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RESEARCH ARTICLE

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Ecotourism Development Potential Based on Environmental Comfort in Gunung Walat University Forest Area, Sukabumi, Indonesia

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ABSTRACT

Gunung Walat University Forest (GWUF) in Sukabumi, West Java, serves as a centre for training, education, and research in forestry. This research analyses the environmental comfort of GWUF, focusing on thermal comfort, visual aesthetics, and visitor perceptions related to their suitability in conducting ecotourism development to increase GWUF income in realizing sustainable forest management. Data was collected from November 2023 to February 2024 at three locations in the GWUF by measuring air temperature and humidity. Interviews were conducted with respondents experienced in landscape assessment to evaluate the aesthetic level of 10 objects in GWUF, and interviews with visitors on aspects of GWUF management and presence. The Thermal Humidity Index (THI), Scenic Beauty Estimation (SBE), and Likert scale analysis were also used. The results showed that the GWUF area was in a comfortable thermal condition. The value varied and became a new attraction, one of which was the beauty of the GWUF cave. Overall, visitors rated the air quality and natural beauty positively; however, there are some points to note regarding the availability of facilities and the accessibility of the site, highlighting areas for improvement in management.

Introduction

Gunung Walat University Forest (GWUF) is one of the forest areas designated as Special Purpose Forest Areas through the decision of the Minister of Environment and Forestry No. 188/Menhut-II/2005 on July 8, 2005. The GWUF area is a forest with an independent forest management unit, meaning that GWUF finances its own management without any assistance or budget from the government. It is evident that the financial resources of GWUF are currently derived from the collection of pine and agathis sap, which has become a customary method of securing financial resources for forest management. However, it should be noted that income from sap is subject to fluctuations and is significantly influenced by prevailing market conditions. A decline in income from sap activities has been observed on an annual basis, attributable to multiple factors, including a diminution in stand production and a decrease in commodity prices [1]. It is imperative to enhance the added value of science in the utilisation of alternative non-timber forest products (NTFPs) and the promotion of nature tourism. Presently, nature tourism encompasses activities with a focus on forestry education, catering primarily to schools and universities.

In addition to NTFPs, the GWUF area has various attractions that have the potential to be developed as natural tourism objects, including flora, fauna, natural scenery and agroforestry [2]. The zero-cutting policy or prohibition of tree felling implemented by the manager has consequences for the forest vegetation that is still in place and can provide a natural, comfortable, cool sensation and the beauty of the landscape. This is one of the potential benefits to be developed in nature tourism activities to increase GWUF income in

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financing sustainable forest management without relying on the results of NTFP utilisation, such as sap, whose value is decreasing. This research aims to analyse the potential for the development of ecotourism in the GWUF area, with particular reference to the level of air comfort and landscape beauty.

Materials and Methods

Study Area

The area of GWUF is 359 ha, and its geographical location is defined by the following coordinates 6°53'35"–6°55'10"S and 106°047'50"–106°051'30"E (Figure 1). In forestry administration, the GWUF area falls within the jurisdiction of the West Gede Forest Management Unit (BKPH/*Balai Kesatuan Pengelolaan Hutan*), *Kesatuan Pengelolaan Hutan* (KPH) Sukabumi, and Perum Perhutani Unit III West Java. Regarding government administration, GWUF is located in the Cicantayan and Cibadak Districts of Sukabumi Regency, West Java Province. The forest is 460 to 726 meters above sea level (masl). The Gunung Walat Mountains extend from east to west, with the southern region exhibiting undulating topography that follows a series of ridges from north to south. Most of the area under consideration is situated at an elevation of 500 meters above sea level, with approximately 10% of the southern part lying below that elevation.

