Cover Letter

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27 January 2024

Dear
Dr. Budi Warsito,
Editor in Chief Jurnal Ilmu Lingkungan

We wish to submit an original research article entitled “Carrying Capacity Analysis of Batu Belimbing Nature Tourism in East Singkawang District Singkawang City West Kalimantan” for consideration by Jurnal Ilmu Lingkungan.
We confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere.

In this paper, we report on / show that Batu Belimbing Nature Tourism has potential as ecotourism from the carrying capacity ecotourism. This is significant because the development of ecotourism does not damage the ecological environment for sustainability and increases the local community economy.

We believe this manuscript is appropriate for publication by Jurnal Ilmu Lingkungan because it is in line with the journal's scope of Environmental Management, Development and Environmental Management, Ecology, Conservation of Natural Resources and the Environment.

This research aims to determine the potential for ecotourism areas to be developed by paying attention to carrying capacity, including Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC) without damage to the natural ecosystem. Several parameters supporting this research show the important role that needs to be paid attention to in developing ecotourism areas in other places, especially in Indonesia.

We have carried out plagiarism testing on this manuscript with Turnitin, and it has a similarity of 15% to the excluded bibliography. We hope our manuscript's originality can meet the publisher's requirements.

We have no conflicts of interest to disclose.

Please address all correspondence concerning this manuscript to me at
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Thank you for your consideration of this manuscript.

Sincerely,

Slamet Rifanjani

Analysis Of Batu Belimbing Nature Tourism In East Singkawang District Singkawang City West Kalimantan

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Carrying Capacity Analysis of Batu Belimbing Nature Tourism in East Singkawang District Singkawang City West Kalimantan

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ABSTRAK

Wisata Alam Batu Belimbing (WABB) yang terletak di Kelurahan Nyarumkop, Kota Singkawang mempunyai potensi ekowisata yang dapat dikembangkan. Terjadi peningkatan jumlah pengujung pada Kawasan WABB. Sehingga potensi daerah tersebut dengan perhitungan kapasitas daya dukung Kawasan Wisata perlu dilakukan. Hal ini bertujuan untuk menjadikan Kawasan WABB tetap berkelanjutan tanpa merusak Lingkungan alam pada sekitar Kawasan ekowisata dengan memperhitungkan daya dukung efektif (ECC), real (RCC) dan fisik fisik. Penelitian dilakukan dengan metode wawancara dan observasi pada March to April 2023. Pemaparan hasil penelitian dilakukan dengan analisis kualitatif. Hasil penelitian menunjukkan bahwa Kawasan WABB memiliki daya dukung fisik sebesar 5.211 orang/hari, daya dukung real sebesar 1.637 orang/hari, dan nilai daya dukung efektif sebesar sebesar 1.637 orang/hari. Hasil ini menunjukkkan bahwa kawasasan WABB masih mampu mendukung semua aktifitas yang ada pada Kawasan WABB tanpa merusak ekosistem alam selama nilai RCC dan ECC lebih rendah dari nilai PCC (5.211 orang/hari).

Kata kunci: *Daya Dukung Wisata, Wisata Alam Batu Belimbing, Ekowisata*

ABSTRACT

Batu Belimbing Nature Tourism (WABB), located in Nyarumkop Village, Singkawang City, has the potential for ecotourism to be developed. There has been an increase in the number of visitors to the WABB area. The Tourism Area's carrying capacity must conducted to calculate the area's potential. This aims to make the WABB area sustainable without damaging the natural environment around the ecotourism area by considering effective (ECC), real (RCC), and physical carrying capacity. The research was conducted using interview and observation methods from March to April 2023. The research results were presented using qualitative analysis. The research results show that the WABB area has a physical carrying capacity of 5,211 people/day, a real carrying capacity of 1,637 people/day, and an effective carrying capacity of 1,637 people/day. These results show that the WABB area is still able to support all activities in the WABB area without damaging the natural ecosystem as long as the RCC and ECC values are lower than the PCC value (5,211 people/day)

