ENVIRONMENT CARRYING CAPACITY OF ECOTOURISM IN AEK NAULI RESEARCH FOREST, SIMALUNGUN REGENCY, NORTH SUMATERA

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Received: 20 June 2020, Revised: 17 August 2022, Accepted: 1 September 2022

ENVIRONMENT CARRYING CAPACITY OF ECOTOURISM IN AEK NAULI RESEARCH FOREST, SIMALUNGUN REGENCY, NORTH SUMATERA. Currently, ecotourism has become an important industry because of its rapid development. Many tourism practices have adverse environmental impacts. Due to the increasingly destructive commercialization of the natural resources on which we depend, there are several negative impacts. Aek Nauli Research Forest (ANRF), with an area of 1,900 hectares, is one of the natural tourist destinations around the Lake Toba Tourism area managed by the Aek Nauli Research Institute for Environmental and Forestry Development (BP2LHK). The location of the study is in Girsang District, Sipangan Bolon, Simalungun Regency, North Sumatera Province. The tourist objects are natural panorama, elephant conservation education tour, and siamang animal ape park. On average, the number of visitors of ANRF on regular days is 100-300 visitors/day and on holidays reaches 300-1,700 visitors/day. The increase in the number of visitors is perceived to have an impact on environmental sustainability. This study aims to determine the capacity of the ANRF ecotourism area to accommodate the number of tourists per day simultaneously. The method used is the effective carrying capacity by Cifuentes method based on several stages of analysis, namely Physical Capacity (PCC), Real Capacity (RCC), Management Capacity (MC), and Effective Capacity (ECC). The environmental carrying capacity analysis results showed that the PCC, RCC, ECC were 26,106 visitors/day, 3,007 visitors/day, 2,505 visitors/day respectively while MC was 0.83. This value can be used to advise managers to limit visitors, particularly during peak season, in order to preserve objects and the quality of visits.

Keywords: Environmental, carrying capacity, ecotourism, Toba lake

DAYA DUKUNG LINGKUNGAN EKOWISATA DI HUTAN PENELITIAN AEK NAULI, KABUPATEN SIMALUNGUN, SUMATERA UTARA. Saat ini, ekowisata telah menjadi industri yang penting karena perkembangannya yang pesat. Banyak praktik pariwisata memiliki dampak lingkungan yang merugikan, karena komersialisasi yang semakin merusak sumber daya alam sehingga menimbulkan dampak negatif. Hutan Penelitian Aek Nauli dengan luas 1.900 hektar, merupakan salah satu tujuan wisata alam di sekitar kawasan wisata Danau Toba yang dikelola oleh Balai Penelitian Pengembangan Lingkungan Hidup dan Kehutanan (BP2LHK) Aek Nauli. Kawasan tersebut terletak di Kecamatan Girsang Sipangan Bolon Kabupaten Simalungun, Provinsi Sumatera Utara. Objek wisata yang dimiliki berupa panorama alam, wisata pendidikan konservasi satwa gajah, dan taman kera satwa siamang. Pengunjung yang datang ke ANRF pada hari biasa rata-rata mencapai 100-300 pengunjung/hari dan pada hari libur mencapai 300-1.700 pengunjung/hari. Peningkatan jumlah pengunjung dikhawatirkan berdampak terhadap kelestarian lingkungan. Penelitian ini bertujuan untuk mengetahui kemampuan kawasan ekowisata ANRF dalam menampung jumlah wisatawan per hari dalam waktu bersamaan. Metode yang digunakan yaitu metode daya dukung efektif oleh Cifuentes berdasarkan beberapa tahapan analisis, yaitu Daya Dukung Fisik (PCC), Daya Dukung Riil (RCC), Daya Dukung Manajemen (MC), dan Daya Dukung Efektif (ECC). Hasil analisis daya dukung lingkungan menunjukkan bahwa nilai (PCC) sebesar 26.106 pengunjung/hari, nilai RCC 3.007 pengunjung/hari, nilai MC 0,83 dan nilai ECC 2.505 pengunjung/hari. Nilai ini dapat menjadi acuan untuk pengelola supaya ada upaya pembatasan pengunjung terutama pada hari libur agar objek wisata dan kualitas kunjungan tetap terjaga.

Kata kunci: Daya dukung, lingkungan, ekowisata, Danau Toba

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 doi:10.20886/ijfr.2022.9.2.147-163

I. INTRODUCTION

Popular tourist destinations such as Aek Nauli's Research Forest (ANRF) will continue to face various problems, both in terms of infrastructure, environmental carrying capacity and sociocultural issues, which may eventually lead to the degradation of the value for the tourist. If not anticipated, it will certainly impact the loss of balance (Hixon 2008, Nuzula, 2017). Meanwhile, new destinations without clear planning and following the rules of development and the character of the area will grow in an unorganized manner (Zhao, 2019). Carrying capacity is a concept that has been widely applied in tourism and recreation studies since the 1960s, although some researchers trace its emergence to the 1930s (Singh, 2006; Kennell, 2017). If you look at the history of global tourism development in recent years, several countries that have popular tourist destinations were invigorated by the issue of over-tourism. For example, China, Venice, Barcelona, Amsterdam, and other areas which later resulted in the emergence of the anti-tourist movement (Solís 2014, Shi 2015, Ye, 2016, Milano 2017).

ANRF is one of the research forests in Indonesia, which is managed by Aek Nauli's Center for Environmental Development and Forestry Research (BP2LHK). ANRF was established through the Minister of Forestry Decree No. 39 / Menhut-II / 2005, 7 February 2005 (Pratiara, 2017). The area of 1,900 hectares is mostly pine and secondary forest with various plant species, located in Girsang District, Sipangan Bolon, Simalungun Regency, North Sumatra Province. ANRF is a forest area essential for the research and development of science and technology, including education, training, religion, and culture, to expand dynamically. Biophysical potential, the expanse of pine forests and biodiversity in the ANRF area are the mainstays of tourist attractions, enhanced by elephant conservation education tourism and the siamang monkey animal park, a leading destination for visitors to come to the ANRF. The location of ANRF is strategic because it is on the main highway to the Lake Toba tourist area. It makes the ANRF area a choice as a tourist destination around the Lake Toba tourist area. The weekday visitors of ANRF are 100-300 visitors/day (BP2LHK Aek Nauli, 2019), and on major holidays or national holidays, the number of visitors reaches 300-1,700 visitors/day (BP2LHK Aek Nauli, 2019). However, the carrying capacity of the ecotourism area in the ANRF has never been studied.