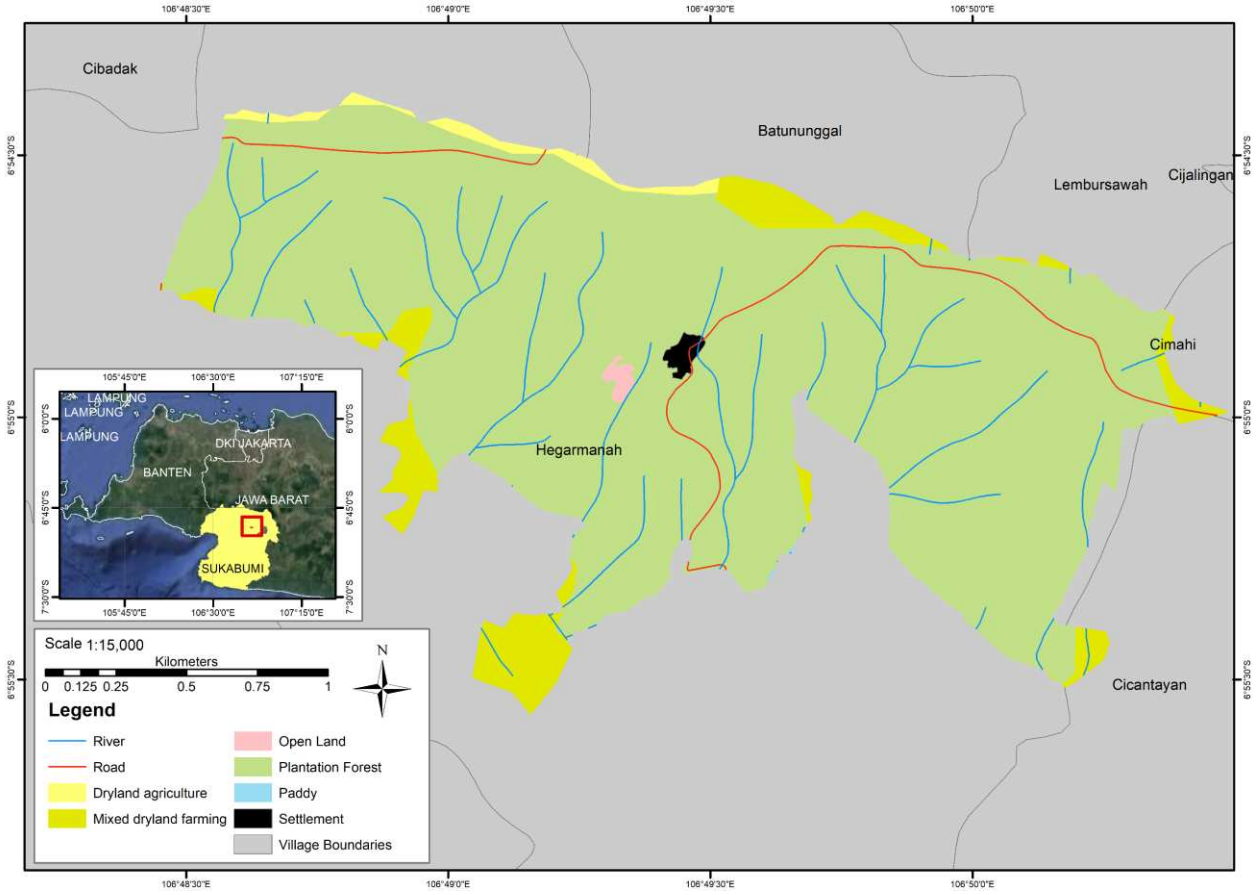

Figure 1. The research location map of GWUF.

Tools and Data

The types of data collected included soil-type maps, topographic maps, geological maps, physical soil data, soil sampling methods, measurement interviews, questionnaires, environmental observation, documentation, and literature studies. Data analysis techniques involved descriptive land suitability analysis, tabulation, and multidimensional scaling (MDS) analysis using the Rapfish Method. The research employed a range of instruments, including digital thermometers, numerical processing software, data analysis software, digital cameras, questionnaires, and writing implements. The subject of this study is the GWUF and visitors. The primary data collected during this study include microclimate (temperature, humidity), the aesthetic level of the area, and the characteristics and management aspects of GWUF. Data collection methods include

direct observation, measurements (including calculations), questionnaires, and visitor interviews. Secondary data is used to support primary data and validate research results. Secondary data is obtained through literature research, including reports, GWUF management documents, and journals.