Keywords: Tourism carrying capacity, Batu Belimbing Nature Tourism, Ecotourism

Citation:

1. Introduction

West Kalimantan is a province with various ecotourisms that can be visited. Ecotourism is a subcategory of alternative tourism that focuses on tourist visits to see natural areas (Kennell 2014). Some of them are tourism in the mangrove forest area in Singkawang (Rifanjani *et al.* 2023b), nature tourism in Lake Sentarum National Park (Maria *et al.* 2019) (Siahaan *et al.* 2018), white-water rafting in BBBRNP (Listiani *et al.* 2023); (Rifanjani *et al.* 2024), Pangar waterfall in Bengkayang (Rifanjani *et al.* 2023a), Bedawat waterfall in Landak (Toha *et al.* 2021), Entoba waterfall in Melawi (Saputra *et al.* 2021), to natural phenomena such as big stone tourism in Bukit Gelam, Sintang (Karmelitha *et al.* 2021), and other natural stones tourism in Singkawang with the name Batu Belimbing.

Batu Belimbing Nature Tourism (BBNT) is one of the natural tourist attractions in Singkawang City. It is located in Nyarumkop Village, East Singkawang District. The natural tourist attraction offered is a huge rock in the middle of the lake with a beautiful view of the Poteng mountains behind it. Batu Belimbing has a threaded shape like a star fruit, and half of its side is black, which is believed to be the result of friction from a meteor. Local people believe the rock was once small but continued growing until it was as big as it is now.

BBNT has long been known and visited by the local community. Still, the management, namely Batu Belimbing Tourism Awareness Group (POKDARWIS), was formed in December 2021, which means the management is relatively new. BBNT is an ecotourism category that offers natural views, flora, and fauna,

contributing to conservation activities and economic income for local communities. Nowadays, BBNT is receiving significant attention from the local community as a tourist attraction, increasing the number of visitors to the area. The potential for ecotourism must be accompanied by the supporting capacity of multiple factors to remain sustainable (He *et al.* 2023). Hence, analyzing the carrying capacity is essential to assess BBNT's ability to accommodate the influx of visitors, considering various existing factors. So, knowledge about the carrying capacity for sustainable ecotourism in an area is essential to preserve the beauty, biodiversity, and natural environmental conditions (Putri dan Ansari 2021).

Ecotourism has a positive influence on the psychology of visitors making visitors happier (Lee *et al.* 2021). However, this effect will not be found if the ecotourism location does not support it well, such as a location with crowded visitors (Manning 2022) and then effect to damage to the ecological environment (Zeng *et al.* 2022). This must also be a consideration for creating sustainable ecotourism locations.

Carrying capacity for ecotourism research was conducted by Salemi *et al.* (2019a); (2019b) for the evaluation and development of ecotourism in protected areas. Several factors significantly influence the development of ecotourism areas, such as slope, coverage of vegetation, type of vegetation, facilities and infrastructure and natural landscape, soil erosion, rainfall and the rural regions (Salemi *et al.* 2019a).

Ecological tourism's carrying capacity relies on three elements: effective carrying capacity (ECC), real carrying capacity (RCC), and physical carrying capacity (PCC) (Wiyono *et al.* 2018). Previous studies indicate that the carrying capacity of nature tourism reflects its capability to handle visitor arrivals. The prescribed conditions for carrying capacity are PCC > RCC or RCC ≥ ECC according to Sasmita *et al.* (2014). A favourable carrying capacity for a tourist destination is achieved when PCC > RCC ≥ ECC, signifying that it can efficiently accommodate visitors and their activities. This occurs when the number of visitors exceeds the RCC limit, allowing managers to increase visitor numbers without surpassing the carrying capacity value. Carrying capacity is exceeded if ECC > RCC and RCC > PCC.