Increasing the number of visitors affects the condition of ecotourism destinations (Sunaryo, 2013) and has an impact on the development of ecotourism which tends to increase the number of visitors without measuring the ability of the quality of attraction objects and facilities for ecotourism and disruption of biophysical potential (Lucyanti, 2013). Tourism development can be done with the concept of ecotourism by prioritizing aspects of nature conservation, socio-economic empowerment of the local communities, and education (Satria, 2009; Alaeddinoglu, 2013). Based on potential and existing conditions, ecotourism development is very feasible. Planning for ecotourism development in ANRF should be adjusted to the regional characteristics and ideal planning based on existing conditions and the carrying capacity of the environment (Muta'ali, 2012).

The environmental carrying capacity of ecotourism is a condition of the ability of the ecotourism area to acquire visits, visit length, visitor behavior at the same time without causing damage to the physical, economic, sociocultural environment and decreased tourist satisfaction. Ecotourism guarantees the sustainable use of environmental resources, while generating economic opportunities for the local people (Farrell & Runyan, 2001; Bhattacharya, Chowdhury, & Sarkar, 2011). The development of a tourist attraction requires good planning if the number of visitors does not exceed the carrying capacity (Cifuentes, 1992) to safe limits and allows to maintain the sustainability of ecotourism activities. According to Catanese

and Synder (1990), every natural system in an area can support a balanced population without experiencing destruction. In achieving the goals and targets of ecotourism development in an area, a management strategy for visitors is needed as an indicator of the success of an activity (Hariadi et al., 2012) the visitor management strategy should be based on the environmental carrying capacity. The maximum development based on environmental carrying capacity is the best approach to prevent environmental damage (Bhuiyan et al., 2012; Alaeddinoglu, 2013; Siswanto & Moeljadi, 2015; Chen & Teng, 2016; Sofian et al., 2019).

An environmental carrying capacity assessment for the ecotourism area in ANRFis is crucial to support the development of sustainable ecotourism as one of the conservation efforts to achieve sustainable ecotourism development (Alikodra, 2012). This research aims is to analyze the carrying capacity of the ANRF ecotourism area. The analysis of environmental carrying capacity is focused on the index of physical, real, management, and effective carrying capacity of the ANRF ecotourism area. The importance of this research is to fill the research gap on how to regulate visitor restrictions by policy makers. This research is useful for saving the environment from the degradation of destination quality. The study's results can be used as a reference so that visitors can feel comfortable and satisfied when doing tourism activities in ANRF.

II. MATERIAL AND METHODS

A. Time and location of the study

The study was conducted in the ANRF ecotourism area, Girsang Sipangan Bolon Sub-District, Simalungun Regency, North Sumatera Province, during March - October 2019, both weekdays, and weekends. The location of ANRF is shown in Figure 1.

B. Material and Devices

The devices used in the study include software Minitab, questionnaires, stationery, recorder, and digital cameras.

