



A Study of Environmental Carrying Capacity on Three Potential Tourism Destinations of Lumajang Regency, East Java

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Abstract: Lumajang Regency in East Java Province has significant potential for tourism development due to its intersection with the Bromo Tengger Semeru National Park (TNBTS). The purpose of this research is to assess the Environmental Carrying Capacity (DDTL) of tourism area to provide a foundation for sustainable tourism development planning in Lumajang Regency. The research focuses on three tourist destinations: Ranu Pane, Wotgalih Beach, and Tumpak Sewu Waterfall. The method used is the DDTL calculation approach by Cifuentes (1992), which includes Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC). Data was collected through observation, literature study, and interviews with key stakeholders. The analysis results display the PCC, RCC, and ECC values in sequence for each location: Ranu Pane (9,941; 1,228; 1,228), Wotgalih Beach (1,641; 1,068; 1,068), and Tumpak Sewu Waterfall (312; 25; 25). The ECC value can serve as a metric for measuring the DDTL status of tourist locations in comparison to the average number of tourists. Ranu Pane and Wotgalih Beach have an ECC value greater than 1,000 when compared to the average number of tourists, which ranges from 500 to 900 people per day. Therefore, their status has not yet exceeded the DDTL. In contrast, Tumpak Sewu Waterfall has an ECC value of less than 50 with an average number of tourists exceeding 100 people per day, and its status is classified as having exceeded the DDTL limit. These results can be considered by the Lumajang Regency Government when planning the development of tourist destinations.

Keywords: Carrying Capacity; Sustainable; Tourism.

Introduction

The tourism sector has experienced significant growth nowadays and it is contributing to Gross Domestic Product (GDP) both locally and internationally (Mariyono, 2017). According to the World Travel & Tourism Council (2023), the tourism sector contributed 7.6% to the global Gross Domestic Product (GDP) in 2022. Similarly, data from the

Indonesian Ministry of Tourism and Creative Economy (2023) indicates that the tourism sector contributes 3.76% to Indonesia's Gross Domestic Product (GDP). The contribution of the tourism sector to the Gross Domestic Product (GDP) has gradually increased after the COVID-19 pandemic. The sector has a positive impact on the Regional Original Revenue (PAD) and has the potential to encourage the growth rate of other sectors, such as agriculture, trade, and services.

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Indonesia is a tropical country with diverse landscapes and ecosystems as well as different cultures from east to west, making Indonesia a popular destination for foreign tourists (Hariwanto, 2022). It is important to develop tourism by promoting the unique advantages of each region in Indonesia in order to maintain and increase the global competitiveness of tourism (Huda, 2020). According to Kumala et al. (2017), Aribowo et al. (2018), Kurniawan (2018), and Sumarsono et al. (2020), the East Java Province possesses significant tourism potential due to its unique biodiversity and culture. This potential is further supported by the 2015 priority tourism development policy, which designates East Java tourist destinations, including the Bromo Tengger Semeru National Park (TNBTS), as one of Indonesia's ten priority tourist destinations. The Bromo Tengger Semeru National Park is a mountainous region situated in East Java, Indonesia. It is located within the administrative boundaries of Pasuruan Regency, Malang Regency, Lumajang Regency, and Probolinggo Regency.

This research focuses on tourist destinations in Lumajang Regency, East Java, which has high potential for tourism sector development due to its diverse natural and cultural attractions (Karunia, 2018; Agustian, 2022). According to the Department of Tourism and Culture of the Lumajang Regency Government (2018), there were at least 37 tourism developing destinations in Lumajang Regency as of 2018, which is located adjacent to the Bromo Tengger Semeru National Park (TNBTS). The government is aware of the potential for tourism development in the area and is actively working on the enhancement of the attractiveness and value of these destinations for both domestic and international tourists.

In the concept of tourism planning and development, sustainable development is a core factor that must be considered to create a balance of environmental, economic, and social components in an area to provide long-term benefits. Parmawati et al. (2022), stated that planning activities also affect a growing number of policies that focus on maintaining sustainable tourism. Proper initial planning and adherence to policies can steer tourism development in a positive direction and prevent gradual damage (Rath & Gupta, 2017). This research focuses on measuring the Environmental Support and Capacity (DDTL), which is a fundamental consideration in spatial planning, in line with the tourism destination planning activities conducted by the Lumajang District Government. The aim of this research is to analyze the Tourism Environmental Support and Capacity (DDTL) in Lumajang district, particularly in priority tourism destinations. This analysis will serve as the foundation

for planning sustainable tourism development in Lumajang district.