This research aims to determine physical carrying capacity (PCC), real carrying capacity (RCC), and effective carrying capacity (ECC) in the BBNT area. This is to analyze the sustainability of the BBNT area as an ecotourism area. The objective of this study is to ascertain the effective carrying capacity (ECC), real carrying capacity (RCC), and physical carrying capacity (PCC) within the BBNT region. The goal is to evaluate the sustainability of BBNT as an ecotourism destination.

2. Materials and Methods

The study occurred at Batu Belimbing Nature Tourism, in the East Singkawang District of Singkawang City, West Kalimantan, Indonesia (Figure 1). The research spanned from March to April 2023.

The instruments utilized in this study include a map indicating the research location, Garmin78s GPS, binoculars, stopwatch, compass, water pass, a questionnaire distributed to a manager, a bird identification guidebook, and a tree identification guidebook. The object of this research is the Batu Belimbing Nature Tourism area.

To calculate the PCC, RCC, and ECC values, the data was collected using the following method:

a. *Physical Carrying Capacity (PCC)*

The tourism area is measured by creating coordinate points using Garmin78s GPS and the results were processed using ArcGIS 10.3. The value of the area needed by a tourist to travel with satisfaction, especially picnicking, was obtained from the literature (Fandeli dan Muhammad 2009). Data obtained from interviews were used to calculate the value of the visitor rotation factor.

b. Real Carrying Capacity (RCC)

Five correction factors were determined, which were obtained from the real situation of BBNT. First, the slope was measured using waterpass to obtain the height difference between two points that represent the condition of the research location. Second, soil sensitivity to erosion was obtained from observing the land type map of Singkawang City to find out the type of soil in the research location and then matching the soil type in the literature to find out its value (Mendicino 1999). Third, rainfall was obtained from a comparison of the number of wet months and dry months from rainfall data for East Singkawang District for 2020-2022 from the Meteorology, Climatology, and Geophysics Agency (BMKG). Fourth, trees were obtained through the process of identifying tree species using the Point-Centered Quarter method (Silva *et al.* 2017). Fifth, birds were obtained through the process of identifying bird species using the Point Count method (Elzinga *et al.* 1995).

c. Effective Carrying Capacity (ECC)

The managers available and the number of managers that are needed during peak season from the interview are used to calculate the management capacity value.

Data analysis was carried out in a qualitative descriptive analysis based on consideration of the values of Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC).

The formula used to calculate the PCC value is (Cifuentes 1992):

$$PCC = A \times \frac{1}{B} \times Rf$$

Information:

A : The area used for tourism (m^2)

B : The area needed by a tourist to travel with satisfaction, picnic activity is 65 m^2 (Fandeli dan Muhammad 2009)

Rf : Rotation factor or operational time/average visiting time.

The formula used to calculate the RCC value is (Wiyono *et al.* 2018):

$$RCC = PCC \times \frac{(100 - Cf1)}{100} \times \frac{(100 - Cf2)}{100} \times \ldots \times \frac{(100 - Cfn)}{100}$$

Information:
PCC : Physical carrying capacity.
Cfn : Correction factor

Slope correction factor (Cf1) was obtained by calculating the slope with the following formula:

$$\text{Slope} = \frac{\text{Height difference}}{\text{Actual distance}} \text{ x } 100\%$$

Then the slope value that obtained was matched with the slope classification table by the Minister of Agriculture Decree No. 837/Kpts/UM/11/1980 (Muta'ali 2012) to obtain the slope correction factor value.

Soil sensitivity correction factor (Cf_2) was obtained by analyzing the type of soil in Batu Belimbing Nature Tourism and then determining the value based on the soil type classification table by Minister of Agriculture Decree No. 837/Kpts/UM/11/1980 (Muta'ali 2012).

