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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) terletak di Desa Nyarumkop, Kecamatan Singkawang Timur, Kota Singkawang, merupakan salah satu objek wisata alam yang potensial untuk dikembangkan. Jumlah pengunjung terus mengalami peningkatan namun kapasitas daya dukung Kawasan Wisata masih Belum diketahui. Nilai daya dukung WABB perlu dianalisis untuk mengetahui kemampuannya untuk tetap berkelanjutan dan dapat menampung pengunjung dengan optimal sehingga dapat tercapai kepuasan pengunjung tanpa terjadinya kerusakan lingkungan. Tujuan penelitian ini adalah untuk menganalisis daya dukung WABB sebagai daya tarik wisata alam berdasarkan tiga faktor yaitu daya dukung fisik (PCC), nyata (RCC), dan efektif (ECC). Penelitian ini menggunakan metode observasi dan wawancara. Analisis deskriptif kualitatif digunakan dalam penelitian ini. Hasil perhitungan menunjukkan nilai PCC sebesar 5.211 orang/hari, nilai RCC sebesar 1.637 orang/hari, dan nilai ECC sebesar 1.637 orang/hari. Nilai daya dukung WABB mempunyai persamaan PCC > RCC = ECC; Artinya daya dukung WABB besar dan masih dapat menampung pengunjungnya dengan segala aktivitas selama nilai RCC dan ECC lebih rendah dari nilai PCC (5.211 orang/hari).

Kata kunci**:** *Daya Dukung Wisata, Wisata Alam Batu Belimbing, Daya Dukung Fisik, Daya Dukung Nyata*

ABSTRACT

Batu Belimbing Natural Tourism (BBNT) is located in Nyarumkop Village, East Singkawang District, Singkawang City, and is one of the natural tourist attractions that has the potential to be developed. The number of visitors continues to increase, but the carrying capacity of the tourist area is still unknown. The carrying capacity value of BBNT needs to be analyzed to determine its ability to remain sustainable and accommodate visitors optimally so that visitor satisfaction can be achieved without environmental damage. The purpose of this research is to analyze the carrying capacity of BBNT as a natural tourist attraction based on three factors: physical (PCC), real (RCC), and effective (ECC) carrying capacity. This research used observation and interview methods. Qualitative descriptive analysis was used in this research. The calculation results show that the PCC value is 5,211 people/day, the RCC value is 1,637 people/day, and the ECC value is 1,637 people/day. The carrying capacity value of BBNT has the equation PCC > RCC = ECC; this means that the carrying capacity of BBNT is large and can still accommodate its visitors with all activities if its RCC and ECC values are lower than its PCC value (5,211 people/day).

Keywords**:** Tourism carrying capacity, Batu Belimbing Nature Tourism, Physical Carrying Capacity, Real Carrying Capacity

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1. INTRODUCTION

West Kalimantan is a province with various ecotourism 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, Siagian, *et al.* 2023), nature tourism in Lake Sentarum National Park (Maria *et al.* 2019) (Siahaan *et al.* 2018), white-water rafting in Bukit Baka Bukit Raya National Park (BBBRNP) (Listiani *et al.* 2023); (Rifanjani *et al.* 2024), Pangar waterfall in Bengkayang (Rifanjani, Altika, *et al.* 2023), 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 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). Therefore, it is necessary to carry out a carrying capacity analysis to determine the ability of BBNT to accommodate the number of visitors who come by 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).

The carrying capacity of ecotourism is based on three aspects such as Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC) (Wiyono *et al.* 2018). Based on previous research, the carrying capacity of nature tourism will show its ability to accommodate visitor visits. Carrying capacity has the provisions PCC > RCC or RCC ≥ ECC (Sasmita *et al.* 2014). The carrying capacity value of a tourist area is good if PCC > RCC ≥ ECC, which means it can accommodate visitors with all their activities well if the actual number of visitors does not exceed the maximum limit of the RCC value so that managers can increase the number of visitors without exceeding the limit of the carrying capacity value. The carrying capacity of a tourist area 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.

2. METHODS

The research was conducted in Batu Belimbing Nature Tourism, located in East Singkawang District of Singkawang City, West Kalimantan, Indonesia (Figure 1). The research was conducted from March to April 2023.

The tools used in this research consist of a research location map, Garmin78s GPS, binoculars, stopwatch, compass, water pass, a questionnaire distributed to a manager, a bird identification guidebook (Myers 2010), and a tree identification guidebook (Thomas 2014). The object of this research is the Batu Belimbing Nature Tourism area.