Method

The research was conducted in the Lumajang district of East Java due to its significant landscape and cultural potential. The study will focus on the primary destinations in three districts of Lumajang Regency, as listed in Table 1.

Table 1. Research location in Lumajang Regency

| Tourism Destination | District | Typology |
|---------------------|--------------|-----------|
| Tumpak Sewu | Pronojiwo | Waterfall |
| Ranu Pane | Senduro | Lake |
| Wotgalih Beach | Yosowilangun | Shore |

The measurement of Environmental Carrying Capacity, which refers to the Cifuentes framework in 1992, involves the study of three main variables: Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC). The steps for the analysis of each of these variables are as follows:

Physical Carrying Capacity (PCC)

The Physical Carrying Capacity measures the maximum number of tourists that can fit in the area at any given time. The calculation formula used is as follows (Formula 1).

$$PCC = A \times \frac{v}{a} \times Rf \tag{1}$$

Notes:

- A : Area for Tourism activities
- $\frac{v}{a}$: Area for specific activities (1 tourist/m²)
- Rf : Rotation Factor
- $Rf = \frac{\text{open duration of tourism destinations}}{\text{average tourist visit duration}}$

Real Carrying Capacity (RCC)

The concept of RCC refers to the maximum number of tourists which can be accommodated in each area without harming the environment and is an objective measure of the balance between tourism and the environment. The calculation formula used is as follows (Formula 2).

$$RCC = PCC - Cf_1 - Cf_2 - \dots - Cf_n \tag{2}$$

To measure Cf_n (Correction Factor) used a calculation formula as follows (Formula 3).

$$Cf_n = \frac{M_1}{M_t} \times 100\% \tag{3}$$

Notes:

- C_f : Correction Factor
- M_1 : Limiter for Variable size
- M_t : Total size of variable

In this study, the Correction Factor (C_f) used in are Precipitation ($Cf1$) dan Soil Sensitivity ($Cf2$).

Effective Carrying Capacity ECC

The Effective Carrying Capacity indicates the maximum number of tourists that the tourist area can accommodate, as determined by the manager's assessment. The calculation formula used is as follows (Formula 4).

$$ECC = RCC \times MC \tag{4}$$

Notes:

- ECC : Effective Carrying Capacity
- RCC : Real Carrying Capacity
- MC : Management Capacity (*based on number & competencies of staff*).

$$MC = \frac{Rn}{Rt} \times 100\%$$

Notes:

- Rn : Number of actual staff
- Rt : Number of needed staff

Result and Discussion

Observation of Study Site (Three Tourism Destination)

Ranu Pane

Ranu Pane serves as one of the starting points for climbing Mount Semeru. It is a tourist destination that features a lake situated at an altitude of 2,100 meters above sea level. The altitude has a significant impact on the ambient temperature, which can drop to -4 °C. The tourist area of Ranu Pane covers 35.79 km² and offers various activities, including camping and hiking. Ranu Pane is accessible 24 hours a day, and there are no limited operating hours. To access the activities at Ranu Pane, tourists must pay an entrance fee of IDR 19,000 on weekdays and IDR 24,000 on holidays. According to data from the Lumajang District Tourism Office (2023), an average of 455 tourists visits Ranu Pane daily.

Wotgalih Beach

Wotgalih Beach is the 11th most visited tourist spot in Lumajang district. The beach features black sand and a flat landscape, and is easily accessible from the city center, located only 19 km away. The average number of daily visitors from 2018 to 2022 is 105 tourists.

Tumpak Sewu Waterfall

Tumpak Sewu Waterfall is situated in the Pronojiwo sub-district at the base of Mount Semeru,

covering a tourist area of 3,000 m². Visitors typically trek from the parking lot to the waterfall's panoramic location. The operational hours of this tourist attraction are from 07.00 WIB to 17.00 WIB. The entrance fee for this tourist attraction is IDR 10,000 for domestic tourists and IDR 20,000 for foreign tourists. On average, this tourist destination receives 74 visitors per day.

The table below (Table 2) presents indicator used to calculate Environmental Carrying Capacity (DDTL) based on observations and literature studies conducted at three research locations.