Rainfall correction factor (Cf_3) was obtained by using the Schmidt-Ferguson formula which uses a comparison between the number of dry months and the number of wet months (Q) (Wirjohamidjojo *et al.* 1996) from rainfall data by Meteorology, Climatology, and Geophysics Agency (BMKG):

$$Q = \frac{\sum \text{bulan kering}}{\sum \text{bulan basah}} \text{ x } 100\%$$

Trees (Cf_4) and birds (Cf_5) correction factors were obtained using the Simpson Diversity Index formula (Odum 1998) as follows:

$$\lambda' = \frac{\sum_{i=1}^{s} ni\ (ni-1)}{n\ (n-1)}$$

$$IDS = 1 - \lambda'$$

Information:
λ' : Simpson index
s : Number of types
ni : Number of individuals of type-i
n : Number of individuals of all types
IDS : Simpson Diversity Index

The formula used to calculate the ECC value is (Cifuentes 1992):

$$ECC = RCC \times MC$$

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

Information:
MC : Management capacity
Rn : Number of managers that available
Rt : Number of managers that needed during peak season.

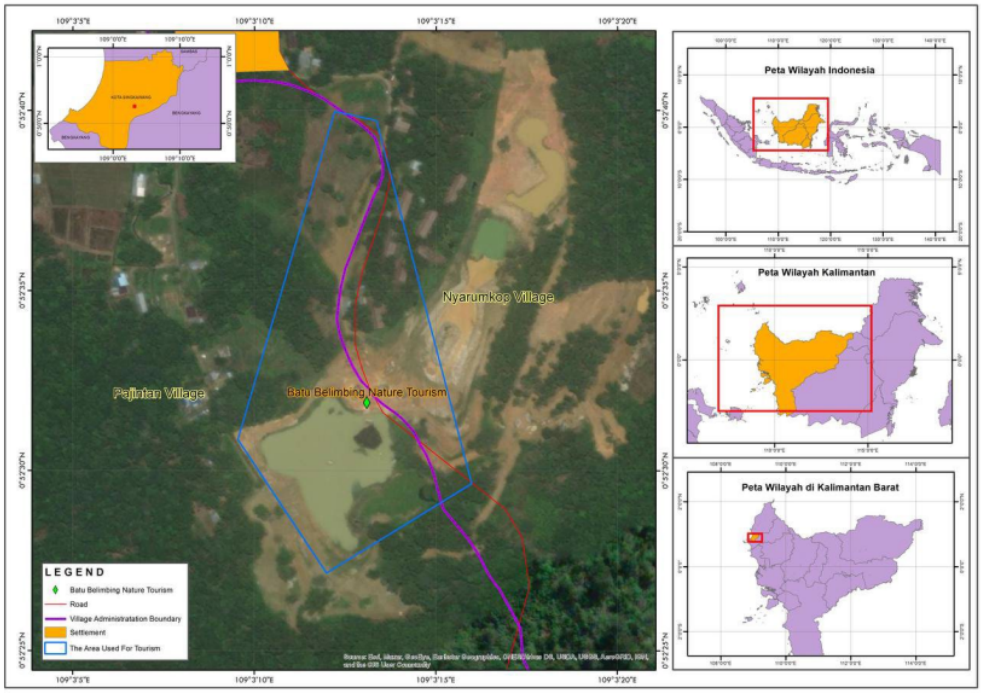

Figure 1. Research map location

3. Results and Discussion

The ecological carrying capacity of nature tourism refers to its capability to accommodate visitors, expressed in terms of the number of visitors per unit area and unit time (Soemarwoto 1983). The environmental carrying capacity analysis at BBNT includes the examination of PCC, RCC, and ECC (Figure 2). The carrying capacity values in nature tourism indicate the maximum number of visitors that can be accommodated simultaneously, correlating with the quality of activities visitors undertake. It is crucial not to surpass the carrying capacity value in nature tourism, as exceeding it can lead to visitor discomfort and compromise the intended relaxation experience. High visitor density can also contribute to environmental damage in tourist areas.