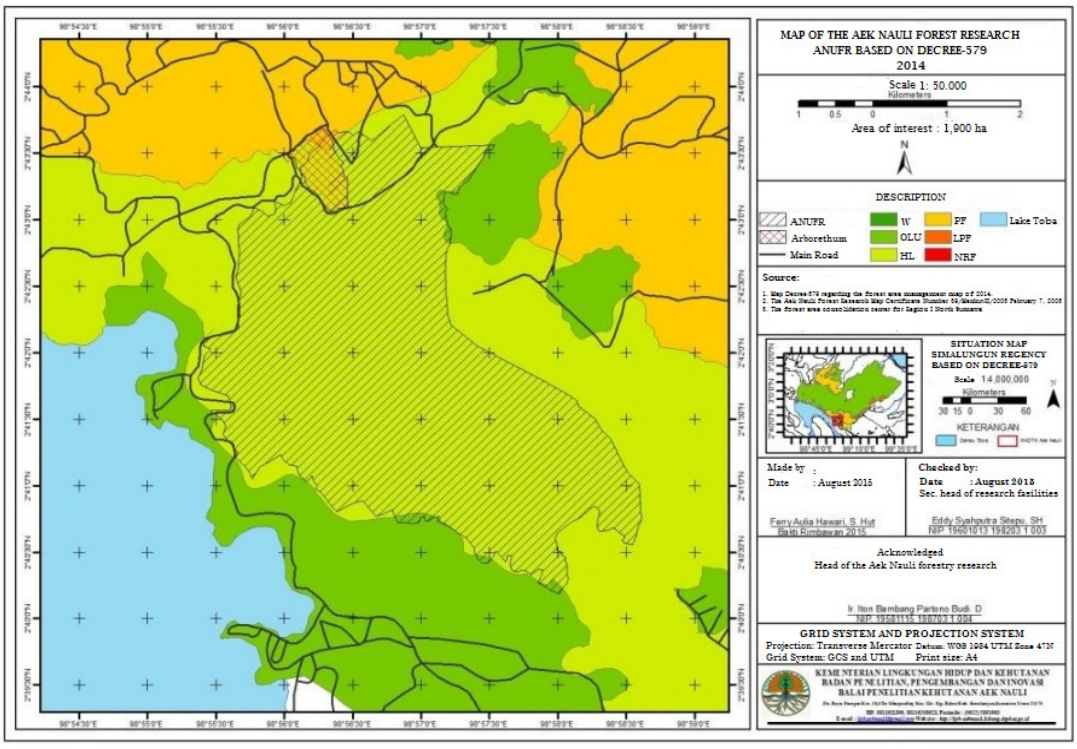

Figure 1. Map of the Aek Nauli forest research area

C. Research Method

Carrying capacity is an important tool for conserving ecological elements, rich biodiversity and rare species, and dense forests in an environment with cultural and natural experience (Arnberger, 2007; He, 2008; Chougule, 2011). A Purposive Sampling Method has been used to determine the location of the study, which reflects the criteria: a) a well-established area, b). established area, and c) less established area. The method used is the descriptive research method, and for data processing, Cifuentes method was used, by calculating the physical carrying capacity (PCC), the real carrying capacity (RCC) and the effective carrying capacity (ECC). The technique of data collection through the purposive interview is an interview conducted with respondents based on data needed. In addition to interviews, observations, and documentation were also used as data collection techniques. This study uses a mixed questionnaire, a combination of closed and open questions so that respondents answer even if they have no choice. The selection of respondents used a targeted sampling method of 107 respondents. The characteristics of the respondents were divided into 4 categories, namely: Gen Z born in 1997-2012 (42%), Gen Y born in 1981-1996 (37%), Gen X born in 1965-1980 (18%) and Baby Boomers born in 1946-1964 (3%). The N value uses the average number of visitors in 2018, which was 18,560 people per month. This data was obtained from the archives of the ticketing manager of the ANRF section. The primary data collected includes the distribution of tourist attraction items, ecotourism support facilities and infrastructure, tourists (perceptions, motives and length of visits during a tour), and correction factors (biotic and abiotic) as a basis for supporting ecotourism research. Secondary data were collected from the area manager, tourists, and the tourism office of the Simalungun Regency. As a guide for assessing carrying capacity, the collected secondary data include the general state of the study site, work charts and the number of visitors. The visitor data collection technique is the purposeful interview, a database of interviews based on the necessary data. The respondents sampled were tourists in the high and low seasons. A sample of 100 respondents was used based on (Egi et al., 2014). Based the environmental carrying capacity of the ecotourism area, data were collected on the correction factor of biotic and abiotic factors. Biotic factor includes the diversity of flora, bird species, and disturbance of the mating season of *Macaca fascicularis*, while abiotic factors includes landscape conditions, slope, soil sensitivity to erosion and climate, animals to find out the duration of visitors to the ANRF ecotourism area. Research data processing uses the carrying capacity management method Sayan and Atik (2011) where the carrying capacity of the ecotourism environment can be seen based on the biophysical characteristics of the tourist area and visitors (Figure 2). Furthermore, the collection and management of the data obtained are compiled in such a way that it can be read and interpreted (Azwar, 2012).

D. Data Analysis

Data analysis for the correction factor uses Simpson's formula to determine the diversity index of flora and bird species. The data analysis for the carrying capacity of the ecotourism environment uses (Cifuentes, 1992) formula. The justification for choosing the Cifuentes calculation method is because the synergy between tourism and nature conservation. It is necessary to consider the physical (area), ecological (environment) and managerial (effective carrying capacity) aspects. Determination and calculation of the carrying capacity and ability of the area to accommodate the number of tourists can be done using the Cifuentes approach. The Cifuentes calculation method has also been proposed by the International Union for Conservation of Nature (IUCN).

1. Vegetation and Bird Diversity Index

Tree-level vegetation is inventoried along the ANRF tourist trail. Vegetation observed was at tree level with a trunk diameter greater than 20

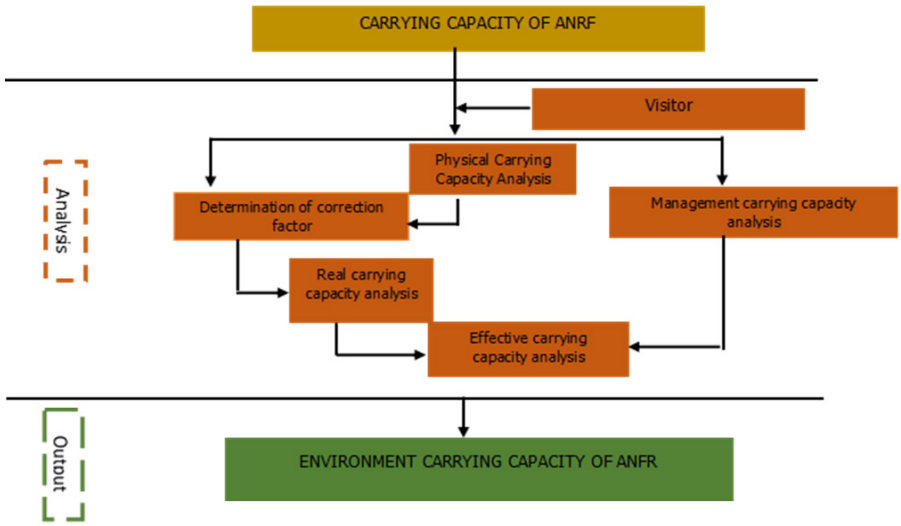

Figure 2. Framework for the flow of research data collection and processing of the environmental carrying capacity of the ANRF ecotourism area

cm measured at a hight of 130 cm from the ground surface. Inventory is done by census method on the left and right lanes with a width of 20 meters with a distance of 20 meters from the left and right lanes (Begon, 1990; Basset, 2011). Based on the vegetation observation results, the Simpson diversity index (I-DS) was calculated using the equation:

$$\mathbf{I - DS = 1 - \lambda} \quad \text{.....(1)}$$

Other correction factors are analyzed using descriptive references adjusted to the current standard values.

2. Environmental Carrying Capacity of Ecotourism Areas

a. Physical Carrying Capacity (PCC)

The Physical Carrying Capacity (PCC) is the maximum number of tourists who are physically satisfied with the space provided at a certain time (Sayan and Atik, 2011). Based on the method (Cifuentes, 1992) and the results of research modifications (Doglas, 1975) by (Fandeli & Muhamad, 2009), PCC was calculated using the formula:

$$\mathbf{PCC = A \times 1/B \times R}f \quad \text{.....(2)}$$

Where:

A = Area of ecotourism in Aek Nauli KHDTK.

