so that their existence does not affect the management and development of Cianjur Urban Forest.

In the Decree of the Regent of Cianjur Number 522.12/Kep.10d-Pe/2010, which is contained in the UKL-UPL document for Cianjur Urban Forest Development in 2017, all costs required in Cianjur Urban Forest Management are from Regional Revenue and Expenditure Budget (APBD), and other sources of income. However, there has been no update regarding this decree. In the decree, the management still belongs to the Dishutbun, and no funds have been given to DLH related to Cianjur Urban Forest's management. Meanwhile, the natural tourism management fund in Cianjur Urban Forest is provided by DISPARPORA, but it is not enough because of the miscalculation during the budget planning.

3.1.7. Strategy formulation of forest health management

The tree health assessment results in the Cianjur Urban Forest illustrated that the trees were classified as healthy. However, several trees needed further maintenance and evaluation. Also, in terms of facilities, management, and institutions are not yet effective. Hence, it can affect the health of Cianjur Urban Forest as the criteria for a sustainable forest. Based on these conditions, it is necessary to formulate a strategy for urban forest health management. Based on analysis results, tree health condition assessment, social condition analysis, and management of Cianjur Urban Forest, several key factors are needed to improve the effectiveness of tree health management. These factors are included in the input stage and form the basic information in the strategy formulation process.

3.1.7.1. The input stage

The key factors that have been obtained are entered into the internal and external factor evaluation matrix. Each factor is weighted based on the level of importance of each strategic factor and is ranked from a value of 1 to 4. The rating shows the scale of weakness and strength for internal factors and shows bad to good responses to external factors to opportunities and threats. The score is obtained based on the product of each weight and rank. The strategic factors that have the highest effect on tree health in Cianjur Urban Forest are land suitability for plant growth, intensive treatment, management, plant biodiversity, and cropping patterns. The total score for internal factors is 2.9 (**Table 7**). This score indicates that the internal position in the management of tree health in the Cianjur Urban Forest as a buffer for the city is relatively strong and indicates a strong organization internally.

Table 7. The Internal Factor Evaluation (IFE) Matrix

	Strategic Factors	Weight	Rating	Scores
Strength				
1	Environment suitability for tree species	0.10	4	0.40
2	Support from people around the forest	0.07	3	0.20
3	Intensive treatment to the facilities and the trees	0.10	3	0.30
4	Clarity of management	0.10	3	0.30
5	Biodiversity	0.10	3	0.30
Weakness				
1	Lack of funds for maintenance and management	0.10	2	0.20
2	Lack of Human Resources	0.07	3	0.20
3	Institutional / unstructured management	0.10	2	0.20
4	Planting pattern	0.10	4	0.40
5	Lack of intensity of urban forest maintenance	0.10	2	0.20
6	Inadequate facilities and infrastructure	0.07	3	0.20
	Total	1		2.90

The EFE matrix shows that factors having the most significant influence on tree health management in Cianjur Urban Forest are government policies, expanding jobs opportunities for people living close to the urban forest, the potential increase of natural tourism, pests and weeds, human activities, and frequency of wind or lightning strikes. The total score on external factors is 3.31 (**Table 8**). This score shows that Cianjur Urban Forest managers respond very well to opportunities and threats in tree health management in Cianjur Urban Forest. So, the previous

development carried out by the Cianjur Urban Forest manager was sufficient to be able to take advantage of existing opportunities and minimize the potential adverse effects of threats.

