FOREST ECOSYSTEM SERVICE UTILIZATION TO INCREASE HUMAN HEALTH: FOREST THERAPY TRIALS IN TAMAN HUTAN RAYA IR DJUANDA

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FOREST ECOSYSTEM SERVICE UTILIZATION TO INCREASE HUMAN HEALTH: FOREST THERAPY TRIALS IN TAMAN HUTAN RAYA IR DJUANDA. Forest therapy is an activity used to obtain health benefits from forest environmental services. This research conducted a systematic literature review, constructed a forest therapy program based on said literature review, and experimented on how the forest therapy program affects human health. The forest therapy program was experimented with in "Ir. H. Djuanda Forest Park (Tahura Djuanda)" in Bandung, West Java, Indonesia. This research also analyzed forest characteristics: temperature, humidity, light intensity, and noise levels. The forest therapy program developed consists of stretching, walking in the forest, forest sensing, and consuming boiled sweet potatoes and warm tea. The temperature of the area ranged from 22 to 25.6°C, with humidity ranging from 61% to 87%. Light intensity ranged from 291 lux to 970 lux and noise levels ranged from 49 dB to 52.5 dB. The forest therapy program, which involved 30 participants, demonstrated a notable impact on reducing pulse rate and alleviating negative emotion (mood), suggesting its effectiveness in fostering both psychological and physiological relaxation. However, the findings also revealed a decrease in oxygen saturation, which contradicts the expected outcome following a forest therapy program. Further research is needed regarding the precise mechanisms through which individuals derive therapeutic benefits from natural interventions. It is also important to experiment with a diverse sample size and characteristics of participants. Additionally, it is also crucial to conduct a study on the economic value of forest therapy as a business opportunity in Indonesian conservation areas.

Keywords: Forest characteristics, forest conservation areas, forest therapy, Djuanda Forest Park

PEMANFAATAN JASA EKOSISTEM HUTAN UNTUK PENINGKATAN KESEHATAN MANUSIA: UJI COBA TERAPI HUTAN DI TAMAN HUTAN RAYA IR H DJUANDA. Terapi hutan merupakan kegiatan yang dilakukan untuk mendapatkan manfaat kesehatan dari jasa lingkungan hutan. Terapi hutan juga diterapkan di seluruh dunia dengan menggunakan berbagai istilah dan metode intervensi. Penelitian ini menganalisis program terapi hutan yang digunakan pada penelitian lain dan menyusun program terapi hutan yang aplikatif. Program terapi hutan tersebut kemudian diuji coba di Taman Hutan Raya Ir H Djuanda di Bandung, Jawa Barat, Indonesia. Penelitian ini juga menganalisis karakteristik hutan: suhu, kelembaban, intensitas cahaya, dan tingkat kebisingan. Program terapi hutan yang dikembangkan terdiri dari peregangan, forest walks, forest sensing, serta mengonsumsi ubi rebus dan teh hangat. Suhu lokasi berkisar antara 22 hingga 25.6°C, dengan kelembapan 61% hingga 87%. Intensitas cahaya berkisar antara 291 lux hingga 970 lux dan tingkat kebisingan berkisar antara 49 dB hingga 52.5 dB. Program terapi hutan yang dilakukan dengan melibatkan 30 responden ini menemukan bahwa program tersebut berpengaruh signifikan terhadap penurunan denyut nadi dan emosi (mood) negatif. Hal ini mengindikasikan bahwa program yang diterapkan mempunyai efek relaksasi. Selain itu, penelitian ini juga menemukan bahwa terjadi penurunan kadar oksigen dalam darah setelah kegiatan terapi hutan, hal ini merupakan kontradiksi luaran yang diharapkan. Mempertimbangkan hal tersebut, penelitian lanjutan dibutuhkan mengenai mekanisme detail respon manusia terhadap karakteristik hutan dan keberagaman karakteristik responden dalam pelaksanaan program terapi hutan. Selain itu, penelitian lanjutan mengenai valuasi ekonomi penerapan terapi hutan di Indonesia juga penting dilakukan.

Kata kunci: karakteristik hutan, kawasan konservasi, terapi hutan, Tahura Djuanda

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I. INTRODUCTION

The legal description of forests in Indonesia is formulated in government regulation Article 1 Paragraph 1 Number 23 of 2021 concerning Forestry. Under Indonesian legislation, a forest is classified as a cohesive ecosystem encompassing a land area rich in natural resources predominantly characterized by trees within their natural habitat, where each element is interdependent. Forests fulfill crucial functions across diverse facets of human existence, akin to other natural resources.

In line with the effort to reduce emissions and the increase of interest in low-carbon development, exploring other low-emission options for forest utilization is necessary. In this context, ecosystem services utilization could be a beneficial option that can potentially increase the livelihood of forest communities. Ecosystem services utilization of conservation areas by communities in Indonesia is carried out in various forms. Using tropical forest environmental services for medical and health purposes is common (Lesmana et al. 2018; Yenti, 2017). Conservation areas are designated to protect biodiversity and resources by limiting anthropogenic stressors. In Indonesia, conservation areas account for almost 23 percent of the state forest with limited allowable uses (Sahide et al. 2018). In that regard, nature therapy is considered suitable for implementation in Indonesia's conservation areas.