B = Area required by a tourist to carry out tourist activities comfortably and obtain travel satisfaction. The need for each person to travel is 65 m² (Fandeli & Muhamad, 2009)

Rf = Rotation factor.

b. Real Carrying Capacity

The real carrying capacity is the maximum number of visitors allowed to visit the ecotourism area in ANRF with the correction factor variable (Cf), namely tree diversity, bird diversity, disturbance of the reproductive process of long-tailed Macaque, landscape, slope, soil erosion sensitivity, and Q / value climate. The formulation of real carrying capacity is based on (Cifuentes, 1992) as follows:

$$CC = PCC\ x\ \frac{100 - Cf_1}{100}\ x\ \frac{100 - Cf_2}{100}\ x\ \ldots\ldots\ \frac{100 - Cf_7}{100} \quad \text{.....(3)}$$

Where:

RCC = Real Carrying Capacity

PCC = Physical Carrying

Cf = Correction Factor

c. Management Capacity (MC)

$$MC = \frac{R_n}{R_t} x100\% \quad \text{.....(4)}$$

Where:

R_n = The number of active officers

R_t = The number of officers available

d. Effective Carrying Capacity (ECC)

Effective carrying capacity (ECC) of the ANRF ecotourism area is the optimum number

of tourists accommodated in the ecotourism area. The calculation used to assess effective carrying capacity refered to Siswanto (2013) as follows:

ECC =RCC x MC .....(5)

Where:
ECC = Effective Carrying Capacity
RCC = Real Carrying Capacity
MC = Management Capacity

III. RESULT AND DISCUSSION

A. Distribution of Objects and Attractiveness of Ecotourism in KHDTK Aek Nauli

Based on the results of field studies and information obtained from the area manager, Aek Nauli KHDTK is 1,900 hectares divided into two management blocks, the 1850 hectares of KHDTK and the 50-hectare of Arboretum block. The two blocks are the entrance to the Aek Nauli ecotourism area, where visitors enjoy the attraction in the Aek Nauli KHDTK area. The developed ecotourism area is currently ± 190 hectares divided into 2 (two) ecotourism area blocks, namely the KHDTK area block of ± 165 hectares and the Arboretum block of ± 25 hectares. The distribution and extent of ecotourism objects in KHDTK Aek Nauli are as follows:

The diversity of Nature Tourist Attractions (NTA) in the KHDTK Aek Nauli region is a wealth of natural resources such as a diversity of flora and fauna, natural panorama, natural phenomena, and many products resulting from research, development, and innovation from researchers. The existence of NTA, especially elephant and camping grounds is a magnet for visitors and has become one of the choices of tourist destinations around Lake Toba tourist area.

Tourist utilise the ecotourism area is for leisure activities, sports, photography, pre-wedding picture taking, family gathering, and research objects. Based on the potential distribution of NTA and the Nauli KHDTK function, the tourism theme is focused as scientific tourism. This scientific tourism which is divided into 5 (five) themes, i.e., scientific tourism based on wildlife attractions, forest experiencing, flora and fauna, nature and environment love and tourism scientific products based on research and development and innovation (Science and Technology).

B. Facilities and infrastructure Ecoturism in Aek Nauli Research Forests

Visitor facilities need additions and improvements such as signposts, tree identification numbers/names, handrails

Table 1. Distribution and extent of ecotourism objects in the Aek Nauli KHDTK

No.	Ecotorusim Object	Acreage (ha)	Entrance/Block
1.	Pine Forest Area	30.00	KHDTK Block
2.	Elephant Attractions	11.00	KHDTK Block
3.	Jungle Tracking	4.00	KHDTK Block
4.	Water Fall	1.00	KHDTK Block
5.	Panorama Summit	5.00	KHDTK Block
6.	Monkey Park	2.20	KHDTK Block
7.	Deer Breeder	1.00	Arboretum Block
8.	Beecosystem Park	4.00	Arboretum Block
9.	Honey Galery	0.50	Arboretum Block
10.	Camping Ground	2.80	Arboretum Block
	Total Area	61.50	

in narrow-slippery tracks/paths and for the safety of visitors, shelters for visitors to rest while exploring the forest. Restroom/toilet facilities are still lacking and seriously need to be considered because the only existing toilet is near the entrance. Also, the Muslim prayer room (Mushola) is not yet available in the ANRF block.

Facilities and infrastructure to support tourism activities in the block of ANRF and Arboretum are not appropriate in terms of the quality, quantity, and aesthetic aspects of tourism activities. In the Arboretum block, facilities and infrastructure for camping grounds such as toilet, garbage dump, and prohibition-signboard are not available yet. Therefore, it may cause damage and be less secure for office facilities, employee housing in the arboretum block, and the safety and comfort of visitors. The ANRF block needs to be added and improved with interpretation boards such as entry signs, paths to tourist attractions, tree species names, and road tracking safeguards.

The placement of facilities and infrastructure needs to be reorganized and expanded corresponding to visitors needs and reconsider the aesthetic value of tourism. Placement and number of toilet facilities should be adjusted to the length of the track and placed in visitor concentration spots to comfort the visitors and increase the beauty of the tourist area. Other tourism-supporting facilities and infrastructures that need to be arranged and adjusted to visitors are vehicle parking and a food and beverages stall. A parking lot and stalls of food, and beverages have not been arranged yet and are still using office grounds with a cramped area. Such conditions will impact the inconvenience of work activities, vehicle safety, and aesthetics, especially during peak season.

There is insufficient parking space as no specific parking lot is available for the visitors buses, cars, and motorcycles. The motorcycle parking area still uses the roadside of the main road around the tourist area. Other facilities that are not yet available are places to eat and drink. For this time, visitors still bring food from outside and buy at the temporary tent on Saturdays and Sundays around the main entrance at the office of the arboretum block.

