Evaluation of Environmental Assets Value on Borneo Using the Travel Cost Method

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Rainforests, as invaluable natural resources, play a pivotal role globally, offering many ecosystem services such as recreation. This study aims to quantify the value of Brunei's rainforest assets (specifically recreational areas and national parks) utilizing the Travel Cost Method (TCM), a prevalent approach for ascertaining the worth of natural sites. The tourism use of Brunei's rainforests holds a high value, estimated at over $300,000 USD per square kilometer, which supports the argument for resource allocation towards their protection not only for ecological reasons but also for their recreational benefits. The authors posit that nature-based ecotourism can be a sustainable and protective mechanism for tropical rainforests. Practical recommendations for ecotourism include a minimalist approach to visitor regulation, limiting access to a small percentage of large recreational areas and national parks to protect flora and fauna, and possibly implementing entry or service fees.

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INTRODUCTION

Policies against deforestation and forest degradation are an important part of global action needed to reduce greenhouse gas emissions and biodiversity loss (De Lacerda *et al.* 2022; Lawrence *et al.* 2022). Rainforests, as invaluable natural resources, play a pivotal role globally, offering a myriad of both tangible and intangible services (McCallister *et al.* 2022; Stabile *et al.* 2022). Localized on the island of Borneo, Brunei harbours one of the world's most biodiverse and undisturbed national rainforest parks. About three-fifths of the country is covered with virgin tropical rainforest and secondary forests (Rifli 2020). The national park is subject to various policies that are summarized in Table 1. These policies are grouped into five sections and are related to certain costs to local as well as the national government. This is why it is necessary to determine the value of the park so that the costs of these policies can be justified economically. The intrinsic and extrinsic values of such pristine ecosystems necessitate meticulous valuation, particularly from a policy-making standpoint, to safeguard these natural treasures (Destiartono and Ekananda 2023). This study aims to quantify the value of Brunei's rainforests utilizing the Travel Cost Method (TCM), a prevalent approach for ascertaining the worth of natural sites (Menendez-Carbo *et al.* 2020).

Various studies have valued natural resources using TCM. These studies are, however, often focused on smaller parks (Blayac *et al.* 2016; Pirikiya *et al.* 2016; Amiri and Limaei 2021), lakes (Desta and Bersisa 2019; Wubalem *et al.* 2023), wetlands (Dehlavi and Adil 2011), and countries with different natural resource policies (Schägner *et al.* 2016; Mayer and Woltering 2018). As far as the authors know, no previous research examined Bruneis tropical rainforests by TCM. At the same time, Brunei represents a unique case study of a successful natural resources policy (Gaveau *et al*. 2019). Localized on the island of Borneo, Brunei harbours one of the world's most biodiverse and undisturbed national rainforest parks (Ikbal *et al.* 2023). Meanwhile, the forest area has decreased on the island of Borneo by 50% in the last fifty years (Ocampo-Peñuela *et al.* 2020). Unlike the largely deforested parts of Malaysian and Indonesian Borneo, Brunei is one of the world leaders in primary resource management (Bryan *et al.* 2013; Ma *et al.* 2023).

Table 1. National Forests and Primary Resources Policy (Brunei Daressalam)

Section and Subsection	Policy Focus	Key Objectives and Strategies
General Policy Statement	Conservation and Management of Forest Resources	Enhance quality of life, socio-economic well-being, and ensure ecological stability through strategic forest management.
National Forest Estate	Rationalization of Primary Resources	Optimize social, economic, and ecological values from forest lands.
	Delineation of Forest Categories	Dedicate areas for protection, production, recreational, and conservation forests, and Recreational areas and national parks.
	Management and Administration	Implement strategic, legal, and protective measures for the National Forest Estate.
Environmental Forestry	Forest Conservation Programme	Develop a program that yields sustainable benefits for present and future generations.
	Management of Genetic Resources	Sustain biodiversity and ecological processes in all ecosystems.
	Recreational Forests and Recreational areas and national parks	Develop and maintain areas for recreation and international nature tourism.
Industrial Forestry	Evaluation of Production Forests Exploitation	Assess long-term social, economic, and environmental impacts of exploitation.
	Sustaining Forest-Based Industry	Implement strategies for improvement, efficient harvesting, regulation, marketing, and investment in the forest-based industry.
Excellence in Tropical Forestry	Application of Forestry Technology	Implement progressive technological changes in forestry.
	Development as a Forestry Excellence Center	Achieve international recognition in forest conservation, management, research, and education.
	International Cooperation in Forestry	Foster and support international and regional cooperation and goodwill in forestry matters.