Figure 2. Batu Belimbing Nature Tourism

3.1 *Physical Carrying Capacity (PCC)*

PCC is a metric indicating the maximum number of visits a space can physically accommodate at a specific time. Calculating the PCC value is essential to determine the daily visitor capacity of a tourist attraction based on its area. Each ecotourism attraction has its capacity following its unique conditions. Surpassing the carrying capacity value of a tourist attraction can lead to discomfort in tourism activities (Manning 2022) and result in environmental harm (Zeng *et al.* 2022). Conversely, suppose the number of visitors is below the PCC value. In that case, it enhances the comfort of tourist activities and minimizes environmental impact within the tourist attraction area (Wiyono *et al.* 2018). The comfort level of tourists will decrease if the density becomes higher (Budiani *et al.* 2019).

BBNT, with 46,125 m^2 of total area used for tourism and 7.34 of rotation factor has a PCC value of 5,211 shows that it can accommodate 5,211 visitors/day. The highest number of visits occurred in January 2023 due to school holidays, New Year, and Chinese New Year holidays. One of the reasons that causes visitor numbers to increase significantly is holidays because it is the right time for everyone to go on vacation (Budiani *et al.* 2019). The number of BBNT visitors has not exceeded its PCC value yet. It means that the managers can still develop BBNT to attract more visitors if it does not exceed the PCC value.

3.2 *Real Carrying Capacity (RCC)*

RCC value needs to be calculated to determine the number of tourists that a tourist attraction can accommodate in a day without causing environmental damage (Sasmita *et al.* 2014). RCC analysis involves correction factors as consideration (Herlambang *et al.* 2016). There are five correction factors in this research, such as soil sensitivity to erosion, slope, rainfall, trees, and birds, with each value presented in Table 1.

Table 1. Correction factor value of RCC.

No.	Correction Factor	Value
1	Slope	20
2	Soil sensitivity to erosion	60
3	Rainfall	0
4	Trees	0.881
5	Birds	0.944

The slope value of BBNT is 7.12% which means it is flat based on the classification of slope by Minister of Agriculture Decree No. 837/Kpts/UM/11/1980, so visitors can still walk around comfortably. Precipitous locations will make tourists spend a lot of energy, making them feel tired easily (Siswantoro 2012).

BBNT has haplohumults soil type according to the soil type map of Singkawang City (Figure 3). Haplohumults is one of the great groups of humults and humults is one of the sub-orders of the ultisols order (USDA NRCS 2022). Ultisols are classified as podzolic soil (Subardja 2012). Podzolic soil has a high level of erodibility or is easily eroded based on the classification of soil type by Minister of Agriculture Decree No. 837/Kpts/UM/11/1980. This soil type becomes a barrier to visitors' activities. This is because soil with high erodibility is very susceptible to erosion caused by rain (Pahlevi *et al.* 2018).

BBNT's rainfall is very high and according to classification rainfall type by Schmidt-Ferguson it is classified as a very wet rainfall type. High or low rainfall at tourist attractions also influences the number of tourist visits because it is related to tourists' comfort (Pangestika *et al.* 2019). The rainfall in the ecotourism area can affect visitors' outdoor activities (Anye *et al.* 2017).

The BBNT area also has 13 types of trees, with 56 trees (Table 2). The most common tree species found is acacia. These trees are an attraction because they provide a natural view for visitors, add aesthetic value, which ultimately affects visitor comfort, produce fresh air, and minimize the occurrence of landslides. The existence of trees is essential for the existence of other animals, such as birds (Lahallo *et al.* 2022).

The observation shows that the BBNT area is also the area for several types of birds (Table 3). The most common bird type found in there is the grey cinenen. Forests in an ecotourism area can contribute to other ecotourism activities, such as hiking and birdwatching (Lestari *et al.* 2023). This research shows that BBNT has the potential for natural viewing, hiking, and birdwatching. These birds are also an attraction because visitors can see flying birds or perching birds on tree branches and hear the beautiful sound of birds chirping (Suana *et al.* 2020). The presence of wild animals, such as birds, will provide an experience for visitors to see their behaviour and open up other ecotourism programs at that location, such as an animal observation program (Wiyono *et al.* 2018). RCC value of BBNT shows that it can accommodate 1,637 visitors/day. RCC value is a consideration for maintaining the environmental conditions of tourist attractions with the number of tourists (Lucyanti *et al.* 2013).