C. Duration of Tourist Visits in ANRF Ecotourism Area

According to (Anindita, 2015) tourism is a human activity carried out consciously that receives services interchangeably between people within a country itself or abroad, which includes the inhabiting of people from other regions for a while looking for diverse satisfaction variety and difference from what was experienced before. Based on a descriptive analysis of 107 respondents at ANRF, 78% of respondents stated that the tourist attraction is very attractive, especially for elephant and ape tourist objects, 12% stated attractive and the remaining 10% stated less attractive. Most visitors (89%) are is to see the elephant and ape and the remaining simply to enjoy the natural panorama and take pictures among the pine trees.

The Aek Nauli ecotourism covers 61.5 hectares or 615,000 m². Based on the categories of (Cifuentes, 1992), the need for a toured area is 65 m²/person. The opening hours of the area are 8.5 hours (7.30-16.00 Indonesia Western Time). Based on the rotation factor, the average visit of each visitor was 3.041 hours or the duration of a single visit is in three hours (Table 2).

D. The Correction Factor of the Carrying Capacity of Ecotourism in ANRF

1. Biotic Correction Factor

Carrying capacity is not a difficult concept, yet it is not simple to calculate, as a result, there are no standard calculations available. This concept is varied wildly according to time, climate, and characteristics of tourist destinations such as coastal, rural, mountain, historical, and protected areas. Douglas (1979) defined the tourism environment carrying capacity as the number of tourists using an area without bringing any change in the quality of tourism (Fandeli & Muhamad, 2009). In the calculation

Tabel 2. The average duration of a tourist visit to ANRF

Visit Duration (hours)	Category of single value (hours)	Total Visitors	Value	Average Duration (Hour)
1-2	1.5	33	49.5	
3-4	3.5	67	234.5	
5-6	5.5	7	38.5	
Total		107	322.5	3.041= 3 hours (0≤30 minute)

of the environmental carrying capacity in the ANRF ecotourism, a correction factor is taken into consideration with the effort to maintain the biophysical quality of the tourist area; as stated by (Simon et al., 2004), visitor comfort lies in the main element of the suitability of the area and its environmental factors.

Based on the field data, 37 species of flora were identified. Pine (*Pinus merkusii*) is the most common one reaching 15 of the 141 individuals (Appendix 1). In total, 60 birds were observed covering 26 species (Appendix 2). The result of the Simpson diversity index calculation for flora and bird are used as inputs to conduct an environmental carrying capacity analysis. The calculation result of the Simpson diversity index of flora is 0.967 and determined as an Mn value. An Mt value is the highest value of the flora diversity, calculation which is 1. Therefore, a correction value of 1- 0.967 = 0.03 is obtained. Similarly, since the calculation result of the Simpson diversity index of bird species is 0.959, the correction value is 1-0.959 = 0.04. Furthermore, the results of field observations and interviews with the manager of the ape tourism park in the ANRF, it is estimated that the mating season occurs throughout the year, and there is no specific mating period for long-tailed Macaque. It confirmed that the presence of visitors at ANRF does not bring disturbances to the animal in the reproduction process.

2. Abiotic correction factors

Based on the Aek Nauli KHDTK management plan document, the ecotourism area is classified in the second slope class. The slope classification is based on the Ministerial Decree of Agriculture No. 837/Kpts/UM/1/1980 regarding the criteria and procedures for determining protected forests. The second slope class means the slope of ecotourism areas in KHDTK Aek Nauli is 8-15% with a flat area so that the Mn value is 57. The Mt value for the slope correction factor is 100. Furthermore, the correction value for the slope is 1 - 0.57 = 0.43. Assessment of soil erosion sensitivity refers to the Ministerial Decree of Agriculture No. 837 of 1980 concerning the classification of soil types based on Irfan's research result (2019). The soil classification in the Aek Nauli KHDTK ecotourism area is dominated by regosol and red-yellow podsolic species. This type of soil classification has a sensitivity to sediment source rock with slow permeability and has a large erosion sensitivity property of 40%.

The correction factor for landscape potential is very important in determining the carrying capacity of ecotourism areas (Fandeli & Muhamad, 2009; Wapole, 2007) because it relates to the physical space available in determining the carrying capacity. The potential of the landscape in the development of ecotourism that exceeds the carrying capacity will disrupt the elements of the landscape in the ecotourism area. Based on the results of the landscape potential index in the ANRF area according to the Bureau of land Management in Fandelli and Muhamad (2009), the landscape potential index in the ANRF ecotourism area is 0.78% (Appendix 3).

The correction index of 0.22% showed that the ecotourism area has low and rough hills and striking peaks with erosion-prone land

formations with dominant land characteristics and an average altitude between 1,100-1,700 meters above sea level. Potential landscape conditions in the ANRF area have different types of vegetation at each altitude, such as at an altitude of 1,400–1,700 m asl dominated by salagundi species (*Vitex trifolia*), scorch (*Baccauera dulcis*), puspa (*Schima wallichii*), sulim (*Leptospermum javanicum*), and fires (*Gordonia excelsa*). The dominant species at altitudes between 1,200–1,300 meters above sea level were rasamala (*Altingia excelsa*), simartolu (*Schima wallichii*), pine (*Pinus merkusii*), tulason (*Mimusops elengi*), modang hoting (*Cinnamomum* sp.), candis (*Schcinia xanthochymus*) and tulason (*Mimusops elengi*), modang hoting (*Cinnamomum* sp.), kandis (*Garcinia xanthochymus*) and frankincense toba (*Styrax paralleloneurum*). The potential of the regional landscape provides an interesting and challenging experience to do jungle trekking toward the attractions of the waterfall and the top panorama of Lake Toba with the sound of bird species and cool air.