To calculate the Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC) values, the data was collected using the following method:

2.1. *Physical Carrying Capacity* (PCC)

The area used for tourism 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.

2.2. *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 (Ralph *et al.* 1995).

2.3. *Effective Carrying Capacity* (ECC)

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

2.4. *Data Processing*

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:

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

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):

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

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.

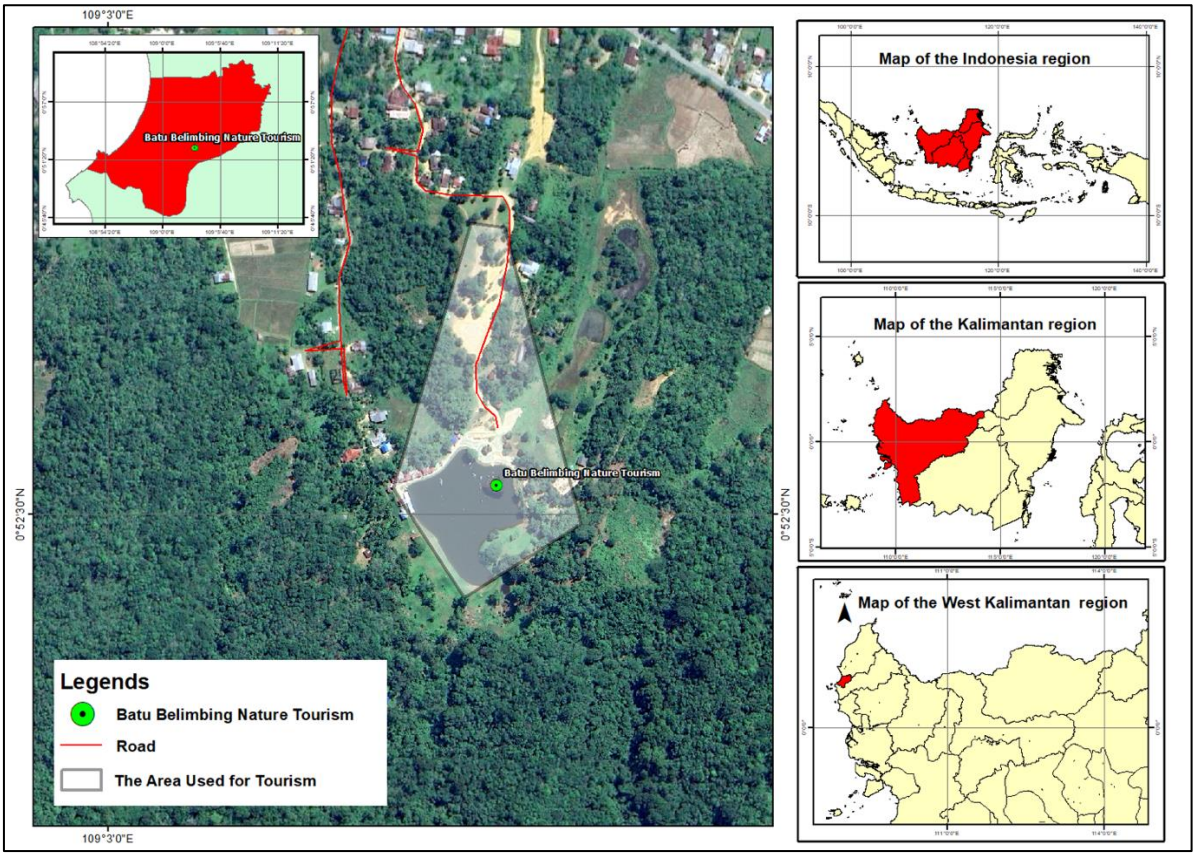

Figure 1. Research Map Location

3. RESULTS AND DISCUSSION

The environmental carrying capacity of nature tourism is the ability of nature tourism to receive visitors, which is stated in the number of visitors per unit area and per unit time (Soemarwoto 1983). The factors analyzed for environmental carrying capacity at BBNT are Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC)) (Figure 2). Carrying capacity values from nature tourism will show the number of visitors who can visit at one time so that it will be related to the quality of the activities carried out by the visitors. The carrying capacity value of nature tourism should not be overloaded because it will make visitors uncomfortable. If it's crowded, it ultimately disrupts their primary goal of relaxing. The density of visitors can also affect environmental damage in tourist areas.