Data Collection

Air temperature and humidity measurements were taken concurrently at each sampling point. Air temperature and humidity were quantified using a digital thermometer. Measurements were taken at three distinct locations: the basecamp area, the camp area, and the tracking path. The measurements were taken on three occasions, once in the morning (8:00–10:00 AM), once in the afternoon (12:00–2:00 PM), and once in the evening (3:30–5:30 PM), on three consecutive days. The resulting dataset was used to calculate the average air temperature and humidity for each time period. Measurements at each observation point are taken at a height of 1.5 meters above the ground surface because, at this height, climatological data can apply to a wider area. Estimating aesthetic quality involves evaluating the beauty of predetermined objects, applying the method proposed by Jin and Miao [3] called scenic beauty estimation (SBE). Several steps are involved in evaluating aesthetic aspects, including observation, photography, photo selection, and presentation of photographs to respondents. The aesthetic quality assessment involves 30 respondents with experience in landscape architecture and eco-tourism.

A closed questionnaire comprising Likert scale ratings was distributed to respondents to ascertain perceptions. Likert scale has become a commonly employed instrument in the field of questionnaire and survey research [4]. Likert Scale is employed to measure individuals' and groups' attitudes, opinions, and perceptions about social phenomena [5]. Respondent selection is carried out using purposive sampling, which involves selecting samples based on the research objectives [6]. Respondents must be at least 17 years old and capable of effective communication. This research involves 100 respondents who visited GWUF. The number of respondents was derived from the 2023 visitor population using the Slovin formula, as proposed by Wijaya et al. [7] (Equation 1). The respondents will evaluate the characteristics and management of the GWUF using nine indicators that have been adapted from Wibowo [8]. The questionnaires were distributed to respondents on two distinct types of visiting days: weekdays (Monday to Friday) and weekends (Saturday and Sunday).

$$n = \frac{N}{1 + Ne^2} \tag{1}$$

Data Analysis

Air Comfort

The forest enhances the microclimate by analyzing air temperature and humidity patterns across multiple locations within the GWUF region. Each observation point's temperature and humidity data encompass the basecamp region, the designated camping ground, and the tracking route. The data were organized according to the measurement time, and the mean values for each period (morning, afternoon, and evening) were calculated. The temperature and humidity measurements were analyzed using the equation proposed by Wang [9], as expressed in Equations 2 and 3.

$$Tr = \frac{(2T\ morning + T\ afternoon + T\ evening)}{4} \tag{2}$$

$$RHr = \frac{(2RH\ morning + RH\ afternoon + RH\ evening)}{4} \tag{3}$$

Where Tr is the average daily air temperature (°C), T is the daily air temperature (°C), RHr is the average daily air humidity (%), and RH is the humidity (%).

The air temperature and humidity data will be employed in calculating the temperature humidity index (THI). This will be done following the equation developed by McGregor and Nieuwolt [10], which has been validated in tropical climates. Subsequently, the THI value obtained will be categorised into one of three conditions, as outlined by Ding et al. [11], and presented in Table 1.

$$THI = 0.8\ Tr + \frac{RHr\ x\ Tr}{500} \tag{4}$$

Table 1. Comfort level criteria.

No	Criteria	THI (°C)
1	Comfortable	≥ 21 – ≤ 24
2	Quite comfortable	> 24 – ≤ 26
3	Uncomfortable	> 26

Aesthetic Level

The result of the respondent's assessment will be calculated for frequency (f), cumulative frequency (cf), cumulative probability (cp), and z value with the SBE approach following the method proposed by Jin and Miao [3]. The SBE value is calculated using the z value (Equation 5). Based on the SBE value result, the next step is classifying objects based on their beauty level. This classification generally categorizes the SBE value into high, moderate, and low categories. The SBE value categories are based on standard deviation, which helps identify objects with significant variations in their beauty assessment.

$$SBEx = [(Zlx - Zts)]\ x\ 100 \quad (5)$$

Where SBEx is SBE value of landscape x, Zlx is the Z-average value of landscape x and Zts is the standard Z-value closest to zero.