Table 8. The External Factor Evaluation (EFE) Matrix

Strategic Factors		Weight	Rating	Scores
Opportunity				
1	Potential increase of natural tourism	0.12	3	0.35
2	Expanding jobs opportunities for people	0.12	4	0.46
3	Support from experts and/or researchers in urban forest management	0.08	3	0.23
4	Technology of tree health treatment and detection	0.08	3	0.23
5	Government policy	0.12	4	0.46
Threat				
1	Pests and weeds	0.12	3	0.35
2	Human activities	0.12	3	0.35
3	Wind/lightning disasters	0.12	3	0.35
4	Tree species that are susceptible to pests, susceptible to diseases, and not wind resistant	0.08	4	0.31
5	Compensation for urban forest disturber	0.08	3	0.23
Total		1		3,31

3.1.7.2. Matching Stage

Internal-External Matrix can be determined based on a combination of the external and internal total score. The position of tree health management in Cianjur Urban Forest is in quadrant II. Quadrant II describes the management in the development phase (growth) (**Fig. 6**). Strategies suitable for a growth position are intensive strategies such as product development, market development, and market penetration. Also, suitable positions are integration strategies, and these are forward integration, backward integration, and horizontal integration.

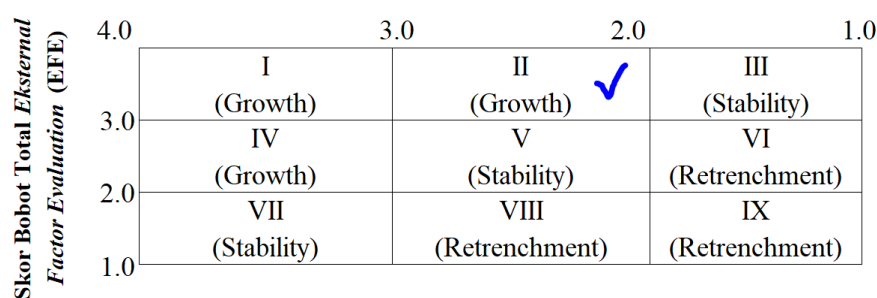


Fig. 6. External-Internal Matrix (IE).

SWOT matrix analysis was used to obtain alternative strategies from the assessment results of each internal and external factor. The SWOT matrix analysis results show different strategies according to the factors (external and internal) that influence them (**Table 9**). Strengths and Opportunities (SO) are strategies to use strength to take advantage of opportunities. Weaknesses and Opportunities (WO) are strategies to minimize weaknesses by taking advantage of opportunities. Strengths and Threats (ST) are strategies to use strength to overcome challenges. Weaknesses and Threats (WT) are strategies to minimize weaknesses and overcome challenges or threats. Based on the IE matrix, the tree health management strategy in Cianjur Urban Forest is in

Quadrant II. Strategies suitable for the growth position are intensive strategies and integration strategies (**Table 9**).

Table 9. QSPM matrix

No	Alternative Strategy	TAS	Priority
Intensive Strategy			
1	Carry out tree maintenance and treatment such as cutting trees, thinning, pruning (SO–S1, 3, 5 and O5)	4,55	V
2	Improving and developing facilities and infrastructure to support the management of Natural Tourism of Cianjur Urban Forest (WO - W5, 6 and O1, 2, 4)	4,66	IV
3	Conducting an assessment, evaluation and action on trees that must be treated (ST–S1, 3, 4 and T1, 3, 4)	6,76	I
4	Optimization of management, maintenance of vegetation, and infrastructure for Cianjur Urban Forest Natural Tourism through cooperation and community development programs for institutional strengthening (WT–W1, 2, 3, 4, 5 and T2, 4, 5)	5,15	II
5	Improving the security of the Cianjur Urban Forest area by managers and related agencies (WT–W3 and T2, 5)	3,40	VIII
Integration Strategy			
6	Involving people living around Cianjur Urban Forest to participate in the monitoring of vegetation and can increase their income (SO–S2, 4 and O1, 2)	3,69	VII
7	Providing knowledge and guidance to the people living around Cianjur Urban Forest (WO - W1, 3 and O2, 3, 5)	4,04	VI
8	Optimizing cooperation and government commitment with agencies (DLH and DISPARPORA) to plans and activities for the development and management of Cianjur Urban Forest Natural Tourism (SO–S4 and O1, 2, 4, 5)	4,59	III

3.1.7.3. Decision-making stage

Based on the SWOT analysis, eight alternative strategies were determined. Determination of the priority strategy is assessed using the QSPM matrix with an Attractiveness Score (AS) assessment. The largest Total Attractiveness Score (TAS) on the alternative strategy illustrates that several key factors that have been determined affect or impact the strategy. Each strategy is compared relative to each key factor. The TAS calculation results on each alternative strategy and priority scale level are shown in **Table 9**.