Nature therapy is a concept that uses activities involving nature as a preventive treatment for human health. Natural components in the forest can contribute to the enhancement of the physiological immune system and psychological relaxation (Song et al. 2016). Utilizing a forest ecosystem to promote the enhancement of human health uses the term forest therapy. Forest therapy research has been implemented in Japan (Furuyashiki et al. 2019), Korea (J. Shin & Choi, 2017), Taiwan (Yu & Hsieh, 2020), China (Mao et al. 2012), Denmark (Corazon et al. 2012), and Poland (Bielinis et al., 2018).

Forest therapy research has a broad range of study designs and activities. For example, Furuyashiki et al. (2019) measured the physical and mental state of participants using the *Oscillometric Monitor* and *Kessler Psychological Distress Scale* K6 before and after walking in the forest for 2 hours. Shin & Choi (2019) compared the effect of walking in a forest ecosystem and urban area on the physical and mental state of participants using HRV (Heart Rate Variability), Profile of Mood States (POMS), and *Semantic Differential* (SD) as measuring instruments. Yu & Hsieh (2020) constructed a three-day forest therapy program with forest therapists guiding activities such as walking, counseling, meditating (using aromatherapy oils), exercising, and making handicrafts. This research further determined if these activities contribute to the enhancement of creativity using the *Chinese Word Remote Associates Tests* (CWRAT) as a measuring instrument. Previous research has also shown that forest therapy activities are proven to reduce anxiety, heart rate (Farrow & Washburn, 2019), depression (Furuyashiki et al. 2019; Lee et al. 2017), and stress (J. Kim et al., 2020). In addition, earlier research by J. Lee et al. (2011) showed that forest therapy activities reduce heart rate variability, *cortisol* (a hormone that indicates stress), and pulse rate.

Based on literature study, research on forest therapy activities has been widely carried out in regions with sub-tropical and temperate climates but is rarely done in tropical climates. This causes limited information on the effect of a tropical rainforest ecosystem on human health. We found that research on this subject in Indonesia from 2021 to 2024 primarily focuses on developing forest therapy concepts. Dahlan et al. (2021), Ramdan et al. (2021), and Putri et al. (2024) analyze the suitability of tropical forest environments for forest therapy sites in Bali, West Java, and West Kalimantan. These studies further conclude that dense tropical vegetation combined with Indonesian cultural wisdom could be developed as forest therapy sites. Implementation of forest therapy and

its benefit on human health was carried out by Baroqah et al. (2021). Baroqah et al. (2021) implemented a forest therapy program with 10 participants in Bandung, West Java. They concluded that the implemented forest therapy program contributes to decreasing blood pressure, and increasing heart rate, and oxygen levels.

Pratiwi et al. (2023) and Sari et al. (2023) analyze the importance of green open spaces on human health in Bogor, West Java. These studies find that spending time in a shady and lush open space is preferable to lower anxiety, alleviate stress, increase relaxation, and lower blood pressure. Although these studies were not implemented in a tropical forest setting, it is important to mention the recent development of nature therapy research in Indonesia.

Forest therapy should be conducted in a therapeutic environment that is quiet and accessible, with a micro-climate that provides a comfortable temperature for the majority of the population in tropical countries. This research was conducted at Ir H Djuanda Forest Park (Tahura Djuanda), located in Bandung Regency, West Java Province. Tahura Djuanda is primarily used for recreational activities (Arief, 2013) as it is situated in a densely populated urban area making it accessible. It also boasts a high density of vegetation and diverse ecosystems (Nuriyah et al. 2021). Considering these characteristics, we assume that it is a suitable location for forest therapy trials. Implementing a forest therapy program in Tahura Djuanda could be financially beneficial thus increasing the livelihoods of locals as we noticed the importance of a new business opportunity for Tahura Djuanda. It could also be considered a low-budget health maintenance option for urban communities.

This research analyzes empirical evidence based on previous research using the systematic literature review method (SLR). SLR differs from traditional narrative reviews by adopting replicable, scientific, and transparent producers. It helps to collect all related publications and documents that fit our pre-defined inclusion criteria to answer a specific research question. It uses unambiguous and systematic procedures to minimize the occurrence of bias during searching, identification, appraisal, synthesis, analysis, and summary of studies. When the procedure is done properly and has minimal error, the study can provide reliable findings and reliable conclusions (Mengist et al. 2020). In this study, the Systematic Literature Review (SLR) method is used to identify the components or activities required for a forest therapy program by analyzing various study designs. This approach helps in developing a simple, suitable, applicable, and beneficial forest therapy program, taking into account the overall condition of Tahura Djuanda. The constructed forest therapy program was then implemented to assess its effects on participants' pulse rate, oxygen saturation, and overall mood.

II. MATERIAL AND METHOD

A. Study Site

This study was conducted for five months from November 2021 to March 2022 at the Ir H Djuanda Forest Park (Tahura Djuanda), located in Bandung Regency, West Java Province, Indonesia.

B. Methods

1. Scientific articles on forest therapy were collected from indexed publications on Google Scholar. Collection and analysis of articles used VosViewer, Publish or Perish, and Zotero software. The articles collected are open-access and fit the following criteria:

a. The article implements a program that uses forests as a medium for the healing process and analyses its impact on human health
b. Articles are written in English or Indonesian
c. Articles were published from 2017 to 2021

Keywords used in the Publish or Perish software search process were "forest therapy", "forest bathing", "forest healing", "Shin-rin Yoku", and "human health". Filtering was done manually by removing articles that did not meet the criteria for further synthesis.