Rainfall of the ANRF and Lake Toba areas range from 2000 to 2600 mm/year. The highest monthly rainfall occurs during June - December reaching more than 260 mm/month, while the dry month with rainfall less than 100 mm occurs during February - March (Sihontang, et al. 2016). The monthly evaporation of Lake Toba ranges from 125.1 mm to 135.9 mm (Acreman et al., 1993). Q value index in Lake Toba and ANRF which is the ratio of the number of dry and wet months is 0.29 and included within B Climate type according to Schmidt-Ferguson, the correction factor value is 0.71. The whole correction factor consisting of biotic and abiotic can be seen in Table 3.

3. Value of Environmental Carrying Capacity of Ecotourism in ANRF - Physical Carrying Capacity (PCC)

The Aek Nauli KHDTK ecotourism used area is 61.5 hectares or 615,000 m². The average length of the tourist visits in one day is three hours (± 3 hours). Opening hours of the ecotourism area are from 7.30 to 16.00 Indonesian Western Time or about 8.5 hours. Thus, a rotation factor value of 3.014 hours is obtained or equal to three hours (Table 2).

Based on the ecotourism area and the visit duration per visit, the results of the ecotourism area's physical carrying capacity (PCC) was 26,106. This value is the maximum number of visitors physically who can visit the ecotourism area, in the sense that the ANRF ecotourism area can physically accommodate 26,106 visitors/day.

4. Real Carrying Capacity (RCC)

The real carrying capacity assessment is based on the correction factor values in the analysis. The correction factor value is obtained from the results of the previous calculation (Table 3). So the real carrying capacity is 3,007 people per day. This value indicates the capacity of tourists with the consideration of physical and biophysical aspects of the environment (correction factor)

Table 3. The correction factor value in the PCC Variable Ecotourism Area in ANRF

Factor Correction Variable	Parameter	Index Value (x100%)	Corrector Factor Value
Biotik	Tree Diversity	0.967	0.03
	Bird Diversity	0.959	0.04
	Macaca fascicularis Mating Season Disturbance	1	-
Abiotik	Landscape Potency	0.78	0.22
	Landscape Potency	0.57	0.43
	Erosion Sensitivity Potency	0.60	0.40
	Climate Potency	0.29	0.71

to visit the ANRF ecotourism area. Based on the data on the number of visitors 63,740 visitors per year (BP2-LHK Aek Nauli, 2019) that value is still below the real carrying capacity value meaning that the ecotourism area is still able to accommodate more visitors physically and biophysically.

5. Management Capacity (MC)

Based on the interview, the Aek Nauli ecotourism area has 24 staff consisted of 20 permanent employees as officers or tour guides and 4 non-permanent employees. The employees are divided based on tourist activities, namely: 9 elephant animal attractions, 4 gibbons attractions, 4 entrance staff, 7 arboretum area officers. Based on the number and status of officers in the ANRF ecotourism region the Rt is 24 and the Rn is 20, so the management carrying capacity is 0.83.

Management capacity is indicated by several variables such as legal basis, policies and regulations, equipment, officers, financing, infrastructure, and other facilities (Cifuentes., 1992). Therefore to develop a tourist attraction, it is necessary to increase the capacity of the management officer to serve the visitors better. This is to anticipate a decrease in the management capacity, especially in the peak season, when the number of visitors exceeds the carrying capacity.

6. Effective Carrying Capacity (ECC)

The effective carrying capacity (ECC) of the ANRFecotourism area is the optimum number of tourists accommodated in the ecotourism area. The calculation of the effective carrying capacity analysis obtained a value of 2.505. This value determines the effective capacity of the ANRF ecotourism area which is 3,007 tourists/day considering physical and biophysical environmental factors (correction factors). The values based on the real carrying capacity and management capacity of managers.

Based on the results of this value compared with the average number of tourist visits to the ANRF ecotourism area, which is 300 tourists per day, the value is still far below the effective carrying capacity. Thus the number of tourists expected to travel to the ANRF without disrupting to the environment and ecosystem is equal to 2,505 visitors per day at simultaneously in each ecotourism activity. So: PCC> RCC and ≥ECC = 26,776 > 3,007 ≥ 2,505. The carrying capacity of the ecotourism area can accommodate the number of visitors in the same area and time of 26,776 visitors per day physical carrying capacity and 3,007 visitors per day for real capacity. The effective capacity is 2,505 visitors/day.

ANRF's management strategy to be sustainable is to link ecological, social, and economic aspects. Recommendations for management strategies at ANRF are: first, limiting and distributing visitors who come to the location because the number has exceeded the EEC of 26,106 visitors per day. The exceeded area's carrying capacity can cause ecosystem disturbances (Milano, 2017). According to Salerno et al. (2013) limiting visitors can reduce negative effects on tourist objects and provide space for visitors to get travel satisfaction. Visitor restrictions are carried out on tourist activities that have exceeded the EEC, such as trekking and camping. When the number of visitors in the trekking zone exceeds the capacity, the visitors are distributed to other activities. It is expected that the visitors are evenly distributed among each activity and that they do not exceed the EEC. Second, to innovate and optimize existing tourism activities. Recommendations for additional zones for alternative tourism activities are the addition of a 1000–1500 m trekking route, an additional 500 m^2 collection park zone, and a 200 m^2 elephant bathing tour. This is expected to increase the capacity of the number of visitors and increase the value of tourism carrying capacity. The tourist activities at ANFR that are visitors favorites are the camping grounds and trekking with beautiful panoramas. This is because other tourist activities are not widely known by visitors and are still in the process of repair and

preparation. Tourism planning activities are expected to be completed as soon as possible to increase visitors attractiveness. The third effort is to optimize and equip facilities according to regional needs. It is necessary to add security for trekking routes, gazebos, souvenir stores, public toilets, and other facilities for photo spots. The number of these facilities is considered less than optimal because it is not proportional to the number of visitors who come. Developing of ecotourism infrastructure and facilities must be environmentally friendly but still provide comfort and satisfaction to visitors who travel.

