The study of environmental carrying capacity for sustainable tourism in Telaga Warna Telaga Pengilon Nature Park, Dieng Plateau, Central Java

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Abstract. The increasing in quantity of the tourists visiting Telaga Warna Telaga Pengilon Nature Park, Dieng Plateau, Central Java, can cause a potential threat toward the conservation sustainability of the tourist attraction and the surrounding area. The utilization of conservation area for tourist attraction has to be carried out based on the principal of Environmental Carrying Capacity so that it will not affect the ecosystem. This study aims to determine the value of Telaga Warna Telaga Pengilon Nature Park environmental carrying capacity as a conservation area used for tourism activities. The environmental carrying capacities calculated in this study were physical carrying capacity, real carrying capacity, and effective carrying capacity. Results of this research show that the physical carrying capacity of The Telaga Warna Telaga Pengilon Nature Park was 31,302 visitors, the real capacity was 869 visitors/day and the effective carrying capacity was 579 visitors/day. Thus, the sustainable tourism development strategy is needed to manage the everlasting natural resources.

1. Introduction

Forest ecosystems in protected areas has the uniqueness of the landscape as well as the biodiversity [1]. As an attempt to preserve the nature, sustainability activities in tourism sector is needed, which is called sustainability tourism. The sustainability tourism will balance the positive and negative impact from tourism activities [2].

Tourism activities in a protected area are related to the characteristic and the congruence of the area as a destination for ecotourism. The right ecotourism planning and management are needed in order to decrease the negative impact caused by the tourism activities and to maximize its positive impact [3]. To preserve the environmental quality of the tourist object, integrated management effort has to be applied [4]. The ability of the environment to support human life, living creatures, and the balance between the two is called the environmental carrying capacity. Environmental carrying capacity studies are very crucial to be conducted. These studies are the preventive precaution measures to avoid the environmental destruction [5].
2. Literature Review

The basic principles of Sustainable Tourism is optimally utilize environmental resources while maintaining the ecology and conservation, respect for cultural authenticity and communities and ensure the long term sustainability [6]. Environmental Carrying Capacity of natural attractions is the ability of natural attractions in the area and a certain time unit to accommodate the number of tourists [7]. Tourism carrying capacity has an important role in the management of the area because it was considered as a systematic, strategic policy tool in the planning process [8].

Management of protected areas as a tourist spot is one effort to build a sustainable management. Development of tourism in the conservation area occurred from mass tourism to an individual or small group tourism. The development of this travel pattern focuses on the experience with the motivation to get the expansion of life [9].

Physical carrying capacity is the maximum number of travellers who are physically fulfilled by the space provided at a certain time. The real carrying capacity was the number of visitors allowed to visit a tourist attraction with a correction factor derived from the characteristics of the object that is applied to the Physical carrying capacity [10]. The effective carrying capacity was the maximum number of visitors received at a tourist attraction, was obtained from the value of the real carrying capacity that related to the capacity management attractions manager [8].

3. Methods

The method used in this study was qualitative. Information was obtained through questionnaires. The carrying capacity of environment in the area was determined by using the calculation of physical carrying capacity, real carrying capacity and effective carrying capacity. The questionnaires was filled out by visitors and the manager of the Telaga Warna Telaga Pengilon. The number of visitors was determined using the formula slovin with accuracy boundary of 10%. The research was located at Jojogan Village, Kejajar District, Wonosobo Regency, Central Java province. The location was one of the tourist attractions at the Dieng Plateau which managed by the Central Java BKSDA, the Ministry of Environment and Forestry.

3.1. Physical Carrying Capacity/PCC

Physical carrying capacity intended to find out the limit of maximum excursions by considering the satisfaction in travelling in a unit of time [10].

\[
PCC = \frac{A}{B} \times Rf
\]  \hspace{1cm} (1)

Note:
- PCC = Physical Carrying Capacity
- A = Area for tourism activities
- B = The required tourist area to obtain satisfaction in tourism activities

3.2. Real Carrying Capacity/PCC

Real carrying capacity was the result value of physical carrying capacity based correction factors that have been determined because it is considered influential in tourism activities. Some elements into the correction factor was vegetation, slope, landscape potential, rate of erosion and rainfall.

\[
RCC = PCC \times \frac{100 - cf_1}{100} \times \frac{100 - cf_2}{100} \times \frac{100 - cf_n}{100}
\]  \hspace{1cm} (2)
Note:
RCC = Real Carrying Capacity
Cf = Correction Factor

3.3. Effective Carrying Capacity/ECC
The effective carrying capacity was the maximum value for the number of visits at certain locations by considering the management capacity and the real carrying capacity.

\[ MC = \frac{Rn}{Rt} \cdot 100\% \]  

(3)

Note:
MC = Management capacity
Rn = The Officer on duty
Rt = The officer required for on duty

The capacity management will affect the real carrying capacity, it’s called the effective carrying capacity

\[ ECC = MC \cdot RCC \]  

(4)

