Drone technology for identification of healing forest spot at Kampung Cisamaya Mount Ciremai National Park

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Abstract. Reconnecting people to nature through healing activities in the forest ecosystem is important. Various studies have shown that forest ecosystems dominated by tree vegetation have positive impacts on physical and psychological health. Not all locations in the forest ecosystem are suitable for healing forests (HF), but their suitability must be identified. Land slope, vegetation density, and easiness access to the site are some physical parameters of the land which are indicators for the development of HF site. Identification of suitable HF spots can be identified using drone technology and GIS. The research objective was the use of drones equipment in identifying potential sites for HF activities. The research site was Kampung Cisamaya in Mount Ciremai National Park. The type of drone used was the Phantom 4 Pro Obsidian equipped with a 20-megapixel RGB camera. The stages of research activities were data acquisition, processing, and analyzing from drone spatial data. Vegetation density was determined through GRVI (Green-Red Vegetation Index), while drone data analyzed the slope classification by DTM (Digital Terrain Model). The accessibility to the location was analyzed through data from the spatial map of the Kuningan Regency. The results found that the use of drones was effective in evaluating the suitability spots for HF activities. From this study can be concluded that the Cisamaya area was suitable for the development of HF activities due to physical parameters of flat to gentle slopes (0-15%), having dense vegetation, as well as the easiness access by people.

1. Introduction
Humans are ecological creatures who always need ecosystems and their ecosystem services. The biophilia hypothesis states that humans and other living things need to connect and affiliation with nature [1]. The forest ecosystem is one of the best ecosystems in providing comfort for human health [2]. By coming and doing activities in the forest with a comfortable biophysical environment, it can positively impact health [2,3]. Forest activities for health are proven to provide positive results for human physical and psychological health. The forest environment can increase positive emotions, decrease negative emotions, increase attention focus capacity, recover attention fatigue, lower blood pressure, lower pulse rate, lower heart rate, stress hormones, and boost the immune system [2,3].

Human connection with nature in the form of forest ecosystems is the main key in healing forests. Not all ecosystem areas are suitable to be used as healing forest spots. Not all locations in the forest ecosystem are suitable for healing forests (HF), but their suitability must be identified. Various studies have shown that forest ecosystems dominated by tree vegetation have positive impacts on physical and psychological health. Forest ecosystem spots that have forest ecosystem services in mountain forests are
characterized by the physical characteristics of the landscape, namely: (a) moderate to dense tree vegetation density; (b) the slope of the land is flat to sloping (0-15%); (c) easily accessible and safe from natural disasters and wildlife disturbance; (d) a comfortable temperature of 20-27º and a relative humidity of 40-80%; (e) wind speed < 1m/second; (f) negative ion content > 1000/cc; and (g) cool light intensity [5, 6, 7]. Determination of vegetation density, land slope, and access to the site is part of the initial stage of identifying suitable sites for healing forest activity. Identification of suitable HF spots can be identified using drone technology and GIS (Geographic Information Systems). For mapping activities, apart from using satellite imagery, drones are also used. Aerial portrait maps from the processing of aerial portraits from drones are more detailed than satellite images. The drone pixel size in centimeters is more detailed than the satellite image pixel size in meters [11, 12, 13]. The research objective was the use of drones to identify potentially suitable sites for HF activities.

2. Methods
The research site was Kampung Pasundan Cisamaya (KPC) in Mount Ciremai National Park which was administratively in Pasawahan Village, Pasawahan District, Kuningan Regency, West Java Province located at 6°48’27.2556” - 6°48’38.1168” South Latitudes and 108°26’5.6508” - 108°26’16.6662” East longitude as shown (figure 1).