Table 2. Carrying capacity calculation indicator

| Variabel | Sub-Variabel | Ranu Pane | Pantai Wotgalih | Tumpak Sewu |
|----------|---|-------------------------------------|------------------------------------|------------------|
| | Area (m2) | 35.790.00 | 720.000 | 3000 |
| | Tourist activities (m2) | Trekking (16 m2) Camping (90 m2) | Picnic (65 m2) Swimming (27 m2) | Trekking (16 m2) |
| | Physical (PCC) | Duration (hour) | 168 | 24 |
| | Average duration of tourist visits (hour) | 60 | 6 | 6 |
| | Rotation factor | 2.8 | 4 | 1.66 |
| | Total of Rainy Day | 165 | 68 | 203 |
| | Total of Operational Day | 365 | 365 | 365 |
| | Real (RCC) | Cf1 | 0.5479 | 0.8136 |
| | Soil Sensitivity score | 58.08 | 15 | 60.95 |
| | Soil sensitivity maximum score | 75 | 75 | 75 |
| | Cf2 | 0.2255 | 0.8 | 0,1873 |

Environmental Carrying Capacity (DDTL)

The concept of Environmental Carrying Capacity (DDTL) can aid regional planning in achieving a balance between humans and the environment, contributing to sustainable development. The Government of Indonesia, through Government Regulation Number 26 of 2007 concerning Spatial Planning, mandates that regional spatial plans consider the environment's carrying capacity (Faiz & Komalasari, 2020). Furthermore, the application of carrying capacity indicators yields precise solutions to manage the negative effects of tourism, alleviate environmental

degradation, and establish a sustainable development plan in the study area (Vandarakis et al., 2023).

Physical Carrying Capacity (PCC)

The table below displays the calculation results for the Physical Carrying Capacity (PCC) variable, which determines the maximum number of tourists that can be accommodated in three tourist destinations in Lumajang Regency.

Table 3. Physical Carrying Capacity

| Location | Area (m ²) | v/a (m ²) | Rf | PCC Value |
|-----------------------|------------------------|-------------------------|------|-----------|
| Ranu Pane | 35.790.000 | 0.00069 | 2.8 | 9.941 |
| Wot Galih Beach | 720.000 | 0.00056 | 4 | 1.641 |
| Tumpak Sewu Waterfall | 3.000 | 0.0625 | 1.66 | 312 |

Ranu Pane has the highest maximum number of tourists per day among the three tourist destinations in Lumajang district, with 9,941 people per day (Table 3). This high visitation value is accompanied by a large tourism area of 35 km². By knowing the PCC value beforehand, the Lumajang district government can make rational decisions in accelerating tourism development in Ranu Pane. Attallah (2015) stated that the value of PCC can serve as a managerial tool to define the threshold at which environmental changes, disturbances, and problems occur. Currently, Lumajang district is concentrating on enhancing two aspects: (1) infrastructure and (2) environmental conditions. Regarding infrastructure, the government is collaborating with local tourism actors to improve tourism services for tourists while constructing facilities and infrastructure. Ranu Pane Lake has the potential to be polluted by garbage and agricultural intensification. Therefore, socialization and ecosystem restoration efforts are being intensively carried out to prevent pollution.

Real Carrying Capacity (RCC)

Each tourist spot will have its own biophysical parameters based on the specific tourist area. The real carrying capacity (RCC) is calculated using the physical carrying capacity value of tourism and the correction factor, as indicated by Cifuentes (1992), Walimbo (2017), Prinajati and Rahmawati (2019), and Budiani et al. (2019).

The Physical Carrying Capacity (PCC) can serve as the foundation for calculating the Real Support Capacity (RCC) variable (Sayan & Atik, 2011). The PCC determines the maximum number of tourists that a site can accommodate based on its physical condition. However, by taking into account correction factors such

as rainfall and soil conditions, the RCC can determine the actual number of tourists that can be accommodated per day.

Table 4. Real Carrying Capacity

| Location | PCC value | Cf1 | Cf2 | RCC value |
|-----------------------|-----------|---------|--------|-----------|
| Ranu Pane | 9.941 | 0.5479 | 0.2255 | 1.228 |
| Wot Galih Beach | 1.641 | 0.18136 | 0.8 | 1.068 |
| Tumpak Sewu Waterfall | 312 | 0.443 | 0.1873 | 25 |

Table 4 match with the assumption that Ranu Pani has a high Real Carrying Capacity (RCC) value. This is due to the high Physical Carrying Capacity (PCC) value and the significant impact of rainfall correction factor (Cf). Ranu Pane's location in the highlands results in increased rainfall intensity, which is dominant from December to March. To prepare for the anticipated high rainfall and to enhance the convenience of tourists, the Lumajang Regency government collaborated with local communities to reforest the Ranu Pane area. The objective is to create a more comfortable ecosystem that can accommodate the increasing potential of both local and foreign tourists.

Effective Carrying Capacity (RCC)

Effective Carrying Capacity (ECC) is defined as the maximum number of visits that a destination can sustain while keep on track within the level of management capacity (MC) (Cifuentes, 1992; Sustri, 2009; Sayan and Atik, 2011). Management Capacity refers to the number of tourism management staff. The effective carrying capacity is calculated using the RCC calculation results and the Management Capacity value obtained from the analysis of the required number of managers or employees.