Likert Analysis

The data collected encompassed perspectives on the condition of management and the existence of GWUF. This was achieved by means of a questionnaire, the respondents to which were invited to provide a rationale for their visit. The measurement is made using a Likert scale, with a score range of 1 to 5 [12], the Likert scale is a commonly used tool in questionnaires and research. In addition, visitor perception data are tabulated and analysed descriptively and qualitatively using Suyono's category scale [13] (Table 2).

Table 2. Likert category scale.

Scale	Classification
1.0–1.8	Very poor
1.81–2.6	Poor
2.61–3.4	Fair
3.41–4.2	Good
4.21–5.0	Very good

Results

Thermal Comfort Level in the GWUF Area

The region's microclimate conditions invariably influence thermal comfort and air temperature. Microclimate refers to the atmospheric conditions in a limited area directly experienced by living things, especially humans [14]. Factors that affect microclimate include land cover, wind speed, human activities, and thermal radiation from specific objects [15,16]. The air temperature comfort index of an area is determined based on the THI obtained from temperature and humidity measurements at locations affected by sunlight [17]. The relative humidity level at various measurement points in the GWUF area is subject to variation depending on the prevailing environmental conditions in each area (Figure 2).

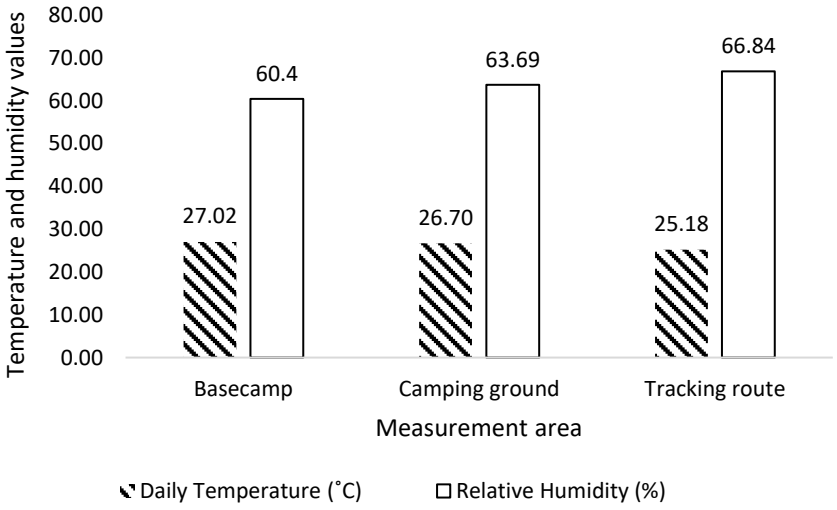

Figure 1. Comparison of air temperature and humidity in three areas of the GWUF area.

The basecamp area exhibits a relatively low humidity value of 60.4%. This phenomenon can be attributed to sparse vegetation stands directly exposed to solar radiation and wind, reducing humidity levels. Subsequently, the camping ground area exhibits a humidity value of 63.69%, while the tracking area displays the highest humidity at 66.84%. The air temperature and humidity conditions generated in this study will impact the THI values presented in Table 3.

Table 3. Thermal comfort condition of GWUF.

Area	THI (°C)	Category
Basecamp	24.88	Quite comfortable
Camping ground	24.76	Quite comfortable
Tracking route	23.51	Comfortable
Average	24.38	Quite comfortable

The results of the analysis indicate that the three measurement points in the GWUF area, comprising the basecamp area with a THI value of 24.88 °C, which can be classified as fairly comfortable, and the camping ground with a THI value of 24.76 °C, which also falls within the fairly comfortable category, the tracking area, which is also within the comfortable category, has a THI value of 23.51 °C. A THI value of 24.38 °C is also within the comfortable range. Based on these findings, it can be concluded that the GWUF area has relatively comfortable air conditions with an average THI value of 24.38 °C. Air conditions are considered comfortable when they reach thermal neutrality, where individuals do not feel too cold or too hot [18].