Source: Ministry of primary resources and tourism Brunei Darussalam (2023)

The emphasis on modern forest management in Brunei has shifted strongly to conservation in the last two decades. A key objective of forestry planning and programs in Brunei is to maintain a pristine forest environment by ensuring prudent but optimal use of forest resources. The country has a significant network of protected areas, with approximately 20% of the country's total area under some form of protection. Brunei has one large national park (Ulu Temburong) and a large number of forest reserves managed mainly for nature conservation and recreation (Noorashid and Chin 2021). Together they constitute an area of 555.6 km^2.

This paper aims to quantify the value of Brunei's recreational areas and national parks per square km utilizing the Travel Cost Method. The deduced value underscores the rainforest's significance to local and national economies, propelling a discourse on policy frameworks (Gwee *et al.* 2019; Matthew *et al.* 2022; Nguyen *et al.* 2023). The rainforest is also the main natural attraction for international tourism (Chin *et al.* 2023). The authors posit that nature-based ecotourism can be a sustainable and protective mechanism for tropical rainforests, contingent upon efficacious regulation and oversight by governmental bodies and destination management organizations (Cetin *et al.* 2021). Consequently, this paper proffers practical policy implications and strategies for ecotourism management, aligning economic valuation with conservation and sustainable tourism practices, thereby contributing to the global dialogue on environmental policy and natural resource management (UN 2024). Based on existing research gaps, the authors established the following questions. What is the economic value of Brunei's rainforest national parks and recreational areas per unit of area estimated by the travel cost method? To what extent can be the established value be a basis for implementing policies to protect natural resources in Brunei?

MATERIALS AND METHODS

Visitors exhibit diverse patterns in the time and money they spend to access a resource. Generally, those living closer to a resource visit more frequently and incur lower costs, while those farther away visit less often and spend more. This pattern allows economists to estimate the value of a recreational site by averaging the transportation and opportunity costs incurred by visitors travelling to the site (Pokki *et al.* 2020).

The travel cost method (TCM), a revealed preference approach, evaluates economic value by examining actual behavior. Various techniques can be employed for data collection and estimation using TCM, which aims to quantify the value individuals assign to a resource based on their travel expenditures and frequency of visits (Brandt *et al.* 2019; Das 2013). For this paper, the total number of visitors to recreational areas and national parks in Brunei is presented in Fig. 1 by the destination. These recreational areas of national parks constitute the study area of this research paper.

The total number of 194,777 visitors to national parks and recreational areas for 2019 was used in this study, as 2020 was already influenced by COVID-19 (MPRT, 2021) as represented in Fig. 2. Also, one of the parks – Sungai Liang Forest recreation park was deleted from the data. Sungai Liang Forest Recreation Park is known for its well-developed facilities and attractions, which may cater to a different type of visitor experience compared to more natural or less developed parks. The total adjusted number of visitors after exclusion of this park was 135,646 visitors. The structure of the visitors was taken from the Immigration & National Department, Ministry of Home Affairs, Brunei Darussalam

(2023). The TCM usually utilizes a set-up of different zones based on the distance to the recreational site.