The pieces of equipment used in the study are shown in figure 2. The drone used was the Phantom 4 Pro Obsidian with a 20-megapixel RGB camera (figure 2a). Drone aircraft are used to determine the vegetation index and land slope. The vegetation index is used to classify vegetation density classes. The vegetation index is determined by the GRVI value approach (Green-Red Vegetation Index). Figure 2b showed Digital Environment Multimeter (DEM), a versatile tool that combines thermometer, humidity meter, lux meter, sound level meter, and anemometer into one tester. This DEM tool can be used to measure temperature, humidity, light intensity, noise pressure, light intensity, and wind speed.
The stages of research activities are data acquisition, processing, and analysis of drone spatial data. Vegetation density is determined by GRVI (Green-Red Vegetation Index), slope class is analyzed by DTM (Digital Terrain Model) from drone data, and the ease of road access is analyzed from the Kuningan Regency spatial map. The flow chart for drone technology to identify the suitability of vegetation density, land slope, and access for healing forest sites is shown in figure 3. The research site was an area of interest (AOI) for drone flights. The AOI attributes used in the Flight Plan were the boundary of AOI, flight attitude, flight overlap, resolution (cm/pixel), and front and side overlaps. The data format of AOI is KML (keyhole markup language). KML flight plan data was analyzed with Google Earth to determine drone flight points and drone flight altitudes that are safe and free from disturbance of objects above the surface. Fixed KML data was imported into the Drone Deploy application as a flight plan from AOI for aerial photography. Drone flights for mapping were executed after flight plans and drone checks were completed. Aerial portraits from drone shots were processed.

There was a drone aerial portrait processing in this research, namely orthophoto mosaic and DTM (Digital Terrain Model) processing. Accuracy can be calculated by comparing sample point coordinates from orthophoto with field coordinates. The coordinates of the orthophoto samples in this research are 108,438 east longitude and 6,808 south latitudes. The coordinates on the ground are 108.4372531 east longitudes and 6.861388889 south latitude. Accuracy (in percent) is calculated by: (1 - (interpretation - field) x 100). The accuracy of the coordinate values in this research reaches an average of 99.61%, so it is considered accurate to use the results of this mapping. The drone aerial portrait processing used software was Agisoft Methashape. Both processes were carried out to obtain thematic data, namely land cover and accessibility, vegetation index, and slope class. Land suitability for the HF site with this drone comprised (a) moderate to dense tree vegetation density; (b) the slope of the land is flat to sloping (0-15%), and (c) easily accessible and safe from natural disasters as well as wildlife disturbances. Field measurements of environmental parameters for HF were carried out at selected and appropriate sites based on the parameters of the vegetation index, land slope, and access for HF based on drone-based spatial analysis. At the spot suitable for HF, environmental parameters were measured are temperature, relative humidity, and noise.

Figure 2. Research equipment: drone phantom 4 pro obsidian (a), digital environment multimeter (b)
Vegetation canopy density data were obtained from aerial photographs that were processed and analyzed using the Green-Red Vegetation Index (GRVI) method. The GRVI value is then interpreted as the vegetation canopy density. The classification of vegetation density classes consists of sparse vegetation density (GRVI value: -1 to 0), medium vegetation density (GRVI value: 0 – 0.1) and dense vegetation density (GRVI value: 0.1 – 1) [8]. In a healing forest, moderate to dense vegetations are preferred to choose. A suitable forest ecosystem site for healing forests has a moderate to dense vegetation density [14]. The forest ecosystem site for a suitable healing forest has a medium to dense vegetation density. The processing of the GRVI vegetation index transformation is carried out using formulae (1) with the raster calculator function in ArcMap.

$$GRVI = \frac{Green\text{-}DN - Red\text{-}DN}{Green\text{-}DN + Red\text{-}DN}$$ (1)

3. Results and discussion
Drone technology for spatial mapping objects above the earth's surface is currently widely used in forestry [11, 12, 13]. Aerial mapping with drones is part of the spatial data source, other spatial data sources from satellite imagery, direct measurement of spatial objects in the field, and base maps and thematic maps made by the supporting agencies/institutions [11]. Forestry planning requires spatial data/information. The availability of up-to-date, fast, effective, and easier-to-operate spatial data will improve suitable HF site identification performance. The outputs of aerial photo processing resulting from drone acquisition are mosaic orthophoto aerial portraits that have been combined (mosaicing process), DSM (Digital Surface Model), DTM (Digital Surfaces Model), and 3D models [11, 12, 13]. DTM data is input data to get contour data and land slope class which is obtained by geographic information system software. Land cover maps can be interpreted from the resulting drone aerial portrait orthophoto, where the pixel values are generally small, generally, in centimeters, the interpretation process will be more detailed and precise compared to spatial data (satellite), which has a large unit size per pixel (generally still in units) meters. The aerial photo data format is generally raster data that is...
processed and analyzed into an aerial portrait mosaic (raster data) which can be processed and converted into vector data in the form of points, lines, and polygons [11, 12, 13].