2. The measurement of light intensity, temperature, and humidity was conducted by taking measurements at three points within the areas designated as Spot A and Spot B. Measurements were carried out twice daily, at 9:00 AM and 11:00 AM. The noise level measurement was conducted for 10 minutes at each location during the same hours. This measurement regime was repeated over the course of seven days. The process of collecting data involved using a Thermohygrometer to measure temperature and humidity, a Noise Level Meter to evaluate ambient noise, and a Lux Meter to measure light intensity. Following this, the gathered data underwent thorough analysis to reveal the full range of micro-climatic characteristics present in the surveyed area.
3. This study used a purposive sampling method for data collection. This study used a sample size of 30 individuals aged 20 to 30 years old, adhering to the Central Limit Theorem (CLT), which suggests that for sufficiently large samples, typically equal to or greater than 30, the sampling distribution of the sample mean approximates a normal distribution, regardless of the shape of the population distribution.
4. A preliminary study was conducted to assess the validity and reliability of the Profile of Mood States (POMS) questionnaire. The preliminary study involved 10 participants within the same age range. There were no differences in the implementation of the forest therapy program during the preliminary research phase.
5. The 30 participants were administered the POMS questionnaire, a validated instrument utilized for mood assessment. Additionally, physiological parameters, including heart rate and blood oxygen saturation, were monitored via pulse oximetry. After data collection, statistical analysis employed a t-test methodology to discern variations in mood states pre- and post-engagement with the forest therapy intervention.
6. The present study design was formulated with a primary emphasis on cost-effectiveness, to cater to the financial constraints often encountered within urban communities. Furthermore, it leveraged the existing infrastructure and human resources within Tahura Djuanda, thereby avoiding the necessity for additional investments or augmentation of manpower. Such strategic considerations underscore the program's practical implementation and contribute to its sustainability and scalability within resource-limited settings.

III. RESULT AND DISCUSSION

A. Constructing a Forest Therapy Program

Physiological explanation

Publications with the keywords "forest bathing", "forest healing", "*Shin-rin Yoku*", "forest therapy" and "human health" from 2017 to 2021 from Google Scholar were collected using Publish or Perish Software. The published articles found amounted to 393 publications. Based on the systematic literature review, there are differences in the use of terminology in forest therapy studies. The terminology used is Forest Bathing (FB), Forest Healing (FH), *Shin-rin Yoku* (SY), and Forest Therapy (FT). In publications found from 2017 to 2021, the terms FB, FH, SY, and FT were used based on the understanding and definition of each researcher. Based on further analysis, the terms *Forest Bathing* (FB) and *Shin-rin Yoku* (SY) are forms of forest therapy that are more in-depth and are supported by various facilities in forest environments that have been specially made for healing purposes, such as the Health Forest Octavia in Denmark (Stigsdotter et al. 2017), Healing Forest Center (H. Kim et al. 2019), and Healing Forest Saneum (Jeon et al., 2021) in Korea.

In Indonesia, the absence of dedicated facilities for Forest Bathing or *Shin-rin Yoku* and a lack of cohesive policy integration concerning the therapeutic use of forests highlights a significant oversight in leveraging

nature's healing potential. At the core of this inventiveness is the acknowledgment of forests as vital spaces for fostering wellness and healing. Thus, the term "Forest Therapy" accurately defines this approach, emphasizing intentional engagement with natural environments to promote holistic well-being and therapeutic benefits (Satyawan et al., 2022).

After collecting published articles, synthesizing (selecting articles that meet the initial criteria) was carried out manually. The vital criteria in synthesizing were study designs that use forests as a medium for healing and further analyze their impact on human health. We found 29 journals that met these criteria. Research examining forest therapy publications between 2017 and 2021 identified several common types of activities, including forest walks, sensory experiences in the forest, therapy sessions held in designated healing forests, individual forest therapy practices, the combination of forest therapy with traditional medicine, and the integration of forest therapy with other therapeutic approaches (Satyawan et al. 2022).

Forest walks are walking activities carried out at a pace that is not tiring on a flat track in the forest ecosystem. Participants are allowed to stop and rest whenever they're comfortable. According to the compiled publications, the psychological benefits of this method are increased moods, reduced anxiety, and increased feelings of relaxation. Forest walks benefit human physical health, such as increased antioxidant function, lowered blood pressure, activation of the parasympathetic nervous system, and increased feelings of relaxation (Han & Koo, 2018; Hassan et al. 2018; Mao et al. 2017; Shin & Choi, 2019).

Forest Sensing or Forest Viewing is an activity of sitting quietly and focusing on sensing the forest ecosystem. This is carried out for 15 minutes. No publications implemented forest sensing activities for more than 15 minutes. This activity increases mood, reduces stress, and increases the return of cognitive functions also called psychological restorativeness (Shin & Choi, 2017; Lyu et al., 2019; Takayama et al., 2019; Simkin et al., 2020; Zeng et al., 2020).