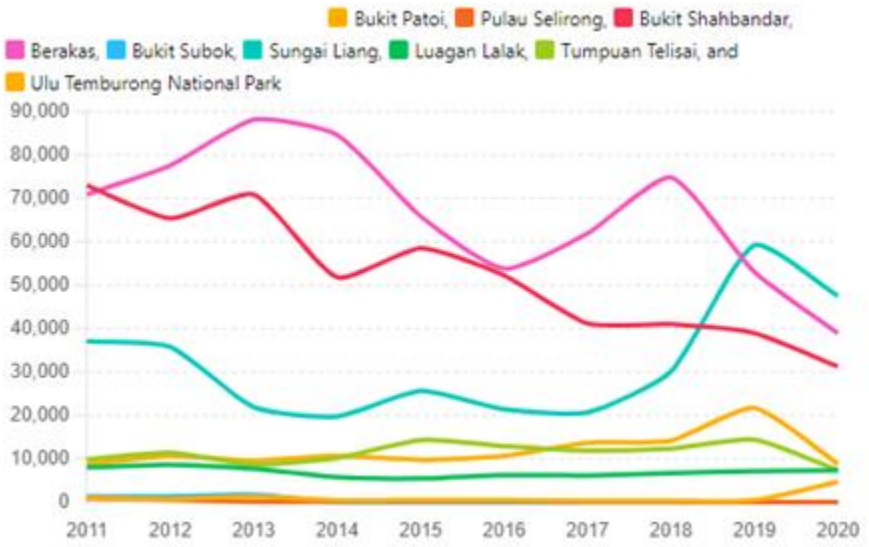

Fig. 1. Visitors of recreational areas and national parks in Brunei; **Source:** MPRT Brunei Darussalam (2021)

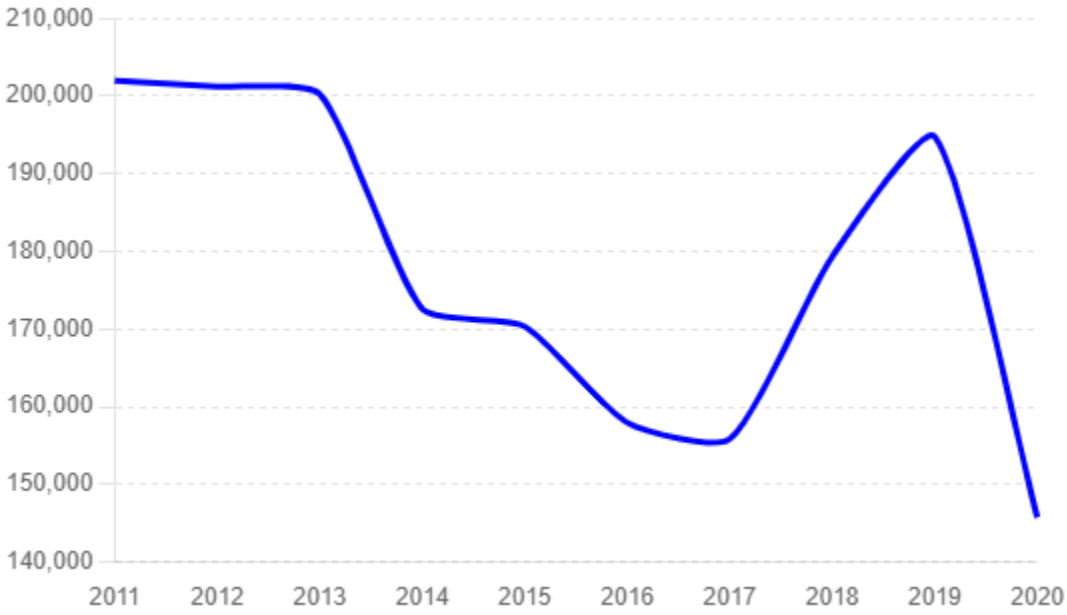

Fig. 2. Total visitors of recreational areas and national parks in Brunei; **Source:** MPRT Brunei Darussalam (2023)

Due to the nature of the authors' data, each country could be defined, from which people were travelling to Brunei Darussalam according to MPRT (2023). These data resources show the total number of tourists by origin. The origin of visitors for 2019 in percentages is visible in Fig. 3.