Aesthetic Comfort Level

Assessment of the landscape's beauty is generally based on the level of satisfaction individuals have with what they see and feel while in that landscape area [19]. This research utilizes the SBE method to assess the landscape quality of GWUF, which was assessed by 30 experienced respondents in landscape and ecotourism. The SBE values of the GWUF area based on the analysis results are presented in Figure 3.

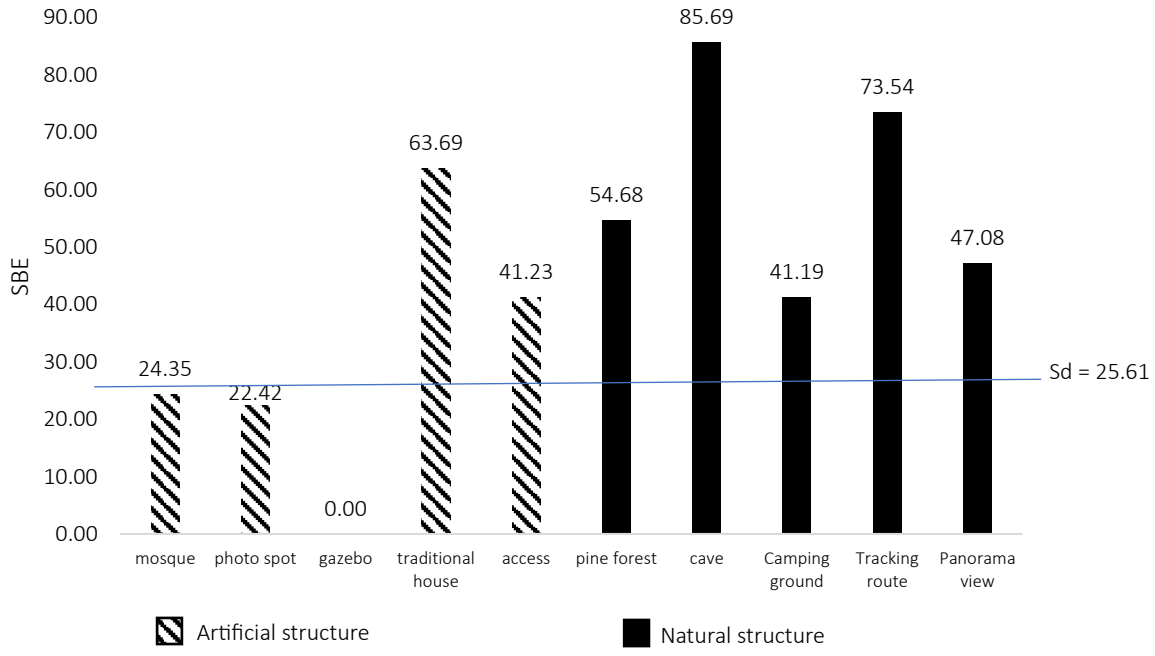

Figure 2. SBE values of 10 objects in the GWUF area, consisting of five natural and five artificial structures.

Respondents' assessments of 10 objects in the GWUF area, including panoramic views, tracking trails, camping grounds, white caves, pine forests, location access, traditional houses, gazebos, photo spots, and places of worship, were selected because they are distinctive features of the GWUF area (Figure 4). These objects were presented in the form of images to be assessed by each respondent. Based on the results, the aesthetic quality of GWUF in this research is categorized into three based on standard deviation values: low (SBE < –25.61), moderate (–25.61 ≤ SBE ≥ 25.61), and high (SBE > 25.61).

Seven objects were found to have high aesthetic quality. These included traditional houses (63.65), access points (41.23), pine forests (54.68), caves (85.59), campgrounds (41.49), tracking routes (73.54), and panoramic views (47.68). Three objects were found to have a moderate aesthetic quality, namely the mosque (24.35), the photo spot (22.42), and the gazebo (0.00). The average SBE of all objects was found to be 45.39, indicating that the aesthetic quality of the GWUF area is included in the high category. The white cave was found to have the highest SBE value (85.69), indicating that this object is perceived to have excellent visual quality and is a preferred choice among respondents. Conversely, the gazebo was assigned a medium SBE value (0.00) due to its suboptimal maintenance, which resulted in a comparatively diminished visual quality relative to other objects.