Some studies created forest therapy programs consisting of forest sensing, forest walks, light exercise, making handicrafts, meditation, deep breathing methods, scenting aromatherapy, drinking tea, and bathing in warm water. Accompanied by a forest therapist, all these activities aim to stimulate the five senses. This method has been shown to increase sleep efficiency, reduce cortisol (stress hormone), lower heart rate, increase serotonin levels, and increase activity and number of NK cells (natural killer). For the human mental state, this method has been shown to increase mood, reduce stress, increase self-esteem, reduce symptoms of depression, and increase self-compassion and creativity (Jeon et al. 2021; J. Kim et al. 2020; Kotera & Fido, 2021; Lyu et al. 2019; Yu & Hsieh, 2020).

Another method found was the combination of traditional medicine with forest therapy. The research combined forest therapy with the traditional *Sasang* Method from Korea and *Qigong* Exercises from China. The *Sasang* Method is an activity based on classifying individual body types. *Qigong* exercises are healing techniques combining meditation, breathing control, and exercise movements. This research showed that the method increased parasympathetic nerve activity and body phase angle (Yi et al. 2019).

Forest therapy was also studied by combining forest therapy with other therapeutic methods such as Mindfulness-Based Stress Reduction (MSBR) and Observational Therapy. Activities in the MBSR include *Seon* yoga (yoga for joint relaxation), lying-down meditation (meditation to relieve muscle pain and improve sleeping habits, performed in a lying position), serotonin walks (walking activities accompanied by body stretching with an appreciation of the forest environment and breathing exercises), healing touch (massage activities carried out in pairs by participants using assistive devices), stress relief meditation (meditation to reduce stress, understanding the factors that cause stress and things that can be done to reduce stress), and

natural meditation (meditation that facilitates the understanding of yourself through five senses). The Observational Behavioral Therapy used in this study combined *Shin-rin Yoku*, Forest Pedagogy, Wilderness Therapy, and learning methods through observation (Macháčková et al. 2021; Park et al. 2020). We also found research comparing forest therapy activities carried out with and without companions. During eight sessions, participants participated in various joint activities, including interacting with the forest, clapping sports, dancing in the forest, using natural materials for games, walking in the forest, telling stories, interacting with nature, and various games. Forest therapy activities with mentors were monitored every session. Participants who follow unaccompanied forest therapy activities include body stretching, breathing exercises, walking, meditation, and exercise (J. Kim & Shin, 2021).

Utilizing the synthesized findings, a series of simplified yet practical activities were curated for the development of a forest therapy program in Tahura Djuanda. This program encompassed physical exercises such as stretching and walking, experiential engagements involving forest sensory experiences, and visual immersion, along with the consumption of healthy snacks. The primary aim of these activities was to foster a deep connection with the forest ecosystem and enhance appreciation for nature. A comprehensive description of the activities and their expected impact is provided in Table 1, drawing upon insights from prior research. The selection process prioritized activities that require no additional infrastructure or manpower within Tahura Djuanda, ensuring ease of implementation under the guidance of a single facilitator.

As depicted in Table 2, the program began promptly at 8:30 A.M. and concluded by 11:00 A.M., strategically chosen to coincide with periods of minimal visitor activity and optimal temperature conditions, thereby fostering a tranquil environment conducive to participant comfort. The program duration was

Table 1. Description of activities

Activity	Description	Time
Body stretching	This body stretching regimen comprised gentle and uncomplicated yoga poses designed to be performed comfortably on the forest floor without inducing fatigue. It was conducive to muscle relaxation and overall well-being.	10 minutes
Forest Walks	This activity was derived from the Mindfulness-Based Stress Reduction therapy framework. Participants were guided to cultivate an appreciation for nature while leisurely walking along a gently sloping jogging track at their own pace. It was hypothesized that engaging in nature appreciation during walking will enhance psychological relaxation and reduce stress levels.	10-20 minutes
Forest Sensing	This activity engaged the auditory, olfactory, and visual senses. Participants would maintain a seated posture in a forest setting for 15 minutes. They would be directed to employ their olfactory sense to inhale the aromas of the forest ecosystem, utilize their visual sense to appreciate the woodland scenery, and employ their auditory sense to listen to the sounds of nature.	15 minutes
Sipping tea and snacking on sweet potatoes	This activity involved the gustatory sense. It was anticipated that this activity would assist participants in their appreciation of nature by enjoying its natural offerings. Priority was given to the consumption of food sourced from nature that was beneficial to the participants' health.	30 minutes

Table 2. Schedule of the Forest Therapy Program

Time	Event
8.30-9.00	Briefing and pre-test (assessment of oxygen saturation, pulse rate, and mood)
9.00-9.10	Strolling to spot A
9.10-9.30	Stretching at spot A
9.30-9.40	Forest walks to spot B
9.40-9.55	Forest sensing or forest viewing at spot B
10.00-11.00	Consuming food from nature and having casual conversations
11.00-11.30	Post-test (assessment of oxygen saturation, pulse rate, and mood)

