ASSESSMENT AND RESILIENCE OF MERAPOH TRAIL, GUNUNG TAHAN, MALAYSIA

By

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Gunung Tahan (2,187 metres above sea level) in Taman Negara National Park is one of Malaysia's ultimate trekking trails into the country's wilderness. The mountain top can be reached via two main trails: The Kuala Tahan Trail and the Merapoh Trail, with the latter receiving more than 70% of the hikers since its establishment. Since it was opened in 1995, the Merapoh Trail has been severely trampled, which poses a challenge to the resource integrity and the quality of recreational experiences. The purpose of this study was to assess the resilience of the Merapoh Trail by (i) assessing trail width, trail depth, and composition of vegetation communities in different altitudinal forest zones, (ii) comparing the 1998's trail width and depth with 2019 based on different altitudinal forest zones, and (iii) examining the relationship between the selected inventory parameters and the degradation of the trail. A total of 321 study stations were established using systematic sampling, and 11 were retrieved from the 1998 and 2000 studies. Based on the result, the trail was widened and deepened as ascending from different attitudinal forest zones with the upper montane forest was recorded with the highest trail width (M=155.11 cm) and trail depth (M=30.18 cm). Vegetation species composition of disturbed and undisturbed areas indicated that the upper montane forest zone had a greater similarity index (CC=0.56) than other attitudinal forest zones and while at the lower montane forest and lowland dipterocarp forest had the lowest vegetation similarity index. The trail width and vegetation similarity index findings suggested that the montane forests had minor vegetation recovery due to the excessive trail widening. Lastly, trail width and depth were significantly associated with the tree canopy cover, slope gradient, and elevation. The results indicated that tree canopy cover, slope gradient, and elevation contributed to the widening and deepening of the Merapoh Trail. These findings provided vital information for managers and park authorities in designing targeted trail monitoring and maintenance programs to minimize the impacts.

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PENILAIAN DAN KEBINGKASAN DENAI MERAPOH, GUNUNG TAHAN, MALAYSIA

Oleh

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Gunung Tahan (2,187 meter di atas paras laut) di Taman Negara merupakan salah satu denai trekking terbaik di Malaysia ke dalam hutan belantara negara. Puncak tertinggi ini boleh dicapai melalui dua laluan utama: Denai Kuala Tahan dan Denai Merapoh, dengan laluan terakhir menerima lebih 70% pendaki sejak penubuhannya. Sejak dibuka pada 1995, Denai Merapoh telah diinjak-injak teruk, yang menimbulkan cabaran kepada integrity sumber dan kualiti pengalaman rekreasi. Tujuan kajian ini adalah untuk menilai daya tahan Denai Merapoh dengan (i) menilai lebar denai, kedalaman denai, dan komposisi komuniti tumbuh-tumbuhan di pengezonan ketinggian hutan yang berbeza, (ii) membandingkan kelebaran dan kedalaman denai tahun 1998 dengan tahun 2019 berdasarkan perbezaan yang berbeza pengezonan ketinggian hutan, dan (iii) mengkaji hubungan antara parameter inventori yang dipilih dengan kemerosotan denai. Sebanyak 321 stesen kajian telah ditubuhkan menggunakan persampelan sistematik, dan 11 telah diambil daripada kajian 1998 dan 2000. Berdasarkan keputusannya, denai melebar dan mendalam apabila menaik dari pengezonan ketinggian hutan yang berbeza dengan hutan gunungan tinggi direkodkan dengan lebar denai tertinggi (M=155.11 sm) dan kedalaman denai (M=30.18 sm). Komposisi spesies tumbuh-tumbuhan bagi kawasan terganggu dan tidak terganggu menunjukkan bahawa zon hutan gunungan tinggi mempunyai indeks persamaan yang lebih besar (CC=0.56) berbanding pengezonan ketinggian hutan yang lain dan manakala di hutan gunung dan hutan dipterokarpa pamah mempunyai indeks persamaan tumbuh-tumbuhan yang paling rendah. Lebar denai dan penemuan indeks persamaan tumbuh-tumbuhan mencadangkan bahawa hutan pergunungan mengalami pemulihan tumbuh-tumbuhan kecil akibat pelebaran denai yang berlebihan. Akhir sekali, lebar dan kedalaman denai dikaitkan secara signifikan dengan penutup kanopi pokok, kecerunan cerun dan aras ketinggian. Keputusan menunjukkan bahawa penutupan kanopi pokok, kecerunan cerun, dan aras ketinggian menyumbang kepada pelebaran dan pendalaman Denai Merapoh. Penemuan ini memberikan maklumat penting