This ecotourism activity is expected to provide education, skills, and innovation for conservation activities. Fourth, provide accommodation or transportation to the location. The unavailability of public transportation to ANRF ecotourism is an obstacle for visitors who do not have private vehicles. Visitors can use a taxi from the highway to the location, but the number of taxis is still very limited and expensive. Managers can cooperate with travel agencies or propose to the local government to procure travel and public transportation. The condition of the main road to the location is paved but needs to be maintained to provide convenience for visitors. Information and directions to tourist attractions are quite good. Fifth, organize soft skills training for the surrounding community regarding ecotourism for manufacturing of special souvenirs such as key chains, t-shirts, or regional specialities. Increasing people's income and welfare will help reduce economic problems in the area. Managers can conduct consultations or comparative studies on areas with ecotourism with other mountain landscapes that have been developed. The ecotourism development plan that will be carried out must always be coordinated with the local leaders or government so that management can be sustainable (Khaery et al. 2016, Zemla 2020). Sixth, take advantage of tourist-attracting events such as the Lake Toba Festival (LTF), which was held in early December. This event is used to attract tourists who are visiting LTF by creating an ANRF booth at the exhibition. Another effort can be made by increasing ticket prices on weekends and allowing visitors to buy t-shirts or souvenirs produced by the community. This will help the community to continue producing handicrafts. Seventh, planting and maintaining ecosystems so that they can grow well. Hopefully, with the development of ecotourism, the rehabilitation activities carried out will continue. Until now, the management is still trying to expand the tree planting area and make understorey enrichment to become elephant food gardens. Planting trees and making feed gardens does not only involve not only managers, but also NGOs, students and the community.

E. Management Implication

Ecotourism at ANRFhas started when Lake Toba became a leading tourist attraction in North Sumatra. This moment is used to develop the sector furthers a separate tourism management plan and action plan should be developed. Many people come to ANRF to see forests, wildlife, and natural beauty and to visit the surrounding tourist places.

ANRF has a good potential for eco-tourism. Management will create opportunities for creating an ecotourism-driven tourism industry based on protected areas. Ecotourism can be promoted as a conservation and sustainable development tool for wildlife and forests and from a community point of view it is expected to provide benefits that eventually increase local support for natural resource conservation. The study's result did not reveal a negative attitude towards tourism growth at ANRF, but as tourism evolves, the attitude trend of tourism may change. Further studies would therefore be needed in the future to collect comprehensive data on tourism performance in protected areas in terms of ecological, socio-economic and community conservation levels.

The management of ANRF through ecotourism has a positive impact on the villagers, the local economy and the preservation of the environment and local culture. Communities who play an active role in the management of

ANRF are increasingly aware of preserving the environment, besides that, ecotourism management of tourist areas has proven to provide new jobs. Limited facilities and infrastructure just because there is no tread design for ANRF so that the arrangement and placement of facilities for support activities on the trekking trail has not been able to finish. It is necessary to immediately design tread design and promote trekking trails related to the carrying capacity that should not be exceeded.

Furthermore, envisioned as a positive approach to sustainable development in tourism ANFR, if unplanned or poorly planned and not implemented can have a serious negative effect, offset the benefits that are designed to be given.

IV. CONCLUSION AND RECOMMENDATION

A. Conclusion

The Aek Nauli KHDTK is 61.5 hectares consisting of attractions of pine forest (30 ha), elephant animal (11 ha), jungle tracking (4 ha), waterfalls (1 ha), panorama peaks (0.5 ha), monkey park (2.20 ha), deer breeding (1 ha), ecosystem park (4 ha), honey gallery (0.50 ha), and camping ground (2.80 ha). The average tourist visit duration was three hours.The physical carrying capacity (PCC) can accommodate of 26,776 visitors per day. The maximum number of tourists in real terms (RCC) by considering two correction factors with seven parameters based on the characteristics of ANRF is 3,007 visitors per day. The value of management capacity is 0.83 and the effective number of visitors taking into account physical, ecological, and management (ECC) aspects is 2,505 visitors per day. The calculation of the environmental carrying capacity of the ecotourism area in KHDTK Aek Nauli shows PCC> RCC> ECC which is 26,776 > 3007 ≥ 2,505. The calculation results mean that the ecotourism area in ANRF can accommodate more visitors with all their activities comfortably at the same time when the actual number of visitors does not exceed the maximum limit of the RCC value.

B. Recommendation

ANRF developed areas in the spirit of local people's participation, appreciation and sensitivity. Facilities in ANSF must be improved to support ecotourism development. Different entrances and exits need to be built so that visitor management can be better monitored and organized, especially during major holidays when the number of visitors is increasing. There must be restrictions on vital and tourist zones, so that office activities and employee housing are not open to the public, allowing visitors without permission to go to the office area and employee housing.

ACKNOWLEDGEMENT

We gratefully acknowledge the Aek Nauli Research and Development Center for Environment which manages South Sumatera conservation area. Special thank to head officer Aek Nauli Research and Development Center for Environment, Pratiara, S.Hut, M.Si for valuable information and financial support. We also thank the staff (Mr. Firman, Mr. Erwin Patriot Manik, and Mr. Darmanto) for generous support and assisting in the conduct of this research. For his much-valued assistance, we would like to thank Ir. Adi Susilo, M.Sc. as a proofreader of this manuscript.