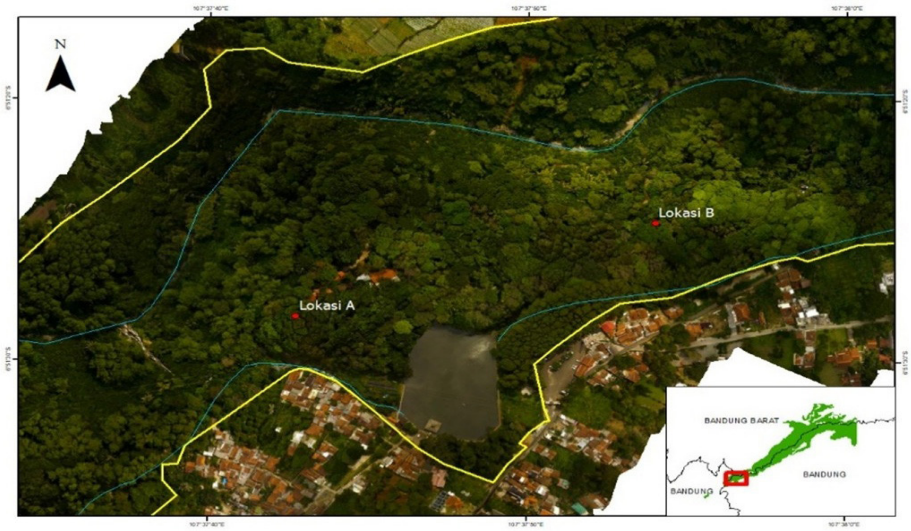

Figure 1. Location of the forest therapy trials

deliberately capped at two hours to mitigate the risk of participant fatigue and sustain engagement levels. Our approach was informed by the understanding that forest therapy activities should be captivating, stimulating, and enjoyable, reflecting our commitment to crafting a meaningful and enriching experience for all involved.

Before the activity started, participants were not advised to operate their gadgets until the forest therapy program ended. Spot A was the stage of body stretching, participants followed simple stretching yoga movements performed by an instructor. The stretching movement included five core movements that were not tiring on the forest floor. After stretching, they proceeded to walk through the jogging track from location A to location B) (Figure 1). Participants were directed to focus their attention on trees and animals that were visible. They were advised to regulate and pay attention to the breathing process and walking speed to not experience fatigue and were allowed to stop walking to rest (as described in Figure 2). When arriving at the next location (location B), participants were directed to sit on a mat and determine a comfortable position to remain silent for 15 minutes (forest sensing). This activity is described in Figure 3. The 15-minute time was determined based on research conducted by Lyu et al., 2019; Shin & Choi, 2017; Simkin et al., 2020; Takayama et al., 2019; and Zeng et al., 2020. Participants were directed to focus on the somatic process of breathing. When attention was focused on something else, the mind was refocused on the breathing process and the forest ecosystem. Participants were advised not to talk to each other. After the forest

Figure 2. Body stretching at spot A (left), forest walks through jogging track (right)

Figure 3. Forest sensing at spot B (left), the subjects were free to choose a comfortable position (right)

sensing activity, participants were served boiled sweet potatoes and hot tea and were facilitated to exchange stories. During this process, the facilitator encouraged the respondent with positive, constructive sentences. The activities at spot B were constructed referring to mindfulness meditation. Mindfulness meditation emphasized the flow of thoughts and focuses attention on the experience. Thoughts that arise were accepted without further evaluation, elaboration, and meaning. This meditation aimed to increase awareness of the experience being felt (Bishop et al. 2004).

Every activity developed for the respondent to participate was assumed to have a significant impact on human health. Hopefully, those activities can be implemented in Tahura Djuanda without any obstacles. The constructed program was simple but applicable considering the limited human resources and facilities at Tahura Djuanda. These activities further aimed to lower pulse rate and increase mood.

B. Forest Characteristics and Microclimate of Forest Therapy Spot in Tahura Djuanda

Tahura Djuanda Forest Park is located in an accessible populated urban area. This Forest Park contributes to fulfilling the need for green open spaces in the urban community of Bandung. The field conditions have an altitude of 770 to 1350 m asl. According to the

Schmidt-Fergusson classification, the climate of Tahura Djuanda is classified as type B. The relative humidity ranges between 70% during the day and 9% at night and in the mornings. The average annual rainfall is 2500-4500 mm/ year. Tahura Juanda is a natural heterogeneous forest consisting of 2,500 trees belonging to 40 *families* and 112 species. The area is planted with native and foreign trees such as Kegelia aethiopica, Mahogany Uganda (*Khaya anthotheca*) native to Africa, *Jacaranda filicifolia* native to South America, Mexican Pine (*Pinus montecumae*), Cengal Pasir (*Hopea odorata*) from Burma, Cedar Honduras (*Cadrela mexicum* M Roam) from Central America. There are also collections of local Indonesian flora such as Sumatran fir (*Casuarina sumatrana*), Sulawesi Bayur (*Pterospermum celebicum*), Ampupu or Eucalyptus (*Eucalyptus alba*), Mango (*Mangifera indica*) and Ki Bima (*Podocarpus* blume).