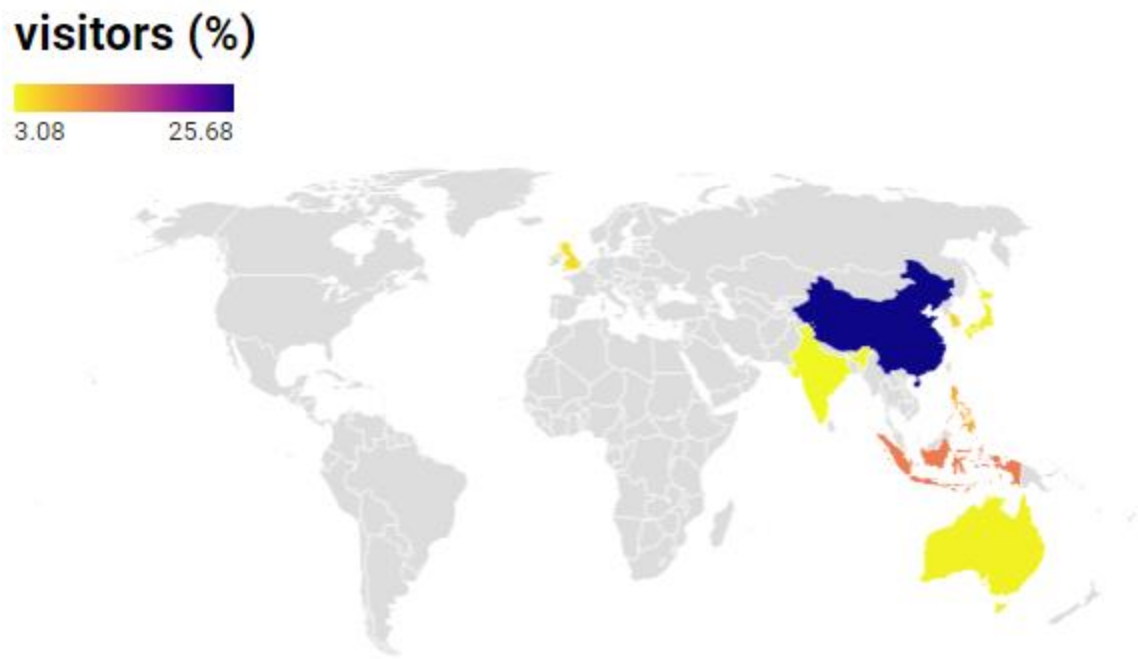

Fig. 3. Structure of visitors to Brunei's recreational areas and national parks 2019; **Source:** MPRT Brunei Darussalam (2022)

For each country, socioeconomic data were collected from Numbeo (2023). For distances from individual countries, data were collected from GCmap (2023). This methodology aligns with previous studies (Das 2013; Pokki *et al.* 2020).

The set-up of the TCM model requires a regression model (Eq. 1),

$$V_n=\alpha+\beta_1 \cdot TC+\epsilon \quad (1)$$

where V is the number of visits from n countries, TC is the total travel cost, α and β_1 are parameters to be estimated, and ϵ is the error term. Total travel cost (TC) can be defined as,

$$TC = \text{Transportation Cost} + \text{TimeCost} \quad (2)$$

where

$$\text{Time Cost}=\text{Average Hourly Wage} \times (\text{Travel Time} + \text{Stay}) \text{ [hours]} \quad (3)$$

and transportation cost is determined by the average price for air tickets.

Travel costs (TC) are calculated as a sum of transportation cost and cost of time, which is equal to the opportunity cost of travel. Time cost is calculated by taking the average hourly wage per country multiplied by the average time to destination multiplied by eight hours of work per day Additionally, average of 4.5 days of stay (Ministry of Primary Resources and Tourism Brunei Darussalam, 2022) is multiplied by eight hours of work per day. The linear functional form is usually the most suitable one. Other approaches could be the log or semi-log functions. Based on the regression equation the absolute number of visitors is determined. Consequently, consumer surplus is calculated as the area above the average total cost line (ATC) below the demand curve, which corresponds to the consumer surplus that leads to the determination of the site value. Average total cost is calculated as the average costs of all visitors.

RESULTS

Following the introduced methodology, the demand curve has been estimated. The regression results with all data did not show a significant value on the slope coefficient β_1. Therefore, several countries had to be eliminated from the regression as they were outliers and were distorting the regression results. The results of the final regression are presented in Table 2.