The highest TAS is 6.76. The strategy is to assess, evaluate, and act on trees that must be treated (damaged trees) and improve the health of trees in Cianjur Urban Forest so that they are safe for visitors. Aside from maintenance and treatment, an assessment and evaluation of the vegetation in Cianjur Urban Forest are also needed to improve tree health. In this case, actions of maintenance and treatment are carried out after specific assessment and evaluation of the vegetation, as well as the general condition of the Cianjur Urban Forest, such as its facilities. Assessment and evaluation of vegetation are needed so that maintenance and treatment are held effectively and efficiently. Based on the assessment results and evaluation results, managers can make decisions according to aspects that are not yet suitable for implementation in Cianjur Urban Forest. So it can optimize budget funds, management arrangements, and human resource management.

The second choice of strategy with a TAS of 5.15 is the optimization of management, maintenance of vegetation, and infrastructure for Natural Tourism of Cianjur Urban Forest through cooperation and community development programs for institutional strengthening. Institutional strengthening in Cianjur Urban Forest management is needed to build a strong foundation between the people living around the urban forest and Cianjur Urban Forest's manager. They can support and assist managers (DLH and DISPARPORA) in realizing the target of management. To have the same vision and mission to Cianjur Urban Forest, the manager can foster and provide knowledge to the people living around urban forest regarding the management plan or further development that will be implemented, as giving roles to the people living around urban forest, thus creating harmonious cooperation.

The third choice of strategy with a TAS of 4.59 is to optimize the government's cooperation and commitment with related agencies (DLH and DISPARPORA) to plans and activities for the development and management of natural tourism of Cianjur Urban Forest. Cianjur Urban Forest Management will be difficult without cooperation and commitment between all parties. Especially the government as the party that makes and takes the decisions. Concerning the management and development of an urban forest, an important aspect that must be considered is the institution that manages the urban forest (Wahyuni and Samsuedin 2012). This institution requires involvement in every stage from the planning, development, maintenance, and utilization stages. Local governments can issue policies in the form of decrees as a basis in managing urban forests, such as a decree regarding urban forest in the short or long term for the sustainability of the urban forest.

4. Conclusions

The trees in Cianjur Urban Forest are classified as healthy in terms of the land productivity, biodiversity of flora, tree crown condition, and tree damage level. The land productivity is classified as high, with a basal area value of 25.72 m²/ha. The biodiversity index ($H' = 2.73$) is classified as a stable environment. The crown condition is 86.41%, 9.71%, 3.88% of the tree crowns were in good, moderate, and poor condition, respectively. 92.70%, 5.34%, 1.31%, and 0.56% of the trees are in healthy, lightly, moderately, and heavily damage conditions, respectively. The dominant type of damage is *A. denticulosa*, and the dominant type of damage is leaf or shoot damage. Cianjur Urban Forest benefits the community as a place for natural tourism, sports, education, and expansion of employment opportunities. Cianjur Urban Forest management is not effective in terms of vegetation maintenance, tourism management, and institution. There are eight strategies proposed to improve tree health in Cianjur Urban Forest. The three priority strategies are conducting assessments, evaluations, and actions on vegetation, community cooperation, institutional strengthening development programs, and optimizing cooperation and government commitment with managers.