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CHAPTER 1

INTRODUCTION

1.0 General Background of Study

The tropical mountains areas are rich in biodiversity, freshwater resources, natural and cultural heritage (Hammitt et al., 2015; Pickering and Barros, 2015; Sam Shor, 2020). There are many rare and endemic species of flora and fauna, religious places, and breathtaking scenery (Blyth et al., 2002). The mountain areas are regarded as the last refuge and frontier for biodiversity and wilderness (Price et al., 2011). Nevertheless, these areas are also highly vulnerable to erosion, terrestrial fluidity, and fast compaction, and have complex climatic conditions with slow flora and fauna regeneration, low productivity, and diverse ecosystems (Pickering and Barros, 2015).

Most mountains are in the most favourable ecosystems on the globe, requiring human intervention (Dearden and Sewell, 1983) to overcome nature's most elemental forms and assure the safety of mountain activities. Mountaineering's mass development began in the early twentieth century and has continued to this day, as the demand, pattern of use, volumes of usage, and degrees of engagement in recreation use have grown in popularity (Dearden and Sewell, 1983; Dolesh, 2004; Moore and Shafer, 2001; Turner and Davies, 1995). Adventurers, scientists, and opportunists congregate at the summit with a goal related to exploration, vocation, recreation, scientific, commercial, patriotic, and self-glorification reasons (Dearden and Sewell, 1985).

Exemplified the popularity of mountain climbing worldwide, it is also becoming increasingly popular in Malaysia (Latip et al., 2020; Mohd Taher et al., 2015; Nordin and Jamal, 2021; Sam Shor et al., 2021). Most of the popular trekking mountains are found in the country's various mountain ranges, such as the Titiwangsa Range in Peninsular Malaysia and the Crocker Range in Sabah (Sam Shor et al., 2012). Gunung Tahan in Taman Negara National Park, Pahang, is one of the mountains that offers a challenging trekking experience to its summit. Gunung Tahan, located in the Tahan Range, attracts over 1,700 trekkers each year (Sam Shor and Shukri, 2017).

Mountain trails in mountaineering always ensure that climbers ascend in the correct direction to reach the mountain summit. However, increased trampling activity associated with trekking has several environmental effects on the trails (Cole, 2004; Leung and Marion, 2000; Marion and Olive, 2006). Trail use has a range of physical, biological, and social repercussions that degrade both the trails and the ecosystem. Physical impact of trail includes soil compaction (Newsome et al., 2012), soil erosion (Leung and Marion 1999), and trail widening and wet or muddy tracks

(Leung and Marion 2000). Biological impacts include fauna disturbance and vegetation damage, while vandalism, litter and loss of wilderness values are examples of the social effects that can occur because of trail use (Newsome et al., 2012). A study by Ólafsdóttir and Runnström (2013) has shown that trails in popular Icelandic highland hiking destinations have widened and deepened into gullies due to increased trampling and unsupervised hiking. Monz et al. (2010) reported that the increased use of hiking trails to mountain summits in the Northern Forest, U.S.A. has led to severe vegetation loss and soil exposure/erosion. Moreover, increased trampling from hikers has resulted in trail widening and soil loss along the trails in the Rocky Mountain National Park, USA (Svajda et al., 2016). Mountain hiking degrades the quality of recreation resources (mostly on trails) and has an impact on visitor recreation experiences. For example, Latip et al. (2020) indicated that soil loss and tree root exposure are among the key concerns of tourists visiting Mount Kinabalu Park in Sabah.

Mountain trails have limitations in their ability to survive natural change and human intervention. The mountain trail will degrade once it has reached its optimum limit.