Figure 4 shows maps processed from aerial drone shots. From orthophoto maps can be analyzed further into land cover maps, GRVI, vegetation index. DTM (Digital Terrain Model) raster data which was continued to process into land slope class data. DSM (Digital Surface Model) raster data with other software (e.g., PCI Geomatica) can be converted into DTM. The difference between DSM and DTM values theoretically is the height of the spatial object above the surface.

The number of aerial shots produced by drone flights was 125 aerial shots. The flight area was 0.715 km² or 71.5 ha, with an average altitude of 288 m. Orthophoto results with Ground Resolution below 10 cm/pixel were good for detailed land cover interpretation (figure 5). The site area of Kampung Cisamaya is 4.89 ha or 6.89% of the total flight area. The land cover interpretation showed that forest tree stands dominate the area of the KPC site. Before being managed as a TNGC conservation area, the KPC site was managed by Perum Perhutani, so that there were trees that grow naturally and are planted. Table 1 shows the existing tree stands at the KPC site. The condition of the road to the location is an asphalt road, making it comfortable to pass. Easy access to the location by road. The location can be reached from Jakarta via toll roads and non-toll roads in less than 3.5 hours.
Table 1. Tree species at KPC site [7]

| No | Family       | Local Name | Species Name                |
|----|--------------|------------|-----------------------------|
| 1  | Euphorbiaceae| Mara       | *Macaranga rhizinoides*     |
| 2  | Flacourtiaae | Picung     | *Pangium edule*             |
| 3  | Gnetaceae    | Melinjo    | *Gnetum gnemon*             |
| 4  | Malvaceae    | Durian     | *Durio zibethinus*          |
| 5  | Pinaceae     | Pinus      | *Pinus merkusii*            |
| 6  | Malvaceae    | Kapuk Randu| *Ceiba pentandra*           |
| 7  | Euphorbiaceae| Kepundung  | *Baccaurea racemosa*        |
| 8  | Fabaceae     | Angsana    | *Pterocarpus indicus*       |
| 9  | Moraceae     | Cempedak   | *Artocarpus integra*        |

Figure 5. Map of orthophoto aerial drone images

In the KPC site, various species of birds were found. The bird survey conducted at the site indicated that there were 29 bird species from 17 families [7]. The species richness of birds at the KPC site was in the high richness category (>26). The sound of birds chirping was a type of sound that is often associated with human restorative experiences when in nature [9]. Bird species at the KPC site are presented in table 2. The repeated sound of birds chirping is part of natural stimuli as a soundscape in the recovery of human stress in nature [9]. Bird sounds and other natural sounds are natural sound therapy for comfortable hearing. The more comfortable the sound received by the hearing, the more calming it will affect the decrease in stress.
**Table 2. Bird species at KPC site [7]**