According to guidelines by The Ministry of Health of the Republic of Indonesia, a suitable room temperature for healing is 22°Cto 24°C with humidity of 30% to 50% (Soekartono, 2012). According to the Regulation of the Minister of Health of the Republic of Indonesia regarding Public Health Centers number 75 of 2014, a light intensity of 200 lux and a noise level of 45 dB to 55 dB are recommended for healing spaces. Another reference to measure the suitability of the location for forest therapy in Tahura Djuanda is a study by Pichler et al. (2022) who analyzed how forest characteristics contribute to improving *well-being* and recreational value. Characteristics of the forest or the trees can be divided into different categories, each with measurable indicators i.e.: (1) size of the forest area: larger, more coherent forests increase well-being and can also increase activity, (2) age of trees: older forests with large and mature trees increase well-being and positively contribute to recreational preferences, (3) stock of trees: mixed forests with deciduous and coniferous trees are perceived as more attractive than monocultures and thus increase well-being, (4) height and structure of the trees: higher trees increase well-being. In addition, different tree heights (levels of the treetops) are perceived as more attractive, (5) stand density: light forests with a rather low stand density of trees and thus a higher incidence of light, increase well-being, (6) characteristics of the treetops: a crown covering of about 75%, combined with sufficient light incidence, increases well-being, (7) characteristics of the forest as a whole: well managed forests and a low proportion of dead wood, but at the same time, no excessive traces of lumbering, are preferred. In addition, the forests should be bright, free of waste and noise, (8) Other vegetation: a varied, green-to-colorful vegetation (in addition to the trees), which is neither too dense nor too open, is generally preferred. We used the guideline by The Indonesian Ministry of Health and the study by Pichler et al as benchmarks for implementing our forest therapy program.

The state of the forest ecosystem and microclimate characteristics in Tahura Djuanda were analyzed to determine the microclimate characteristics. Characteristic analysis was carried out for seven consecutive days to increase the data's validity in two locations that could be reached within 5 minutes from the entrance gate of Tahura Djuanda. Tests were carried out in the morning (9:00 to 11:00 AM) at both locations. The time was determined based on our understanding of the dynamic at Tahura Djuanda, it should have low levels of activities, noise, and favorable temperatures in the mornings thus ensuring comfort and relaxation. The first location (Spot A) showed temperatures ranging from 22°C to 25.4°C, with humidity ranged from 62.6% to 87%, light intensity ranged from 291 lux to 959 lux, and noise levels of 49 dB to 52.5 dB with dominant vegetation *Cedrela mexicana* and *Swietenia macrophylla*. The second location (Spot B) showed a temperature range of 22.3°C to 25.16°C, with a humidity of 61% to 87%, a light intensity of 345 lux to 970 lux, and a noise level of 47.87 dB to 52.41 dB with dominant vegetation of *Toona sinensis*, *Swietenia mahogany*, and *Swietenia macrophylla*.

Tahura Djuanda is a coherent forest with an area of 514 Ha and a heterogeneous forest with different tree heights. Having been established since the Dutch East Indies era, the location of forest therapy is dominated by mature trees with canopy density of up to 90% but still with adequate light intensity (291 lux to 970 lux). Overall, Tahura Djuanda is a forest area that is safe and free of waste and noise. Based on the indicators and borders we set to define a forest healing site; Tahura Djuanda is suitable for improving overall well-being. The lush forest environment contributes to the feeling of calmness and relaxation.

C. Forest Therapy Impact on Human Health

This forest therapy program involved 30 participants. The participants were selected by purposive sampling of individuals within the productive age range of 20 to 30 years old without histories of major medical conditions. Based on the collected data, 90% of participants were between 20 to 25 years old, and the rest was between 26 to 30 years old. The gender characteristics of the participants in this study were divided into 53% women and 47% men. In this research, we ensured there were no disparities in the number of each sex to produce representative data.

The effect of forest therapy on the mental and physical health of individuals was reviewed using three leading indicators. These indicators were the POMS, blood oxygen saturation, and pulse rate. Before implementing the research activities, we tested the reliability and validity of the questionnaire on ten participants as a form of preliminary research. The reliability test was tested on six conditions: (*tension–anxiety* (T–A)" "*depression-dejection* (D)", "*anger–hostility* (A–H)", "*fatigue* (F)", ' "*confusion* (C)", and "*vigor* (V)").

If the *Cronbach Alpha* value was greater than the r table value, then the item can be said to be reliable. *Tension-anxiety* had a *Cronbach Alpha* value of 0.955 which was greater than the r table value of 0.707. *Depression-dejection* had a *Cronbach Alpha* of 0.973 which was greater than the r table value of 0.514. *Anger-hostility* had a *Cronbach Alpha* of 0.956 which was greater than the r table value of 0.602. *Fatigue* had a *Cronbach Alpha* of 0.942 which was greater than the r table value of 0.878. *Confusion* had a *Cronbach Alpha* of 0.942 which was greater than the r table value of 0.811. *Vigor* had a *Cronbach Alpha* of 0.942 which was greater than the r table value of 0.754 (with 5% of significance). Based on these data, we can conclude that all the items in the POMS Questionnaire were valid and reliable for data collection.