1.1 Problem Statement

Gunung Tahan, or Mount Tahan (2187 metres above sea level), is Peninsular Malaysia's highest peak and sixth highest mountain in Malaysia. It was discovered by British explorers in 1905 and is now one of Malaysia's most popular mountaineering destinations (Sam Shor, 2019). According to Department of Wildlife and National Parks (PERHILITAN) records, Gunung Tahan has been visited by 48,240 visitors over 23 years (1995 to 2018) (Figure 1.1). The Merapoh Trail is the most popular trail, with 70% of visitors trekking to Gunung Tahan.

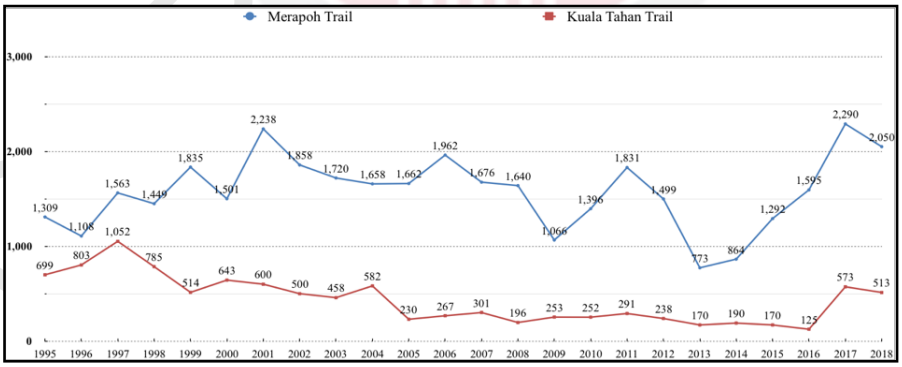

Figure 1.1: Gunung Tahan trail visitation
(Source: DWNP, 2019)

Excessive recreational use, along with poorly constructed and/or maintained trails, has resulted in a variety of resource impacts (Leung and Marion, 2001). The poor construction of trails leads to a lot of ecological change, which also is considered inevitable, and degradation caused by both recreational use and natural processes like rainfall and water flow (Birchard and Proudman, 2000). As reported, the Merapoh Trail's massive and repeated visitation has had a profound impact over the years since its establishment in 1995. Previous studies indicated the condition of mountain ecology is deteriorating due to the increasing number of continuous visits (Nor'Ain et al., 2010; Siti Noorbaizura et al., 2014), particularly along the trails (Azita et al., 2009; Md Sabri et al., 2016). In addition, the width and depth of Merapoh Trails are among the physical impact indicators of concern due to the heavy trampling along with them (Sam Shor et al., 2021). According to Hammitt et al. (2015), disturbance of natural environments is primarily caused by recreational activities such as trekking to Mount Tahan.

The Merapoh Trail is located at a high elevation with step areas that are highly vulnerable to ecological degradation (Lafsdóttir and Runnström, 2013). Therefore, the potential for trail erosion in these areas is high (Leung and Marion, 1996; Turton, 2005). Since 1998, a few research stations with permanent stakes along the Merapoh Trail's left and right sides have been established (Sam Shor, 2019), enabling the prior study station to be reviewed for data comparison. Moreover, several studies have found that the trails leading to Gunung Tahan's summit have shown loss of topsoil (Arham, 2003; Aziz, 2001; Rahim, 2004; Azita, 2009; Safarin, 2001; Sam Shor and Azlizam, 2002; Subari, 2002; Suhaimi, 2003). Thus, this could be an attributed to higher precipitation rates in the mountains, which results in muddy soils and a greater risk of erosion (Leung and Marion, 1996).

The negative physical impacts of recreation use on the Gunung Tahan nature resource should be thoroughly explored to promote trail durability and a better user experience. The trail impacts and many types of trail assessments, such as inventories, maintenance, and condition evaluation techniques, were used to indicate the empirical evidence about trails and their condition to identify trends, manage trail repair efforts, and assess the necessity for visitor management and resource protection measures (Leung and Marion, 2001; Sam Shor, 2019). As suggested, most of the physical impact indicators of recreation impact applicable for the Gunung Tahan Trail are associated with soil characteristics. This includes trail depth, width, presence of muddy areas, presence of wet surfaces, presence of gully, bare surface area, soil compaction, problematic area condition, soil drainage, loss of organic matter, and problem area coverage (Sam Shor, 2021).