| No | Family                  | Local Name          | Species Name                   |
|----|-------------------------|---------------------|--------------------------------|
| 1  | Timaliidae              | Pelanduk topi hitam | Pelloreum capistratum          |
| 2  | Timaliidae              | Pelanduk semak      | Malacocinela separium          |
| 3  | Coraciiformes           | Cekakak jawa       | Halcyon cyanovenris            |
| 4  | Pittidae                | Paok pancawarna    | Hydronis guajanus              |
| 5  | Laniidae                | Bentet loreng      | Lanius tigrinus                |
| 6  | Apodidae                | Walet sapi         | Collocalia esculenta           |
| 7  | Dicaedae                | Cabai jawa         | Dicaeum trochileum             |
| 8  | Coraciiformes           | Cekakak sungai     | Todirhamus chloris             |
| 9  | Capitonidae             | Takar tenggeret    | Psilopogon australis           |
| 10 | Campephagidae           | Sepah kecil        | Pericrocotos cinnamomeus       |
| 11 | Ploceidae               | Bondol jawa        | Lonchura leucogastroides       |
| 12 | Columbidae              | Delimukan zamrud   | Chalcophaps indica             |
| 13 | Columbidae              | Tekukur biasa      | Spilopelia chinensis           |
| 14 | Piciidae                | Caladi tilik       | Picoles moluccensis            |
| 15 | Cuculidae               | Kadalan birah      | Phaenicophaeus curvirostris    |
| 16 | Sylvidae                | Cinenen kelabu     | Orthotomus ruficaps            |
| 17 | Columbidae              | Perkutat jawa      | Geopelia striata               |
| 18 | Cuculidae               | Kedasi hitam       | Sarniculae lugubris            |
| 19 | Meliphagidae            | Barsang madu srnganti | Cinnyris jugularis           |
| 20 | Hirundinidae            | Layang-layang rumah | Delichon dasypus              |
| 21 | Coraciiformes           | Raja udang meninting | Alcedo meninting               |
| 22 | Columbidae              | Walik kembang      | Ptilinopus melanospilus         |
| 23 | Apodidae                | Kapinis rumah      | Apus nipalensis                |
| 24 | Cuculidae               | Wiwik uncuing      | Cacomantis merulinus           |
| 25 | Motacillidae            | Kicuit kerbau      | Motacilla flava                |
| 26 | Timaliidae              | Berencet kerdil    | Pnoepyga pusilla               |
| 27 | Hirundinidae            | Layang-layang api  | Hirundo rustica                |
| 28 | Caprimulgidae           | Cabak kota         | Caprimulagus affinis           |
| 29 | Accipitridae            | Elang ilar bido    | Spilornis cheela               |

**Figure 6. Map of GRVI value**

**Figure 7. Map of vegetation cover – GRVI index**

The GRVI value can distinguish between vegetation (value >0), water bodies (value 0), and soil (value <0) [8]. The value will be negative when detecting grass. However, the denser the detected vegetation, the GRVI value will be positive. Figure 6 and figure 7 show maps of GRVI values and vegetation density. Vegetation density is determined based on the GRVI value. GRVI values for healing forests are 0 to 1 which are categorized as medium and dense vegetation density. The medium to dense
vegetation density at the KFC site is 4.85 Ha and the sparse vegetation density is 0.03 Ha. The medium and dense vegetation density at the KPC site indicates that the site is suitable for a healing forest site. Dense tree vegetation cover maintains microclimate stability. Small changes in climatic factors due to dense tree cover provide a more comfortable health response. The more comfortable the health response, the fewer stress levels.

The next stage of spatial analysis was to overlay the spatial data of vegetation density with slope class. As for access to the KPC site for the HF site, it is considered appropriate. Map of a suitable site for healing forest in KPC site is shown in figure 8. There were three classes of site suitability for KPC site: (a) suitable for healing forest (3.86 ha); (b) suitable for healing forest but requires revegetation or vegetation enrichment (0.03 ha); and (c) not suitable for healing forest (1 ha). The suitable location for HF in KPC was a site with moderate to dense vegetation density and flat to the gentle slope (<15%) and easy access. What is not suitable is the slope of the land is rather steep, steep, and very steep (>15%) with sparse vegetation density. As for what is appropriate but needs vegetation enrichment, the slope of the land is flat to gentle (<15%) and the vegetation density is low, so it is necessary to enrich the vegetation.