3.1. *Physical Carrying Capacity* (PCC)

Physical Carrying Capacity (PCC) is a value that indicates the maximum limit of visits that can be physically received in space at a certain time. PCC value needs to be calculated to determine the number of visitors that a tourist attraction can accommodate in a day based on its area. Ecotourism attraction certainly has its capacity according to its circumstances. The number of visitors that exceeds the carrying capacity value of a tourist attraction will cause discomfort to tourism activities (Manning 2022) and cause environmental damage (Zeng *et al.* 2022). If the number of visitors is lower than the PCC value, it will affect tourist activities to be more comfortable and minimize environmental damage at 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 (Table 1). 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 yet exceeded its PCC value. 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 slope, soil sensitivity to erosion, rainfall (Table 3), trees (Table 4), and birds (Table 5), with each value presented in Table 1.

Table 1. Correction Factor Value of Real Carrying Capacity

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

Figure 2. Batu Belimbing Nature Tourism

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. 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 (Table 3). 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 4). 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 5). The most common bird type found 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).

Table 2. Total of Visitors to Batu Belimbing Nature Tourism

Month	Year	Visitor (people)
January	2022	3.032
February	2022	4.168
March	2022	5.998
April	2022	5.577
May	2022	17.427
June	2022	9.972
July	2022	14.860
August	2022	6.267
September	2022	8.505
October	2022	6.458
November	2022	6.550
December	2022	33.661
January	2023	54.359
February	2023	20.915
March	2023	9.299

Source: Tourism Awareness Groups (Pokdarwis) of Batu Belimbing, 2022-2023

Table 3. The Rainfall in East Singkawang District for 2020-2022

Month	Accumulated rainfall (mm)		
	2020	2021	2022
January	399	357	219
February	253	289	361
March	210	363	88
April	197	106	233
May	427	408	133
June	548	263	276
July	642	159	152
August	248	474	493
September	315	152	181
October	219	298	470
November	623	339	493
December	143	130	446

Source: BMKG Supadio Class I Meteorological Station

Table 4. 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 5. 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

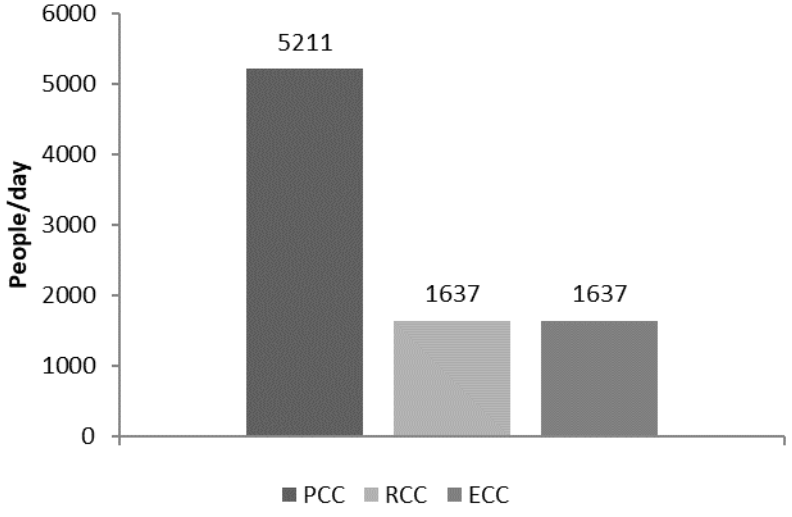

Figure 3. Comparison Among PCC, RCC, and ECC in Batu Belimbing Nature Tourism

3.3. *Effective Carrying Capacity* (ECC)

Effective Carrying Capacity (ECC) is a value that shows the number of visitors who are allowed to visit at one time by considering correction factors and the management of the manager (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 level of visitor visits to BBNT during the peak season is higher than in the normal season. ECC value also

shows the number of visitors that can be handled by the current management (Lucyanti *et al.* 2013). According to the results of the 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 3). 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 it is 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.

4. CONCLUSIONS

Carrying capacity analysis at BBNT is based on three aspects such as Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC). The PCC value is 5,211 people/day, the ECC value is 1,637 people/day, and the RCC value is 1,637 people/day (PCC > RCC and RCC = ECC). It means the number of visitors has not exceeded the environmental carrying capacity because the RCC and ECC values have not exceeded the PCC value.

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