Figure 3. The condition of 10 landscape objects in the GWUF area of the SBE measurement in the GWUF area.

Visitor's Perception

The perception of an object is contingent upon the individual's cognitive aspects or knowledge, which vary from person to person. The process of perception formation commences with the presence of informational stimuli, which are subsequently processed into knowledge that serves as the foundation for perception [20]. Therefore, perception is subjective. Visitors' perceptions of the management aspects of GWUF are formed through the interaction between their sensory organs and the environmental conditions within the forest. The assessments made by respondents can serve as important considerations and evaluations for improving forest management in the future. Visitors' perceptions of the characteristics and management of GWUF are presented in Table 4.

Table 4. Visitors' perception of the characteristics and management aspects of GWUF.

Indicator	Scale					Average	Conclusion
	1	2	3	4	5		
Location sanitation	0	0	38	43	19	3.81	Good
Maintenance of vegetation	0	0	7	62	31	4.24	Very good
Complete facilities	0	17	40	42	1	3.27	Fair
Maintenance of facilities	0	18	46	36	0	3.18	Fair
Access to location	2	46	44	8	0	2.58	Poor
Location security	0	1	35	37	27	3.9	Good
Tranquility and noise	0	1	10	39	50	4.38	Very good
Landscape beauty	0	0	2	48	50	4.48	Very good
Air quality and coolness	0	0	2	46	52	4.5	Very good

The table illustrates that almost all visitors respond positively to the aspects present in GWUF. Respondents' assessments of environmental comfort, including air coolness quality and landscape beauty in the GWUF area, are rated very good according to the THI and SBE analysis results. However, visitors give less favorable responses to the completeness and maintenance of GWUF facilities and access to the location, which is poor due to the GWUF area being located approximately 2 km from the main road, namely *Jalan Raya Cibadak*, and access to the basecamp through relatively small village roads. Furthermore, the road conditions are mostly uphill, consisting mainly of dirt and rocky terrain, posing some danger to visitors during the rainy season. This aspect should be considered in the future development of GWUF.

Discussion

Thermal Comfort Level in the GWUF Area

The air temperature levels in the three GWUF areas are classified as ideal criteria. According to Baroqah et al. [21], for environmental comfort in tropical regions, there are ideal-moderate values for air temperature ranging from 22.5 to 27.5 °C. The differences in air temperature are due to the different density of canopy vegetation. A dense canopy in an area results in lower air temperatures because vegetation in green open spaces can have a cooling effect on the surrounding environment [22]. The basecamp area is dominated by buildings, while the camping ground area has vegetation, but it is sparser compared to the tracking area. Radiation that reaches areas with dense canopy tends to be used to increase air temperatures. Conversely, if the canopy cover is dense, it will provide shade that obstructs the entry of radiation and results in a decrease in air heating [23]. The mean THI value indicates that the air quality in the GWUF area is generally satisfactory. Air conditioning has been demonstrated to influence human physical health. Individuals who are unable to regulate their level of physical activity in extreme temperatures, both high and low, frequently experience fatigue and are susceptible to disease, as Rohman et al. [24] demonstrated that climatic conditions, including air temperature, humidity, solar radiation, wind speed, rain, and other factors, significantly impact human performance, productivity, and health. It is therefore vital to ensure a balance of air temperature to guarantee visitor comfort and support their health in the GWUF area.

It is evident from the provided explanation that the GWUF area, characterised by air temperatures ranging from 23 to 25 °C, exhibits the capacity to mitigate human stress levels [25,26]. This phenomenon is called 'forest therapy' or 'forest healing'. The SNI (*Standar Nasional Indonesia*) pertaining to forest tourism for health therapy, designated SNI 9006:2021, is a regulatory document that establishes guidelines and standards for operating and managing forest tourism activities specifically designed to promote health and well-being. The standard stipulates the requisite physical environmental parameters for designated forest therapy locations. The considered parameters included vegetation density, air temperature and humidity, lighting levels, wind speed, and air negative ion content. In accordance with the stipulations outlined in SNI 9006:2021, the recommended range of values for air temperature in the context of health therapy forests is set between 20 °C and 26 °C, with the corresponding humidity levels ranging from 40 to 80% [27]. The use of the SNI 9006:2021 reference renders the GWUF compliant with the stipulated recommendations for the development of forest tourism activities for health therapy within the parameters of temperature and humidity.