Based on images taken by mountain guides and climbers in 2007 (Figure 1.2) and 2016 (Figure 1.3) and the systemic evaluation required to substantiate the alleged condition, the Merapoh Trails have been reported to be in the process of recovery. The evidence for this recovery process on one of the physical impact indicators (trail width) at different elevations, according to Sam Shor (2019), demonstrates a reduction in trail size. This evidence indicated a need for a conscious and serious

effort to understand the current conditions of the Merapoh Trail after recreation use. Exploring more data from past study stations to have a better understanding of the recovery pattern as in previous study also suggested to conduct the full assessment along the entire trail system every 10 – 15 years for monitoring approaches (Tomczyk et al., 2017). The width and depth of the trail as physical trail impact indicators, in addition to vegetation return species after disturbance of the previous research station with permanent stakes, will lead to development of resilience indicator, and thus could be introduced to the physical indicator of recreation impact and determining the carrying capacity of the recreation resources along the trails.

Figure 1.2: The recovery of trail width size at Merapoh Tail after 9 years (200 m a.s.l.)
(Source: Sam Shor, 2019)

Figure 1.3: The recovery of trail width after 18 years (500 m a.s.l.)
(Source: Sam Shor, 2019)

1.2 Research Question

A tropical mountain trail can have long-term effects on the soil characteristic and vegetation communities' composition. Thus, a series of questions would be used to establish the state of the trail impact in three different time periods (1998, 2000, and 2019).

1) The soil physical impact and vegetation composition of the Merapoh Trail.

    i. What is the soil compaction rate between the disturbed and undisturbed areas at the research station along the Merapoh Trail?

    ii. What is the distribution of vegetation species in disturbed and undisturbed areas at the research station along the Merapoh Trail?

    iii. What is the similarity in vegetation species in disturbed and undisturbed areas at the research station along the Merapoh Trail?

    iv. What is the density of vegetation species in the disturbed area of the research station along the trail?

2) The trail width and depth of 1998, 2000, and 2019 in different elevation of the forest zone.

    i. What is the trail width of 1998, 2000, and 2019 in different elevations of forest zone?

    ii. What is the trail depth of 1998, 2000, and 2019 in different elevations of forest zone?

    iii. What are the width differences in disturbed and undisturbed areas at the research station along the Merapoh Trail?

    iv. What are the depth differences in disturbed and undisturbed areas at the research station along the Merapoh Trail?

3) The inventory parameters that influence the width and depth of the trail.

    i. What is the relationship between elevation, tree canopy cover, and slope gradient as inventory parameters that contribute to the trail width and depth at the research station along the Merapoh Trail?

1.3 Research Objective

The primary objective of this study is to assess the Assessment and Resilience of the Merapoh Trail, Gunung Tahan, Taman Negara, Pahang, Malaysia during the comparative periods of 1998, 2000, and 2019. The specific objectives derived from the study's primary objective were as follows:

i. To assess the soil physical impact and vegetation composition of Merapoh trail.

ii. To compare the trail width and depth of 1998 and 2019 in different elevation of the forest zone.

iii. to examine the elevation, tree canopy cover, and slope gradient as inventory parameters contributing to the trail width and depth.

1.4 Research Contributions

The significance of this study is discussed from two perspectives: (1) practical contributions to recreation resource management in Malaysia's protected areas and national parks, and (2) contributions to the body of knowledge about status of physical trail impact on the recreation ecology in the tropical environment.