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

4. Results
Telaga Warna Telaga Pengilon was located at an altitude 1965-2300 meters above sea level. Telaga Warna and Pengilon was geographically located between 7° 12' 3" and 7° 13' 3" LS and the 109° 54' 47" and 109° 55' 10" BT. The area was composed of ecosystems covered by plants such as *Acacia Sp.*, *Podocarous sp.*, *Melaleuca Sp.*, *Schima Sp*, *Casuarina junghuniana*. Relative Frequency value, relative density and relative dominance was as follows:

![Figure 1](image1.png)

**Figure 1.** (a) Relative frequency, relative density and relative dominance; (b) Location of Telaga Warna Telaga Pengilon.

| Name           | Attendance | Total individu | Total basal area [cm²] | INP [%] |
|----------------|------------|----------------|------------------------|---------|
| *Schima Sp.*   | 5          | 8              | 13381.53               | 53.18   |
| *Acacia Sp*    | 10         | 27             | 69555.73               | 167.14  |
| *Podocarous sp.* | 1         | 1              | 200.96                 | 7.20    |
| *Melaleuca Sp.* | 2          | 4              | 31428.03               | 44.89   |
According to the table 1. Telaga Warna Pengilon has 21 types of trees that dominated by Acacia Sp. were classified as type mountain forests. Podocarous Sp. has the smallest attendance since rarely encountered in research. The composition of mountain forests was one of the main factors Telaga Warna Telaga Pengilon was a nature-themed recreation. Visitors motivation in tourism activities were based on the physical motivation among others, to refresh their body and soul, rest for health, sports, recreation for fun [11]

Tourism activities were increased the number of visitors over the last few years. These trends were influenced by the nature-themed tourism, accommodation and the ease of access information such as internet information, newspaper on the objects that they visit. Telaga Warna Telaga Pengilon area was a challenging locations as destination activities and nature tourism activities in accordance with the natural surroundings. In the conservation area it was possible to obtain the knowledge so that it can be packaged into various forms of tourism activities [9].

Table 2. Total visitors the last 4 years

| Year | Total Visitor [visitor/year] |
|------|-----------------------------|
| 2012 | 155,516                     |
| 2013 | 210,372                     |
| 2014 | 345,393                     |
| 2015 | 388,521                     |

The value of physical capacity shows that customer satisfaction will remain awake even if the visitors of Telaga Warna Telaga Pengilon raise into 31,302 people. The value of the physical carrying capacity was based solely on the area of conservation without considering other environmental factors. Biotic and abiotic environmental conditions are the limiting factor in the physical carrying capacity so that it can be regarded as the real carrying capacity of a tourist area.

Table 3. The correction factor value of environmental carrying capacity

| Correction Factor                                      | value Index | Value Factor Correcting |
|--------------------------------------------------------|-------------|-------------------------|
| Simpson diversity index                                | 0.586       | 0.414                   |
| Bureau Of Land Management index                        | 0.56        | 0.44                    |
| Slope Index                                            | 0.48        | 0.52                    |
| The type of soil against erosion sensitivity            | 0.60        | 0.40                    |
| Rainfall index                                         | 0.267       | 0.733                   |

Calculation of the real carrying capacity of Telaga Warna Telaga Pengilon was 869 visitor/day. It means that the Telaga Warna Telaga Pengilon will be received a negative impact on the biotic and abiotic environments when the number of visitors exceed into 869 visitors per day. The negative impact on the abiotic environment can be seen in the area, such as degradation of water quality due garbage, vandalisme action, etc. While the negative impact on the biotic environment also has been happen such as disruption of the distribution of birds in the area.

The value of the effective carrying capacity of the Telaga Warna Telaga Pengilon was 579 visitor/day. That means if one day the tourist area can accommodate 579 visitors in accordance with the capacity management. It can be said that if the number of visitors is not more than the value of ECC, the ecosystem will not be negatively affected and the visitors will still get good service Management Capacity with a value of 66.67% has an effect on the level of visitor satisfaction. Management capacity less than optimal, it can affect the maintenance and monitoring of the tourist area. The value of Management Capacity can be increased 33.33% by adding the officers in accordance with the necessary
requirements so that it will correspond to the real carrying capacity calculation. Adding a place to enjoy the lake it is possible to break the concentration of visitors. It was intended so that visitors do not accumulate at one point. Carrying capacity is flexible, because the physical carrying capacity of the region would change which is influenced by other factors including the pattern of a visit, the experience of the visit, the climate, and policy manager. Flexible carrying capacity can be maximized by adding attractions and supporting facilities in the area provided [12].

The value of the real carrying capacity was not exceeded in comparison with the average amount of visitors/day in the last four years, namely 753 visitors/day. However, when it was compared to the effective carrying capacity, the value had exceeded the average amount of visitors per day in the last 4 years. An ecosystem had the ability to recover against a disturbance, on condition that the disorder does not take place continuously, and requires a certain time [4].

5. Conclusions
The environmental carrying capacity in the area is not constant but dynamic, so the ability of a system can be increased or decreased. Sustainable development strategy tourism is necessary for the management of natural resources sustainability. Sustainable tourism aims to manage all natural resources as best as possible. Management of tourism is determined based on the ability of the manager to manage resources and potential, with attention to the impact on the environment.

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