Aesthetic Comfort Level

The analysis results show that landscapes with high SBE scores are more likely to have intrinsic visual attributes, including scenic vistas, the unchanging topography of the White Cave, and a rich tapestry of plant life. These natural features provide a high level of visual comfort for humans, thereby increasing respondents' preference for the landscape. In addition, vegetation plays an important role in enhancing the landscape's aesthetic appeal by providing attractive visual qualities and shade. The presence of different vegetation elements, including trees, shrubs, grasslands, and other plants, contributes to the overall aesthetic appeal of the landscape by providing a refreshing shade of green and a sense of natural beauty. Therefore, vegetation plays an important role in enhancing the aesthetic appeal and comfort of the landscape [28].

This beautiful landscape owned by GWUF is a gift from God, which is very beneficial for managers if it can be properly utilised, especially the white cave landscape. In addition to its high SBE value, white cave, also known as Cipereu Cave, has the potential for interesting special interest tourism. This tourism includes the adventure of exploring a cave with ornaments dominated by white colour and the presence of unique fauna. The development and management of special interest tourism in the White Cave, considering aspects of its sustainability, can be an attractive option, offering tourists a different and exclusive experience. Special interest tourism in the GWUF White Cave has great potential to be optimally developed, considering the environmental impacts that may occur. The type of tourism offered includes adventure and education, including an introduction to the flora and fauna of the cave. It is hoped that the development of cave tours in GWUF will increase public awareness of the importance of preserving existing natural resources.

Visitor's Perception

A review of visitor perceptions of the completeness and maintenance of facilities in GWUF indicates that these facilities are considered inadequate. For example, parking lots are less extensive, and the condition of public toilets lacks intensive maintenance, resulting in damage to some facilities. Furthermore, many respondents have expressed concerns regarding the lack of reliable internet connectivity on several starter packs within the area. This has led to difficulties in communicating with family members and engaging in social media, which has become necessary for most students. The field of telecommunications is inextricably linked to the modern way of life. The provision of reliable telecommunication services is essential to facilitate travel-related activities. Purwanto et al. [29] state that the tourism industry can become a lifestyle choice when supported by convenient communication access. Telecommunication networks constitute a pivotal component that undergirds the entirety of activities within the tourism sector [30]. It is anticipated that the seamless telecommunication access within the GWUF will foster a favorable environment for the advancement of ecotourism. The likelihood of a visitor returning is contingent upon their initial impression of the destination. One factor influencing this impression is the completeness and maintenance of the facilities provided by tourist destinations, which contribute to an area's overall appeal. It is imperative that the management of GWUF consider the importance of completeness and maintenance of facilities.

Conclusion

The THI values of 24.88 °C, 24.76 °C, and 23.51 °C, respectively, measured at the basecamp, the camping ground, and the tracking path in the GWUF area, indicate that the GWUF can provide adequate air comfort for visitors. This suggests the potential for developing forest therapy tourism in the GWUF area. Furthermore, the aesthetic quality of the GWUF area is of varied value and has become a new attraction, one of which is the beauty of the GWUF Cave. Visitors concur with the established comfort values, thereby substantiating the notion that the level of cool air and natural beauty in GWUF is regarded as very good. However, facilities and access to the location are still considered inadequate, and improvements are required to realise sustainable tourism development.

Author Contributions

RA: Conceptualization, Methodology, Software, Investigation, Writing - Review & Editing; **OR**: Writing - Review & Editing, Supervision; **HH**: Writing - Review & Editing, Supervision.

Conflicts of Interest

There are no conflicts to declare.

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