Table 2. Regression Results

Dependent variable	V*i*
Independent variable	*TC*
R^2	0.98
Intercept (p-value)	108742.5 (0.12)
Coefficient (p-value)	24.435 (0.049)

Source: Own calculations

This leads to the definition of the regression Eq. 4,

$$V = 108742.5 - 24.335\ TC \quad (4)$$

where all variables were already described in the methodological section. The calculation of consumer surplus was done from Fig. 4. In order to calculate it, it is necessary to determine the maximum willingness to pay. This is the point *Max WTP* in Fig. 1, which is equal to $4,450 USD. Also, it was necessary to determine the average travel cost (ATC) which was equal to $733 USD. Substituting this number into the regression yields 90,831 visitors. Finally, the total consumer surplus per square kilometer of Brunei National Park was calculated as the area under the demand curve above the average costs divided by the area of the park. This yields the value per square kilometer equal to $304,487 USD.

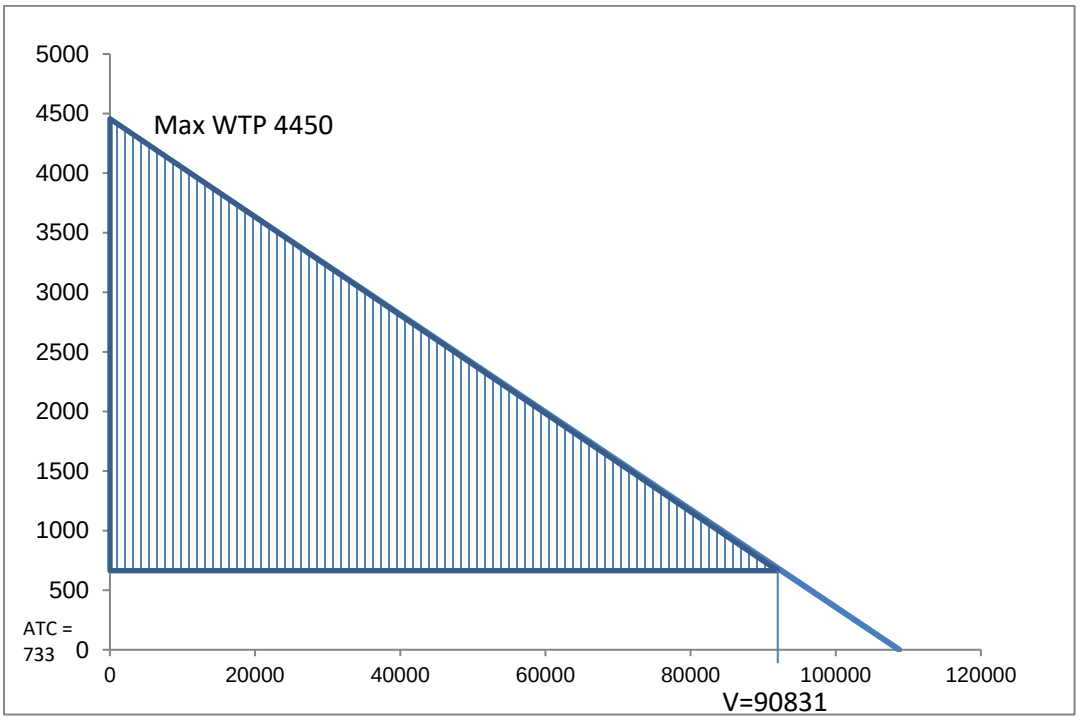

Fig. 4. Consumer surplus; **Source:** Own calculations

DISCUSSION AND LIMITATIONS

Compared to previously published studies (Gührlük and Rehber 2008; Pirikiya *et al.* 2016), the quantified value of Brunei's rainforests (more than $300,000 USD per square kilometer) corresponds to the valuation method used and the geographical characteristics of the country. Comparable values in relative terms per square kilometre have been estimated using the TCM by Mayer and Woltering (2018) for 15 national parks in Germany, Schägner *et al.* (2016) for national parks in Great Britain, or Pirikiya *et al.* (2016) for Karnataka Nagarhole Park. The perceived value of the Brunei Rainforest, measured using the TCM approach, outperforms natural sites in heavily forested and sparsely populated countries with a low number of visitors. Another recent study by Tang (2019) investigated the economic value of urban green spaces using the TCM. Tang's research focused on urban parks and the associated travel expenses of visitors. The study demonstrated that urban green spaces hold substantial economic value, which can be crucial for urban planning and resource allocation. By examining the detailed travel costs, including the opportunity cost of time, Tang (2019) illustrated how TCM could effectively capture the economic value of non-market goods such as urban parks. The results emphasized the importance of these green spaces for urban dwellers and the need for their preservation (Tang 2019). Schägner *et al.* (2016) quantified the price of national parks in the Nordic countries (Norway, Finland, and Sweden), Switzerland, and Poland in the value of up to $10,000 USD per square kilometer.

Table 3. Values of Nature Parks and Resources by Travel Cost Method

Nature Parks	Value Per km² in $USD Per Year
All recreational areas of national parks within Brunei	304,487
All NPs within Austria	50,166
All NPs within Belgium	128,117
All NPs within Switzerland	5,130
All NPs within Czech Republic	59,768