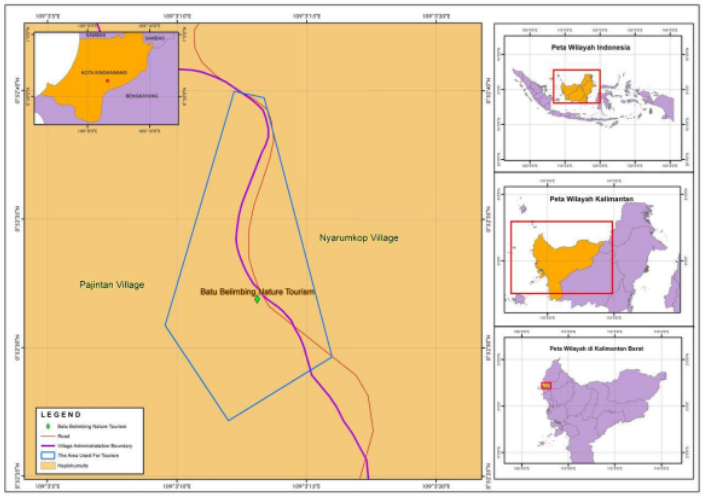

Figure 1. Soil-type map of Batu Belimbing Nature Tourism

Table 2. Species of Trees in the Batu Belimbing Nature Tourism area.

No	Local Name	Scientific name	Family	Ni	Ni(Ni-1)	IDS
1	Pulai	*Alstonia scholaris*	Apocynaceae	5	20	
2	Karet	*Hevea brasiliensis*	Euphorbiaceace	7	42	
3	Nangka	*Artocarpus heterophyllus*	Moraceae	5	20	
4	Mahang	*Macaranga peltata*	Euphorbiaceace	3	6	
5	Jambu monyet	*Anacardium occidentale*	Anacardiceae	2	2	
6	Laban	*Vitex pinnata* L	Lamiaceae	3	6	
7	Sengon	*Paraserianthes falcataria*	Fabaceae	8	56	
8	Akasia	*Acacia mangium* Willd.	Fabaceae	15	210	
9	Meranti putih	*Shorea bracteolate* Dyer	Dipterocarpaceae	2	2	
10	Durian	*Durio zibethinus*	Malvaceae	2	2	
11	Ketapang	*Terminalia catappa* L	Combretaceae	2	2	
12	Mentawak	*Artocarpus lanceifolius*	Moraceae	1	0	
13	Jengkol	*Archidendron pauciflorum*	Fabaceae	1	0	
				56	368	0,881

Table 3. Bird species in the Batu Belimbing Nature Tourism area.

No	Local Name	Scientific name	Family	Ni	Ni(Ni-1)	IDS
1	Burung Madu Sriganti	*Nectarinia jugularis*	Nectariniidae	8	56	
2	Burung Madu Pengantin	*Nectarinia sperata*	Nectariniidae	10	90	
3	Isap Madu Indonesia	*Lichmera limbata*	Meliphagidae	9	72	
4	Cipoh Kacat	*Aegithina tiphia*	Aegithinidae	2	2	
5	Merbak Cerukcuk	*Pycnonotus goiavier*	Pycnonotidae	12	132	
6	Merbak Mata Merah	*Pycnonotus brunneus*	Pycnonotidae	8	56	
7	Layang-layang Batu	*Hirundo tahitica*	Hirundinidae	13	156	
8	Burung Madu Sepah Raja	*Aethopyga siparaja*	Nectariniidae	9	72	
9	Cinenen Kelabu	*Orthotomus ruficeps*	Cisticolidae	14	182	
10	Cinenen Merah	*Orthotomus sericeus*	Cisticolidae	10	90	
11	Walet	*Collocalia vestita*	Apodidae	6	30	
12	Prenjak Rawa	*Prinia plaviventris*	Cisticolidae	4	12	
13	Bubut Besar	*Centropus sinensis*	Cuculidae	2	2	
14	Cekakak Sungai	*Todiramphus chloris*	Alcedinidae	7	42	
15	Bondol Kalimantan	*Lonchura fuscans*	Estrildidae	5	20	
16	Kutilang	*Pycnonotus aurigaster*	Pycnonotidae	5	20	
17	Ciung Air Coreng	*Macronous gularis*	Timaliidae	7	42	
18	Kareo Padi	*Amaurornis phoenicurus*	Rallidae	3	6	
19	Burung Gereja Erasia	*Passer montanus*	Passeridae	16	240	
20	Kipasan Belang	*Rhipidura javanica*	Rhipiduridae	5	20	
				155	1342	0,944