According to the observations and interviews conducted with respondents of each tourism attraction, the number of present staff is sufficient for the required tourism tasks. Therefore, the Management Capacity value for Ranu Pane, Wotgalih Beach, and Tumpak Sewu Waterfall is 1.

Table 5. Effective Carrying Capacity

| Location | RCC Value | MC | ECC Value |
|-----------------------|-----------|----|-----------|
| Ranu Pane | 1.228 | 1 | 1.228 |
| Wot Galih Beach | 1.068 | 1 | 1.068 |
| Tumpak Sewu Waterfall | 25 | 1 | 25 |

According to Lagmoj et al. (2013), the Effective Support Capacity (ECC) that aligns with the managerial system in tourist destinations can maximize the number of tourists. Table 5 shows that the number of staff

involved in the managerial system is adequate. Currently, the Lumajang Regency Government has indirectly developed Community Based Tourism (CBT). This approach emphasizes cooperation with local communities, both for direct and indirect involvement in the tourism industry. It provides access opportunities in tourism management and development.

Tourism Carrying Capacity Level

To determine the level of tourism sustainability can be done with comparing the values of Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC) variables with the average daily number of visitors. Average number of visitors value is obtained from interviews with managers and data record of tourist arrival. The table below shows the sustainability of tourism in three destinations within Lumajang Regency.

Table 6. Tourism Carrying Capacity Level

| Location | PCC | RCC | ECC | Avg. tourist | Notes. |
|-----------------------|-------|-------|-------|--------------|--------------------|
| Ranu Pane | 9.941 | 1.228 | 1.228 | 998 | Balance |
| Wot Galih Beach | 1.641 | 1.068 | 1.068 | 515 | Balance |
| Tumpak Sewu Waterfall | 312 | 25 | 25 | 109 | Exceed the Balance |

The tourism carrying capacity analysis shows that Ranu Pane and Wotgalih Beach have not exceeded their physical, real and effective tourism carrying capacity. Therefore, these attractions can still be developed to attract more tourists. However, it is important to note that the analysis is only an indication of the limit of daily tourist visits that is acceptable for the maintenance of the tourist environment. To maintain the sustainability of tourism, it is necessary to anticipate an increase in the number of tourists during certain periods, such as Eid al-Fitr, school holidays, and national holidays.

Tumpak Sewu Waterfall tourism carrying capacity has been exceeded in both actual and effective tourism carrying capacity. This means that the number of daily tourists visiting has surpassed the ability of tourist sites to safely and sustainably accommodate them, considering natural condition factors such as rainfall and soil sensitivity. The Tumpak Sewu waterfall tour's beauty must be preserved to ensure continued tourist visits that generate economic value for business owners and local governments without compromising the natural beauty.

Conclusion

In planning for tourism development in Lumajang Regency, it is important to consider the results of the

environmental carrying capacity and capacity analysis (DDTL), which is then further specialized into tourism capacity. The PCC, RCC, and ECC value can serve as a metric for measuring the DDTL status of tourist locations in comparison to the average number of tourists. Ranu Pane and Wotgalih Beach have an ECC value greater than 1,000 when compared to the average number of tourists, which ranges from 500 to 900 people per day. Therefore, their status has not yet exceeded the DDTL. In contrast, Tumpak Sewu Waterfall has an ECC value of less than 50 with an average number of tourists exceeding 100 people per day, and its status is classified as having exceeded the DDTL limit. Tumpak Sewu Waterfall has a tourist capacity that exceeds the carrying capacity value, indicating its potential to attract many local and international tourists. To enable the Lumajang Regency Government to make more targeted movements and development in this location. These results can be considered by the Lumajang Regency Government when planning the development of tourist destinations to meet a sustainable development standarts.

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Author Contributions

Conceptualization, Y.H.W and R.P.; methodology, M.M.; software, M.M.; validation, Y.H.W., R.P. and M.M.; formal analysis, Y.H.W., R.P. and M.M.; investigation, M.M.; resources, M.M.; data curation, Y.H.W., R.P. and M.M.; writing—original draft preparation, Y.H.W., R.P. and M.M.; writing—review and editing, Y.H.W and R.P.; visualization, R.P. and M.M.; supervision, M.M.; project administration, Y.H.W.; funding acquisition, Y.H.W. All authors have read and agreed to the published version of the manuscript

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Conflicts of Interest

The authors declare no conflict of interest.

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