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References

- Abimanyu, B., Safe'i, R., and Hidayat, W. 2018. Analisis Kerusakan Pohon di Hutan Kota Stadion Kota Metro Provinsi Lampung. *Jurnal Hutan Pulau-Pulau Kecil* 3(1): 1-12. DOI: [10.30598/jhppk.2019.3.1.1](https://doi.org/10.30598/jhppk.2019.3.1.1).
- Abimanyu, B., Safe'i, R., and Hidayat, W. 2019. Aplikasi Metode *Forest Health Monitoring* dalam Penilaian Kerusakan Pohon di Hutan Kota Metro. *Jurnal Sylva Lestari* 7(3): 289-298. DOI: [10.23960/jsl37289-298](https://doi.org/10.23960/jsl37289-298)
- Budiman, A., Sulistyantara, B., and Zain, A.F.N. 2014. Deteksi Perubahan Ruang Terbuka Hijau pada 5 Kota Besar di Pulau Jawa (Studi Kasus: DKI Jakarta, Bandung, Semarang, Yogyakarta, dan Surabaya). *Lanskap Indonesia* 6(1): 7-15. DOI: [10.29244/jli.2014.6.1.7-15](https://doi.org/10.29244/jli.2014.6.1.7-15)
- Cavalli, J.P., and Finger, C.A.G. 2017. Modeling of Upper Crown Exposed to Light of *Cedrela fissilis* (Vell.) Open-Grown Trees by a Non-Destructive Method. *Forestry* 90(2): 312–317. DOI: [10.1093/forestry/cpw046](https://doi.org/10.1093/forestry/cpw046)
- Cline, S.P. 1995. *FHM: Environmental Monitoring and Assessment Program*. Environmental Protection Agency, Office of Research and Development, Washington D.C.: U.S. 296p.
- Cumming, A.B., Twardus, D.B., Nowak, D.J. 2008. Urban Forest Health Monitoring: Large-Scale Assessments in the United States. *Arboriculture & Urban Forestry* 34(6): 341–346.
- Darmuh, S., Arif, A., and Taskirawati I. 2018. Keragaman Jenis Jamur yang Menyerang Tanaman Mahoni (*Swietenia Macrophylla* KING.) di Kampus Universitas Hasanuddin Makassar, Sulawesi Selatan. *Perennial* 14(1): 9-16. DOI: [10.24259/perennial.v14i1.4998](https://doi.org/10.24259/perennial.v14i1.4998)
- David, F. 2011. *Strategic Management, Concepts and Cases*. New Jersey: Pearson Education Inc.
- Dinas Kehutanan dan Perkebunan Cianjur. 2013. *Dishutbun Cianjur Galakkan Penanaman Pohon*. <http://dishut.jabarprov.go.id/index.php?mod=detilBerita&idMenuKiri=&idBerita=1870>
- Fachrul, M.F. 2007. *Metode Sampling Bioekologi*. Jakarta: Bumi Aksara.
- Hidayati, N., and Nurrohmah, S. H. 2015. Karakteristik Morfologi *Ganoderma steyaertanum* yang Menyerang Kebun Benih Acacia mangium dan Acacia auriculiformis di Wonogiri, Jawa Tengah (Morphological Characteristics of *Ganoderma steyaertanum* which Attacks Seed Orchard of *Acacia mangium* and *Acacia auriculiformis* at Wonogiri, Central Java). *Jurnal Pemuliaan Tanaman Hutan* 9(2): 117-130. DOI: [10.20886/jpth.2015.9.2.117-130](https://doi.org/10.20886/jpth.2015.9.2.117-130)
- Kijkar, S. 2004. *Part II- Species Description: Gmelina arborea Roxb.* Thailand (TH): Forest Tree Seed Center.
- Lubis, S.H., Arifin, H.S., and Samsuudin, I. 2012. Analisis Cadangan Karbon Pohon pada Lanskap Hutan Kota di DKI Jakarta. *Penelitian Sosial dan Ekonomi Kehutanan* 10(1): 1-20.
- Mangold, R. 1997. *Forest health monitoring: Field Methods Guide*. USA: USDA Forest Service.
- Mawazin., and Subiakto, A. 2013. Keanekaragaman dan Komposisi Jenis Permudaan Alam Hutan Rawa Gambut Bekas Tebangan di Riau (Species Diversity and Composition of Logged Over Peat Swamp Forest in Riau). *Indonesian Forest Rehabilitation Journal* 1(1): 59-73. DOI: [10.9868/ifrj.1.1.59-73](https://doi.org/10.9868/ifrj.1.1.59-73)
- Nuhamara, S.T., and Hadi, S. 1999. Anatomi Jaringan Kayu Terserang Penyakit Lapuk Kayu Teras (LKT) pada Tegakan *Acacia mangium* Willd. *Jurnal Manajemen Hutan Tropika* 5(1): 23-29.
- Nuhamara, S. T., and Kasno. 2001. *Present Status of Forest Vitality*. Technical Report No 6 dalam *Forest Health Monitoring to Monitor the Sustainability of Indonesian Tropical Rain Forest Volume II*. Japan: ITTO dan Bogor: SEAMEO-BIOTROP.

- Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., and Anthony, S. 2009. *Agroforestry Database: A Tree Reference and Selection Guide Version 4.0*. Kenya(KE): World Agroforestry Centre, Kenya.
- Pertiwi, D., Safe'i R., Kaskoyo H., and Indriyanto. 2019. Identifikasi Kondisi Kerusakan Pohon menggunakan Metode Forest Health Monitoring di Tahura WAR Provinsi Lampung (Identification of Tree Damage Condition using the Forest Health Monitoring Method at Tahura WAR Lampung Province). *Perennial* 15(1): 1-7.
- Philip, M.S. 1994. *Measuring Trees and Forest*. CAB International, Wallingford. 324p.
- Pratiwi, L., and Safe'i, R. 2018. Penilaian Vitalitas Pohon Jati dengan Forest Health Monitoring di KPH Balapulang (Teak Tree Vitality Assessment with Forest Health Monitoring at KPH Balapulang). *Ecogreen* 4(1): 9-15.
- Putra, E.I. 2004. Pengembangan Metode Penilaian Kesehatan Hutan Alam Produksi [Tesis]. Bogor: Institut Pertanian Bogor.
- Rusmana, C., and Susanti, S. 2015. Komposisi dan Struktur Tegakan Hutan Alam di Hutan Pendidikan Gunung Walat, Sukabumi. *Jurnal Silviculture Tropika* 5(3): 210-217.
- Safe'i, R., Hardjanto., Supriyanto., and Sundawati, R. 2013. Pengembangan Metode Penilaian Kesehatan Hutan Rakyat Sengon (*Falcataria moluccana* (Miq.) Barneby & J.W. Grimes). *Penelitian Hutan Tanaman* 12(3): 175-187. DOI: [10.20886/jpht.2015.12.3.175-187](https://doi.org/10.20886/jpht.2015.12.3.175-187)
- Safe'i, R., and Tsani, M. K. 2016. *Kesehatan Hutan: Penilaian Kesehatan Hutan Menggunakan Teknik Forest Health Monitoring*. Plantaxia. Yogyakarta. 101 hlm.
- Safe'i, R., Erly, H., Wulandari, C., and Kaskoyo, H. 2018. Analisis Keanekaragaman Jenis Pohon sebagai Salah Satu Indikator Kesehatan Hutan Konservasi (Analysis of Tree Diversity as An Indicator of the Health of Conservation Forests). *Perennial* 14(2):32-36.
- Safe'i, R., Indriani, Y., Darmawan, A., and Kaskoyo, H. 2019. Status Pemantauan Kesehatan Hutan yang Dikelola oleh Kelompok Tani Hutan SHK Lestari: Studi Kasus Kelompok Tani Hutan Karya Makmur I Desa Cilimus, Kecamatan Teluk Pandan, Kabupaten Pesawaran, Provinsi Lampung. *Jurnal Silva Tropika* 3(2): 185-198.
- Sagita, Y. 2015. Penilaian Kesehatan Hutan Kota di Kabupaten Garut [Thesis]. Bogor: Institut Pertanian Bogor.
- Septiana, D., Indrawan, A., Dahlan, E.N., and Jaya, I.N.S. 2004. Prediksi Kebutuhan Hutan Kota Berbasis Oksigen di Kota Padang, Sumatera Barat. *Jurnal Manajemen Hutan Tropika* 10(2): 47-57.
- Sharma, R.P., Vacek, Z., and Vacek, S. 2016. Individual Tree Crown Width Models for Norway Spruce and European Beech in Czech Republic. *Forest Ecology and Management*. 366: 208–220. DOI: [10.1016/j.foreco.2016.01.040](https://doi.org/10.1016/j.foreco.2016.01.040)
- Soerianegara, I., and Indrawan, A. 1982. *Ekologi Hutan Indonesia*. Bogor: IPB.
- Stuckle, I.C., Siregar, C.A., Supriyanto, Kartana, J. 2001. *Forest Health Monitoring to Monitor the Sustainability of Indonesian Tropical Rain Forest*. ITTO Project No. PD 16/95 Rev. 2 (F). Southeast Asian Regional Center for Tropical Biology (SEAMEO BIOTROP). Bogor.
- Sulendra, S., Suryantini, R., Wulandari, R. S. 2017. Ketahanan semai akasia (*Acacia mangium*) pada variasi umur terhadap infeksi *Ganoderma* spp. *Hutan lestari*. 5(3): 653-658.
- Supriyanto, and Iskandar, T. 2016. Penilaian Kesehatan Kebun Benih Semai *Pinus merkusii* dengan metode FHM (Forest Health Monitoring) KPH Sumedang. *Jurnal Silviculture Tropika* (9)2: 99-108.