The findings of this study can be used to supplement the existing module in the body of knowledge for the physical indicator of recreation impact in tropical mountain areas. The exploration of physical trail impact status led to development of resilience indicators, which are relevant to the tropical environment and indicated by users. In addition, this will enhance a new level of recreational resource management. The exploration of current trail impact status and the indicators are significant, particularly for agencies directly involved in managing national parks and protected areas, such as Peninsular Malaysia's Department of Wildlife and National Park (PERHILITAN). The indicators will help the agency set guidelines for limiting recreation resource usage in mountain areas and determining the carrying capacity of the recreation resources along the trails. This proactive or preventative approach can be successful by developing management action plans and a suitable carrying capacity framework. Furthermore, resilience indicators are an essential component of any planning framework. It will potentially result in preserving recreation resources along the Merapoh Trail at Gunung Tahan, assuring future mountain climbers a higher level of leisure experience and satisfaction.

1.5 Research Limitation

The researcher conducted specific research with localizing features to determine the trail impact status in the comparative period that would apply to the tropical mountain trail environment in Peninsular Malaysia. However, in this study, the researchers only evaluated and identified soil (based on the soil compaction, the trail width and depth) and vegetation composition (species distribution, similarities, and density) of physical impact parameters. Furthermore, to examine the inventory parameters that influence the width and depth of the trail, the researcher only assessed elevation (in five altitudinal forest zones), tree canopy cover, and slope gradient. A different kind of indicator is, therefore, not within the scope. In addition, other limitations, including the lack of data on visitor numbers and trail use in the forest was an impediment in our study. The impact of environmental controls and management on trails degradation cannot be fully represented without this data. Visitor information is also essential for managerial strategies such as trail setting priorities and the identification of key management and monitoring activities.

1.6 Definition of Key Terms

1.6.1 Physical Factors

These physical factors influence the quality of recreation that can take place in the area. In addition, these variables impact each area's structural types of behaviour (Douglass, 1975). Such a trend could have harmed the recreational activities sector, particularly forest trails and camping areas (Leung and Marion, 2000; Hammitt et al., 2015; Olive and Marion, 2009). Under certain conditions, the physical factor, particularly in troubled areas, can increase the degree of impact. For example, during the rainy season, trail widening may be more difficult.

Physical factors influencing the impact of trail resources are classified into two categories: use-related factors and environmental factors, and both of which can be altered through management action (Marion and Leung, 2001). The amount of use, type of use, and user behaviour are all affected by use-related factors; environmental factors include vegetation, soil type, topography, and climate. This study selected three physical factors for total trail conditions: slope gradient, height, and canopy coverage.

1.6.2 Recreation-use Impacts

Understanding the cause of impacts and exploring practical ways to mitigate the effects to conserve wilderness resources while providing enjoyable recreation experiences is part of recreation ecology or recreation resource impacts. Impact

refers to any unfavourable biophysical change in natural resources caused by visitors (Leung and Marion, 2000; Lidle, 1997).

The term recreation-use impacts are used in this study to describe the condition of Gunung Tahan via the Merapoh Trail (GTMT). The impact has been classified into two types: trail width and trail depth. Each was measured using scientific and standard methods.

1.6.3 Vegetation Species Composition

The term vegetation species composition refers to the variety of species found at the Merapoh Trail research station. There are two types of composition involved in these studies: species similarity and species density. Two communities are involved in this composition of undisturbed and disturbed area at the research station. The disturbed area referred to the recovered site at Merapoh Trail that was not used after a period, and some vegetation species existed and started occupying that area.

1.7 Structure of the Thesis

This thesis is divided into five chapters. The first chapter discusses the study's background, problem statement, objectives, and justification. At the end of the chapter, the terms used in this study are defined. The second chapter examines relevant literature related to this study, including topics such as mountain trail in Malaysia, recreation ecology, trail impact, trail depth, trail width, soil erosion, impact on vegetation, resilience, scientific methods used in recreation impact studies, type of trail assessment and monitoring, standard trail width, and species composition. The third chapter expands on the research frameworks, including the study area, data collection procedures, and statistical analysis performed in the study. The fourth chapter discusses the research's findings and analysis concerning the research objectives. The information and interpretation of each research objective and result are mapped out to improve readers' comprehension of each rational and given analysis. The fifth chapter contains the research's conclusions and recommendations. Several conclusions are drawn in this chapter by combining results and information from the previous research literature. This chapter also identifies research "gaps" and suggests several implications, such as management guidelines and prospect research topics, that should be addressed further.

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