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Apendix 1. The tree-level vegetation diversity index in Aek Nauli KHDTK

Local Name	Latin Scientific Name	ni	ni(ni-1)	n	n(n-1)	λ	IDS
Api-api	*Gordonia excelsa* Blume	6	30				
Boli-boli	*Sauraula nudiflora* Dc.	3	6				
Dori	*Syzygium cf. lineatum* (DC.) Merr.&Perr.	2	2				
Goring-goring	*Baccauera dulcis* Merr.	3	6				
hapas-hapas	*Symingtonia populnea* Steem.	4	12				
harimotting	*Rhodamnia cinerea* Jack.	8	56				
Hatinggiran	*Syzygium* sp.	3	6				
Hatuang	*Litsea velutina* Boerl.	1	-				
Hau dolok	*Syzygium sp.*	2	2				
Hau dolok baringin	*Eugenia suringariana* K.et.V.	5	20				
Horbo-horbo harangan	*Xylopia sp.*	3	6				
Horing engket-engket	*Lithocarpus daphnoideus*(Blume.) A. Carnus	4	12				
Hoting batu	*Quercus maingayi* Bakh.	2	2				
Hoting bunga merah	*Lithocarpus hystrize* (Korth.) Rehd	3	6				
Hoting bunga putih	*Castanopsis rhamifolia* (Miq.) Dc.	2	2				
Hoting merah	*Castanopsi*s sp.	5	20				
Hoting turi	*Quercus gemiflora* Blume	3	6				
Jambu-jambu	*Eugenia fastigiata* Miq.	3	6				
Kandis	*Garcinia celebica* L.	7	42				
Kemenyan	*Styrax benzoin* Dryand.	2	2				
Kemenyan durame	*Styrax sp.*	1	-				
Kemenyan toba	*Styrax sp.*	1	-				
Logan	*Dipterocarpus kunstleri King.*	2	2				
Losa	*Cinnamomum porectum (Roxb.) Kosterm*	1	-				
mayang	*Palaquium obovatum Engl., var.*	4	12				
Medang landit	*Litsea odoratissima Kosterm.*	6	30				
Meranti batu	*Shorea resinosa Sym.*	4	12				
Modang	*Litsea odorifera Valeton*	3	6				
Modang putih	*Neolitsea cassiifolia Merr.*	2	2				
Modang siak	*Cinnamomum subavenium Miq.*	4	12				
Pinus	*Pinus merkusii*	15	210				
Puspa	*Schima wallichii Korth.*	3	6				
Rasamala	*Altingea exelca*	6	30				
Salagundi	*Rhodoleria theymanii Miq*	4	12				
Sampinur bunga	*Dacricarpus sp.*	2	2				
Sanduduk bolon	*Melastoma pulcherrimum Korth.*	5	20				
Sulim	*Leptospermum javanicum*	7	42				
	Total	**141**	**642**	**141**	**19740**	**0.033**	**0.967**

Apendix 2. Bird diversity index in KHDTK Aek Nauli

Bird Species	Nama Latin	ni	ni(ni-1)	N	n(n-1)	λ	IDS
Burung madu leher	*Antherepte rhololaema Shelly*	2	**2**				
Cikrak daun	*Phylloscopus trivirgatus Strickland*	5	**20**				
Cinenen belukar	*Orthotomus atrogularis Temminck*	2	**2**				
Cinenen gunung	*Orthotomus cuculatus Temminck*	6	**30**				
Kucica kampung	*Copsychus saularis L*	3	**6**				
Kutilang	*Pycnonotus aurigaster Vieillot*	1	**-**				
Layang-layang rumah	*Delichon dasypus Bonaparte*	1	**-**				
Poksai hitam	*Garrulax lugubris Muller*	1	**-**				
Poksai jambul	*Garrulax leucolophus Hardwicke*	2	**2**				
Punai besar	*Treron capellei Temminck*	3	**6**				
Punai kecil	*Treron olax Temminck*	7	**42**				
Sikatan bubik	*Muscicapa dauurica*	1	**-**				
Srigunting bukit	*Dicrurus remifer Temminck*	1	**-**				
Srigunting kelabu	*Dicrurus leucophaeus Vieillot*	1	**-**				
Bubut besar	*Centropus sinensis Wagler*	1	**-**				
Poksai hitam	*Garrulax lugubris Muller*	3	**6**				
Punai besar	*Treron capellei Temminck*	2	**2**				
Punai kecil	*Treron olax Temminck*	4	**12**				
Kucica kampung	*Copsychus saularis L*	2	**2**				
Kutilang	*Pycnonotus aurigaster Vieillot*	3	**6**				
Layang-layang rumah	*Delichon dasypus Bonaparte*	1	**-**				
Kucica kampung	*Copsychus saularis L*	1	**-**				
Burung cabai hutan	*Dicaeum concolor Ferdon*	2	**2**				
Burung madu belukar	*Anthreptes singalensis Gmelin*	3	**6**				
Burung madu	*Antherepte rhololaema Shelly*	1	**-**				
Kacamata gunung	*Zosterops montanus Bonaparte*	1	**-**				
	Total	60	**146**	**60**	**3540**	0.041	**0,959**

Apendix 3. Landscape potential index in the Aek Nauli Ecotourism area

Lanscape element	Criteria	Score	Value
Land shape	Low and undulating hills, hill at the mountains foot or valley bottoms are not attractive features of landscaping.	1	
	Steep canyons, volcanic cones, or interesting erosion patterns or variations in land size and shape or dominant detail characteristics.	3	5
	High vertical relief with striking peaks; a spire-like summit; giant rock profile or amazing surface variations; easily eroded formations or very striking dominant features.	5	
Vegetation	Little or no difference in vegetation	1	
	Some vegetation but only 1-2 species are dominant.	3	5
	A variation of vegetation type that is indicated by attractive patterns, textures and shapes	5	
Colour	Color Subtle and contrasting color variations, generally dead.	1	
	Different types of colors, opposites of soil, rock and vegetation but not the dominant view	3	3
	A variety of color combinations or beautiful contrasts and colors of soil, rock, water vegetation and others	5	
Scenery	The nearby scenery has little/no effect on the quality of the scenery.	0	
	The nearby scenery is quite influential on the quality of the scenery.	3	3
	The nearby scenery greatly influences the quality of the scenery.	5	
Characteristic	Having an interesting background but almost the same as the general situation in an area	1	
	Distinctive though almost the same as in certain regions.	3	3
	Distinctive/different from other objects and bring impression	5	
Modification	Modifications add variety but are very contrary to nature and cause disharmony	-4	
	Modifications add little or no diversity of scenes	0	2
	The construction of facilities such as installations/ electricity, waterways, houses provides modifications that can increase visual diversity; no modification	2	
	Total	27	21
	Landscape potential Index		0.78