- Suratissa, D.M., and Rathnayake, U.S. 2016. Diversity and Distribution of Fauna of the Nasese Shore, Suva, Fiji Islands with Reference to Existing Threats to the Biota. *Journal of Asia-Pacific Biodiversity* 9: 11-16. DOI: [10.1016/j.japb.2015.12.002](https://doi.org/10.1016/j.japb.2015.12.002)
- Susilowati, A., Ahmad, A. G., Silalahi, V., Rachmat, H. H. 2018. The Detection and Monitoring the Tree Health of *Swietenia macrophylla* in University of Sumatera Utara's (USU) Campus Area. *IOP Conf. Series: Earth and Environmental Science* 203: 012028. DOI:[10.1088/1755-1315/203/1/012028](https://doi.org/10.1088/1755-1315/203/1/012028)
- USDA. 1999. Forest Health Monitoring 1999 Field Methods Guide. United States Department of Agriculture (USDA) Forest Service. Washington DC.
- Wahyuni, T., and Samsuudin, I. 2012. Kajian Aplikasi Kebijakan Hutan Kota di Kalimantan Timur. *Jurnal Analisis Kebijakan Kehutanan* 9(3): 219-239. DOI: [10.20886/jakk.2012.9.3.219-239](https://doi.org/10.20886/jakk.2012.9.3.219-239)
- Wasis, B., and Anggraini, N. 2017. Pertumbuhan Semai Gmelina (*Gmelina arborea* Roxb.) pada Media Bekas Tambang Silika dengan Penambahan Pupuk Kandang Kambing dan Arang Kayu (Growth for Gmelina (*Gmelina arborea* Roxb.) on the Post Mine Silica with the Addition of Goat Manure and Wood Charcoal). *Jurnal Silvikultur Tropika* 8(3): 203-207.
- Widyastuti, T. 2018. *Teknologi Budidaya Tanaman Hias Agribisnis*. Yogyakarta: CV Mine.