All NPs within Germany	1,457,967
All NPs within Spain	75,086
All NPs within Finland	5,619
All NPs within Sweden	5,989
All NPs within Norway	4,516
All NPs within Netherlands	31,795
All NPs within United Kingdom	207,779
All NPs within Portugal	105,719
All NPs within Italy	53,951
All NPs within Poland	6,449
All NPs within Greece	20,288
Bellenden Ker Range, Australia	2,720
15 German national parks	110,000
Karnataka's Nagarhole Park, India	129,600
Shahid Zare Forest Park, Iran	525,580
Gamla Nature Reserve, Israel	4,580
Kuşcenneti National Park, Turkey	646,000

Source: Becker *et al.* 2005; Nillesen *et al.* 2005; Gührlük and Rehber 2008; Pirikiya *et al.* 2016; Schägner *et al.* 2016; Mayer and Woltering 2018; own calculations

A similar value was reached by Nillesen *et al*. (2005) when analyzing the Bellenden Ker Range in Australia. In contrast, studies of locations with a high intensity of tourism, a

small area of national parks and an above-average level of recreation facilities and hiking trails estimated considerably higher values per square kilometre. Record values were quantified by Schägner *et al.* (2016) for national parks in Germany, Belgium, and Denmark. However, the value of national parks in Germany was probably overestimated by including visitors to the entire North Sea coast (Mayer and Waltering 2018). The overview of the studies dealing with the value of national parks is provided in Table 4.

Consistent with prior studies (Puhakka and Saarinen 2013; Saarinen 2016), there is justification to recognize the importance of the value of tourism in the planning and management of natural areas (Haukeland 2011). The growing demand for travel to protected areas while respecting aspects of sustainability is indisputable not only in Brunei but also on a global scale (Sæþórsdóttir *et al.* 2022). Ecotourism can be understood as a gentler industry than traditional industrial sectors (Gwee *et al.* 2019; Kitaibekova *et al.* 2023). Theories declare that with the growth of the economic maturity of the country, there is the promotion of more gentle approaches to the environment (Adila *et al.* 2021; Caravaggio 2022). The improvement of the economic and social conditions of the local population as a result of the development of the regional economy and employment in environmentally friendly service sectors can act as a motivating factor for residents to protect nature (Esfandiar *et al.* 2020; Baloch *et al.* 2023). At the same time, the main purpose of tropical rainforests is not to provide recreational services, but to preserve the unique biodiversity and global climate for future generations (Kuvan 2005; Chazdon 2017; Brandt *et al.* 2019). Finding a balance between tourism and nature conservation is key to the functioning of the rainforest ecosystem. In response to the increasing public demand for nature-based tourism, it is necessary to strategically manage the recreational, protective, and production activities of forests (Hikmah *et al.* 2021; Wang *et al.* 2021; Zoysa 2022).