3.3 *Effective Carrying Capacity (ECC)*

ECC is a metric indicating the maximum number of visitors permitted to visit simultaneously, considering correction factors and the manager's oversight (Wiyono *et al.* 2018). ECC value describes the maximum number of visitors who can visit so the tourist attraction remains sustainable by considering its management capacity (Sasmita *et al.* 2014). With a total of 28 managers, BBNT has an ECC value of 1,637 people/day. The volume of visitor arrivals at BBNT increases during peak seasons compared to regular periods. The ECC value also indicates the number of visitors the existing management can handle effectively (Lucyanti *et al.* 2013). According to the results of interviews, the current number of managers is sufficient to serve the number of visitors.

The results of the carrying capacity calculation at BBNT show that PCC > RCC (5,211 > 1,637) and RCC = ECC (1,637 = 1,637) (Figure 4). PCC value is greater than RCC and ECC values, which means that BBNT can accommodate the number of visitors coming at this time well. Batu Belimbing Tourism Awareness Group (POKDARWIS) as the manager still can increase the number of visitors by carrying out maintenance and development in BBNT area if it does not exceed the limits of its carrying capacity.

BBNT needs to be developed so that it remains a tourist destination in the long term. Tourism development needs to be carried out because if it is not implemented, the tourists who come to relax will disturbed due to the lack of space available, so tourists will be dissatisfied, influencing them not to come back

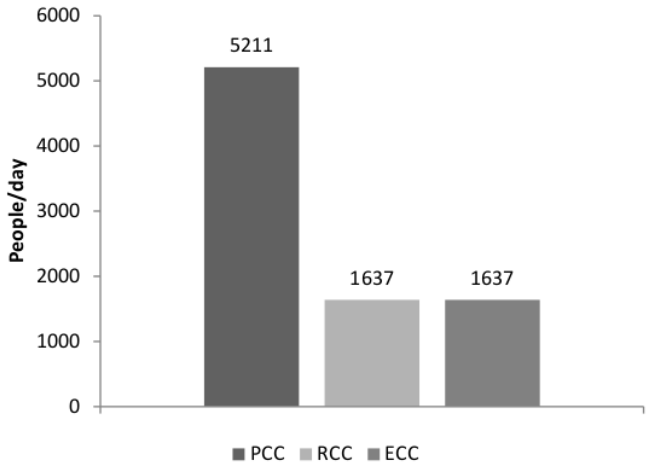

Figure 4. Comparison among PCC, RCC, and ECC in Batu Belimbing Nature Tourism

4. Conclusions

The carrying capacity assessment at BBNT considers three dimensions: PCC, RCC, and ECC. The PCC value is determined to be 5,211 people per day, while the ECC and RCC values are 1,637 people per day (with PCC > RCC and RCC = ECC). This implies that the number of visitors has not surpassed the environmental carrying capacity, as RCC and ECC values remain below the PCC value. The BBNT area has great potential to be developed as an ecotourism area without destroying the initial ecosystem.

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