Figure 4 shows the oxygen saturation of 30 participants before and after the forest therapy program which tends to decrease. Before the forest therapy program, the average oxygen saturation was 99.1%, this reduced to 98.7% after the forest therapy program with a standard deviation of 1.185. The T-test analysis showed a significance of 0.238, which indicates that statistically forest therapy does not affect oxygen saturation. Although it tended to decrease, the average oxygen saturation remained within the standard threshold (above 95%). Eroğlu et al. (2018) stated that one is considered Hypoxia when having low oxygen saturation below 95%. The reduction of oxygen saturation was caused by the body stretching and forest walk activities in this program. This is a valuable finding for future research because the expected result was an oxygen saturation escalation after implementing a forest therapy program. However, Zeng et al. (2020) mentioned that forest therapy activities maintain oxygen saturation at a high level. Because this study was only tested on 30 participants, future research is needed to further conclude the effect of forest therapy on oxygen saturation.

Figure 5 describes the pulse rate per minute before and after forest therapy trials. The average pulse per minute measured before and after the forest therapy for 30 participants was 89.67 bpm and 82.07 bpm respectively, with a deviation of 9.255. The t-test results showed a significance value of 0.00 meaning there was a significant difference in pulse rate before and after participating in this forest therapy

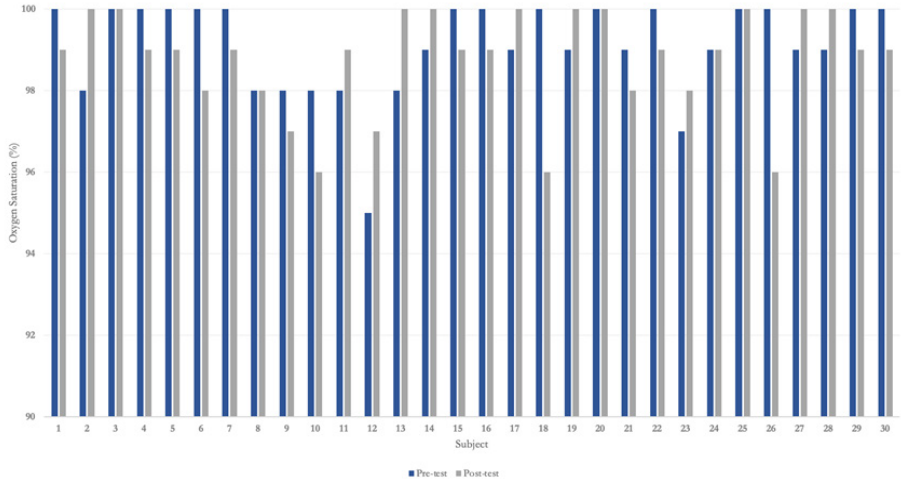

Figure 4. Oxygen saturation of subjects before and after forest therapy trials

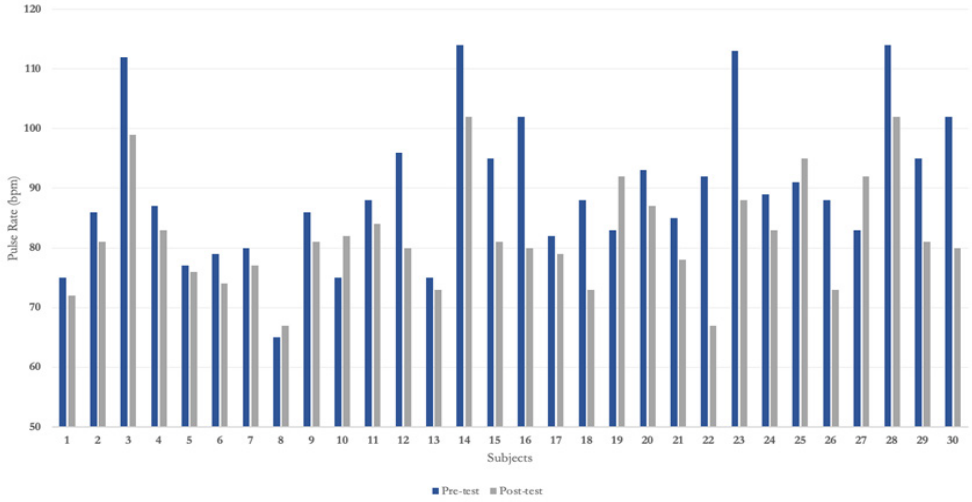

Figure 5. Pulse rate per minute before and after forest therapy trials

program at a 95% confidence. The average pulse rate after treatment decreased by 7.6 bpm, which shows that the forest therapy program is proven to slow participants' heart rate.

The parasympathetic nervous system regulates the body's response when in a state of relaxation. The activated parasympathetic system reduces respiration and heart rate. It also increases digestive activity. The decrease in heart rate occurs because the forest therapy activities decrease noradrenaline and urinary dopamine, further reducing the activity of the parasympathetic nervous system (Li et al., 2016; Lyu et al., 2019).

Forest environmental factors and their characteristics have an essential role in the results obtained. Integration of elements in a forest environment, such as trees, fresh air, comfortable temperature, and humidity, can stimulate the senses of sight, smell, hearing, and touch (H. Kim et al., 2019). Our findings are in line with the study done by Zeng et al. (2020), who found a decrease in pulse rates of participants in forest walking and forest sensing activities. This observed decrease in pulse rate serves as a direct indicator of the therapeutic effects of the program, clarifying the profound relaxation induced by visual stimuli, therapeutic

auditory inputs, and mindful engagement with the natural environment.