![Map of Suitable Site for Healing Forest](image)

**Figure 8.** Map of suitability site for healing forest at KPC

At the appropriate site, measurements were made of several environmental parameters: air temperature, relative humidity, light intensity, wind speed, and noise. Observations were made in the morning between 08.00 – 10.00 which was considered the best for carrying out forest healing activities. The results of measurements at two location points are shown in table 3. Air temperature, relative humidity, wind speed, and maximum noise pressure at the KFC site meet the requirements for a healing forest location. The effect of ecosystem microclimate on health was related to the presence of negative
air ions that positively affect human health. The concentration of NAI (Negative Air Ions) in mountainous spots is significantly correlated with relative humidity and rainfall intensity and negatively correlated with air temperature [10].

| Measurement time | Spot | Temperature (℃) | Relative humidity (%) | Light intensity (Lux) | Wind velocity (m/detik) | Maximum noise pressure (dba) |
|------------------|------|-----------------|-----------------------|-----------------------|-------------------------|-----------------------------|
| Morning (08.00-10.00) | A    | 24.61           | 83.41                 | 3919.20               | 0.29                    | 46.55                       |
|                  | B    | 26.68           | 74.06                 | 3467.00               | 0.20                    | 49.60                       |
| Average          |      | 25.65           | 78.74                 | 3693.10               | 0.25                    | 48.08                       |

4. Conclusion
Drone technology is effective for identifying sites in the ecosystem that are suitable for healing forest activities. Vegetation density, land slope, access, and land cover resulting from the spatial data processing of drone aerial portraits were used to determine the initial suitability of the forest ecosystem for forest healing activities. The results of the spatial analysis of the site of Kampung Pasundan Cisamaya (KPC) which had vegetation in dense density, the area flat to the gentle slope (<15%), and the easy access indicated that the KPC site was suitable to be developed as a healing forest site. The spatial suitability of the site was supported by the acceptable environment condition of the environmental physical parameters (temperature, relative humidity, sunlight intensity, wind speed, and sound noise) as the KPC forest ecosystem is comfortable for human health.

5. References
[1] Wilson, E O 1984 Biophilia Harvard University Press Cambridge, Ma
[2] Miyazaki, Yoshifumi 2018 Shinrin-yoku: The Japanese Ways of Forest Bathing for Health and Relaxation Octopus (London : Publishing Group Ltd)
[3] Lie and Qing 2018 Forest Bathing: How Trees Can Help You Find Health and Happiness (Publisher New York : Viking)
[4] Zhu S-x, Hu F-f, He S-y, Qiu Q, Su Y, He Q and Li J-y Comprehensive Evaluation of Healthcare Benefits of Different Forest Types: A Case Study in Shimen National Forest Park, China Forests 12 207
[5] Baehaqi I 2020 Study of the Relationship between Physical Characteristics of the Healing Forest Environment on the Health Response of Visitors in the Puncak Bintang Forest Area of Perum Perhutani KPH North Bandung, West Java Biomanagement Master Program Thesis Institut Teknologi Bandung
[6] Kendali M 2019 Development of Healing Forest Ecosystem Services at Wana Wisata Situ Cibeureum, Garut, West Java Biomanagement Master Program Thesis Institut Teknologi Bandung
[7] Prameswari S A 2021 Analysis of the Suitability of the Pasundan Cisamaya Village in the Mount Ciremai National Park Area as a Healing Forest Site Biology Undergraduate Thesis Institut Teknologi Bandung
[8] Motohka T, Nasahara K, Hiroyuki O and Satoshi T 2010 Applicability of green-Red Vegetation Index for Remote Sensing of Vegetation Phenology Remote Sensing 2
[9] Ratcliffe E, Gatersleben B and Sowden P T 2013 Bird sounds and their contributions to perceived attention restoration and stress recovery Journal of Environmental Psychology 36 221-228
[10] Ling D 2013 Review on Research of the Negative Air Ion Concentration Distribution and its Correlation with Meteorological Elements in Mountain Tourist Area Earth Sciences 8(1) 60-68
[11] Dainelli R, Toscano P, Di Gennaro S F and Matese A 2021 Recent Advances in Unmanned Aerial Vehicles Forest Remote Sensing-A Systematic Review Part II: Research Applications Forests 12 397
[12] Annuar A 2011 Digital Mapping Using Low Altitude UAV Pertanika J.Sci & Technol 19 51 - 58
[13] Banu T P, Borlea G F and Banu C 2016 The Use of Drones in Forestry Journal of Environmental Science and Engineering B 5 557-562
[14] National Standardization Agency of Indonesia 2021 Draft Indonesian National Standard Number 9006:2021 concerning Forest tourism for health therapy (healing forest)

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