Concrete practical recommendations in the field of ecotourism include a minimalist approach that strictly regulates the number of visitors. In the case of large national parks, it is reasonable to open only a small percentage of the area to tourists. Thanks to such regulation, it is possible to preserve rare species of flora and fauna Protected area managers may even charge entry fees or at least charge user fees for services. Tourism infrastructure should respect the principles of sustainable development (*e.g.*, Uusitalo 2017; Heslinga *et al.* 2019; Mondino and Beery 2019; Forje and Tchamba 2022).

When building recreational resorts, the impact on the environment should be minimized, including current technologies that enable the use of recycled material and alternative energy sources (*e.g.*, solar energy) in natural locations (Htay *et al.* 2022). In recent years, the risk of fires has been increasing due to global warming and human behaviour. For the long-term sustainability of tropical rainforests, it is necessary to create adequate institutional, technical, and legal conditions for fire prevention. Technical measures may include the construction of monitoring towers, early detection and warning of fires, or restricting visitor access to risk areas. An understanding of environmental issues is also important.

Rainforests can also serve as university research centres and training facilities for the public. Environmental education and awareness positively influence the self-regulation and setting of personal standards of visitors and entrepreneurs (Haukeland 2011; Dodds *et al*. 2016). The behaviour of the population is strongly determined by the economic level of the country and the policies of the governments. In Brunei, oil and natural gas are paradoxically important factors in the sustainability of unique forest stands (Hamdan and Low 2014; Ibrahim and Ghani 2018). The country achieves high export earnings and can thus regulate logging and limit deforestation. A large part of the consumption of wood

products in Brunei is even met by foreign production. A risk for the long-term sustainability of the Brunei Rainforest may be the depletion of resources and the limitation of oil and natural gas extraction in the long term.

The needed research is limited by methodological, statistical, and geographical constraints. The travel cost method data, estimated based on the structure of tourist visitors to Brunei, assumes that these visitors are primarily in the country for tourism purposes, including visits to recreational reserves and national parks. This assumption introduces a potential bias, as it may lead to an overestimation of the location's value when visitors have multiple purposes for their trip. The allocation of tourism costs across different purposes is challenging to accurately capture due to limited data sources. Estimating the opportunity cost of time is difficult, as leisure time can vary and affect work productivity. This study uses eight hours of working time to calculate opportunity costs, which might be an overestimate compared to other studies that use a shorter duration. The travel cost method also has limitations in reflecting user benefits, assuming that two tourists traveling the same distance derive identical benefits. For future research, it is recommended to enhance the analysis of consumer preferences through comprehensive methods such as questionnaire surveys, guided interviews, or contingent valuation methods (CVM), both on-site and off-site. Geographically, the study focused on Brunei as a case study. Replicating this research in other neighboring countries and regions on Borneo could improve the generalizability of the findings.

CONCLUSIONS

1. The recreational use of Brunei's rainforests holds a high value, estimated at over $300,000 USD per km^2, which supports the argument for resource allocation towards their protection not only for ecological reasons but also for their recreational benefits.
2. Estimations of natural parks' values are crucial for effectively planning recreational facilities, transport, and tourism infrastructure. With a clear monetary value, it becomes easier to allocate budget for conservation projects. This can include funding for park management, restoration projects, and community programs that promote sustainable use of natural resources. Understanding the high economic value can deter activities that might degrade these areas, such as illegal logging, pollution, or unplanned development.
3. Increasing demand for nature-based tourism necessitates strategic management of recreational, protective, and production activities within forests.
4. Practical recommendations for ecotourism include a minimalist approach to visitor regulation, limiting access to a small percentage of large national parks to protect flora and fauna, and possibly implementing entry or service fees.
5. Sustainable development principles should guide tourism infrastructure, with minimal environmental impact and the use of recycled materials and alternative energy sources while addressing the increasing risk of fires due to global warming and human activities requires adequate institutional, technical, and legal fire prevention measures.
6. The economic status of a country and government policies significantly influence behaviour towards environmental sustainability. In Brunei, the paradox of relying on oil and natural gas revenues helps regulate logging and limit deforestation, with a

significant portion of wood product consumption met by foreign production. The long-term sustainability of Brunei's rainforests may be threatened by resource depletion and the potential limitation of oil and natural gas extraction.

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