The Profile of Mood State questionnaire has six dimensions: tension, depression, anger, fatigue, confusion, and vigor. The Total Mood Disturbance (TMD) value is calculated from these six dimensions. The TMD value is obtained by adding the score for negative items such as tension, depression, anger, fatigue, and confusion, then subtracting vigor. The higher the TMD value, the worse the mood is.

Figure 6 describes TMD scores before and after forest therapy trials of the 30 participants. The average TMD score before and after forest therapy was 35.30 and 6.76 with a deviation of 40.25 and 28.30 respectively. This proved that the program decreased overall mood disturbance and significantly promoted mood improvements in participants. We further analyzed the difference and significance of each dimension before and after forest therapy using a t-test for paired data on tension, depression, anger, fatigue, confusion, vigor, and TMD scores.

The forest therapy trials do not have any significant effect if the significance value before and after trials are <0.05. The results of the t-test showed a significance value below 0.05 for the dimensions of tension (p-value < 0.001), depression (p-value < 0.001), anger (p-value < 0.001), fatigue (p-value < 0.001), confusion (p-value < 0.001) and TMD scores (p-value < 0.001). Vigor had a p-value of 0.251, which was greater than 0.05. It can be concluded that forest therapy had a significant effect on the decrease of tension, depression, anger, fatigue, confusion, and TMD values. Vigor increased from 16.7 to 18.03, indicating good mood or emotions. However, due to the insignificant increase, t-test results showed no significant effect before and after forest therapy trials.

The decrease in TMD value indicated a decrease in negative emotions after forest therapy activities. This finding is in line with other forest therapy studies that use the POMS instrument to measure mood (Furuyashiki et al. 2019; Jeon et al. 2021; G. Park et al. 2018; C. S. Shin et al. 2015; J. Shin & Choi 2019). Research conducted by Kaplan (1995) found that activities carried out by focusing attention on the forest environment through meditation and forest sensing activities facilitated the process of restoring attention which affected self-awareness of one's thoughts and behavior. Self-awareness supports the ability to heal independently (self-heal). After forest therapy activities, there was an increase in feelings of "comfortable", "natural" and "relaxed" (Ochiai et al. 2015).

This study provides empirical evidence supporting the effectiveness of the program in reducing pulse rate, oxygen saturation levels, and alleviating mood disturbances. While a statistically insignificant increase in positive mood (vigor) was observed, it is noteworthy that the forest therapy program exhibits areas

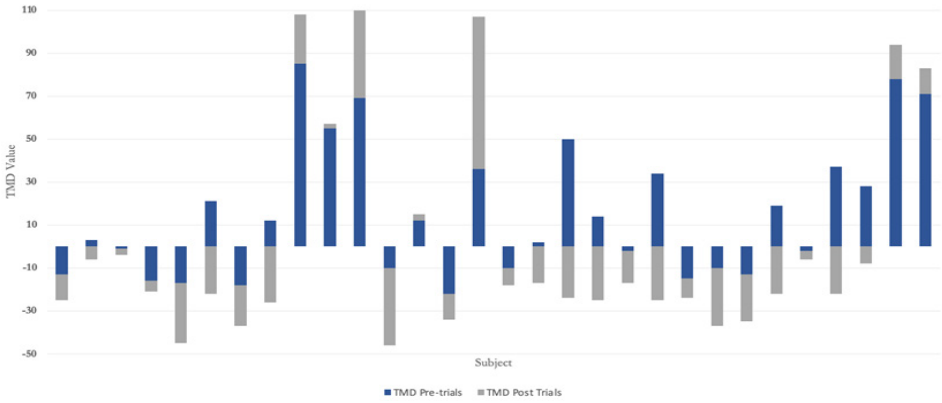

Figure 6. TMD Scores before and after forest therapy trials

requiring optimization, particularly evident in the observed decrease in oxygen saturation. Usually, forest therapy interventions are associated with increased oxygen saturation post-treatment, thus underscoring the need for program adjustments in light of our findings. Moreover, the reliance on a modest sample size of 30 healthy young adults highlights the necessity for future research to include larger and more diverse samples. Furthermore, there's a gap in existing research on the precise mechanisms through which individuals derive therapeutic benefits from natural interventions, emphasizing the need for more studies in this field.

Contrarywise, an essential aspect deserving of future studies is the economic valuation of forest therapy programs. A comprehensive analysis of its economic viability is essential for informing potential investors and stakeholders about its feasibility and scalability. Therefore, future research should include multifaceted inquiries aimed at comprehensively understanding the therapeutic efficacy, underlying mechanisms, and economic implications of forest therapy interventions

IV. CONCLUSION

Indonesian conservation areas have great potential for utilization. Forest therapy should be an option for low-carbon development in Indonesian conservation areas. This research is needed considering forest therapy is mainly applied in sub-tropical and temperate climates. Both locations in Tahura Djuanda have a temperature of 22°C to 25.4°C, a humidity of 62% to 87%, light intensity of 291 lux to 970 lux, and noise level of 47 dB to 52 dB. These micro-climate characteristics have positively affected the decrease of pulse rate and mood disturbances, indicating the direct impact of forest therapy on relaxation. However, we found a decrease in the oxygen saturation of participants, contradicting the desired output of a forest therapy program. Future research is needed regarding improvements of the forest therapy program, trials on diverse sample sizes, and the economic analysis of the forest therapy program as a business opportunity.

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