Environment carrying capacity of Pandawa Beach ecosystem and how to optimize it to support sustainable development

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Abstract. Tourist visits to Pandawa beach in 2017-2018 experienced a very sharp increase reaching 273\%. It is necessary to analyse the environment's carrying capacity as a basis for planning and the right strategy in its management. The purpose of the study was to analyse the environmental carrying capacity of the Pandawa coast, Kutuh Village, Badung Regency and their utilisation strategies for sustainable development. The study examined the physical carrying capacity (PCC), actual carrying capacity (RCC), management capacity (MC), and adequate carrying capacity (ECC). The results showed the current number of actual visitors with an average of 3,727 visitors/day, which is still far below the physical carrying capacity, which is 20,618 visitors/day, while the actual carrying capacity is 18,864 visitors/day. So, the estimated amount visits per month that can be received is as many as 565,927 visitors/month. At the same time, the ECC value of the number of tourist visits can still be optimised by 109 visitors/day. It means that the number of officers currently available is quite capable of serving 3,727 visitors/day. The strategies to optimise the visit are the addition of facilities, tourist attractions, promotions and increasing the role of local communities in environmental preservation.

1. Introduction

Kutuh Village in Kuta Selatan District, Badung Regency, located near the Nusa Dua tourist area, is also facing the rapid growth of tourism development. Kutuh village has one of the very famous beaches, named Pandawa Beach. There is also Gunung Payung Temple which provides its attraction. Besides the cultural and art attractions, paragliding flying is also a breathtaking attraction, referring to the condition of cliffs and white sandy beaches. In the last two years, the number of visitors in Kutuh Village has increased very slightly, reaching out 273\% and was dominated by domestic visitors. The development of the tourism sector in this area causes various problems both from the community itself and external challenges from outside Bali Island. The tourism sector in Kutuh village was not managed well and was seaweed cultivation operated by the local community \cite{1}. Since the establishment of Pandawa Beach as a tourist area in the Badung Regency, the development of the coastal area is aligned.

On the other hand, the Pandawa Beach coastline is quite near to the settlement. So, it has a high risk due to that abrasion and potentially damages the building \cite{2}. Some authors also mention if the development of tourist areas will cause changes and environmental damage \cite{3,4,5}. Sustainable tourism development will be an option to apply in the current tourism and further \cite{6}. Sati's research \cite{7} found that sustainable tourism in the Gangotri circuit Himalayas can increase economic activities such as income and work opportunities because all-natural, cultural, and aesthetic potentials are combined and
integrated. Therefore, the analysis of the carrying capacity of touristic areas is vital to initiate sustainable development.

The tourism sector in Kutuh village was struggling since it has not been appropriately managed, especially tourism facilities [8]. Considering that the tourism industry is the highest income generator in Badung Regency and contribute to regional income, Kutuh Villa was not in a proper condition [5, 9,8,10,11]. Therefore, these negative impacts should be controlled by planning proper public facilities and should be fit to the current environmental carrying capacity. The environment’s carrying capacity affects the satisfaction quality and comfort issues for the visitors [12]. The carrying capacity in the tourism environment is an integration of various factors such as ecological, economic, social [13], and is related to the limitation that can be achieved without a negative impact on the ecosystem [14] and as a baseline of sustainable development [6]. It is urgently needed to know the maximum capacity for the number of visitors who show up at tourist destinations simultaneously to become a reference for the managers in development planning of tourist attraction [15].

According to Law No. 32/2009 [16], the environment is a harmony of nature with all objects, forces, conditions, and living creatures and their behaviour that affect nature itself, the lifecycle, and the welfare of creatures. The environment has an essential and strategic function in human life, other living things in keeping the balance between them. Thus, the primary function of the environment needs to be preserved. The preservation of environmental functions is an effort to maintain the sustainability of the environment’s carrying capacity. Environmental carrying capacity has become a concern in the field of tourism. The environment’s carrying capacity aims to study the of tourists that can be received by a tourist destination and its impact on visitor satisfaction. Environmental carrying capacity can be used as a reference for decision-making and regulatory action towards improving tourism management. Based on the current issue, this paper will figure out: 1) how are the environmental carrying capacity of the Pandawa beach tourism area and 2) what is the strategy for optimizing the carrying capacity of the Pandawa beach tourism area. This study aims to analyze the environmental carrying capacity of the tourist area of Kutuh Village, Badung Regency and its strategy to keep the optimum carrying capacity to achieve without causing environmental damage to the tourist area.

2. Methodology
This research was held in Pandawa Beach, Kutuh Village, Badung, from March 2019 to October 2019. The data was collected from primary and secondary sources. In this study, the data collection method was carried out by 1) Direct observation, 2) Structured interviews concerning the perceptions of tourism actors (community, visitors and managers), 3) Literature studies to collect secondary data and others related to research. 4) Analyse the environmental carrying capacity of tourist areas by analysing the Effective Carrying Capacity of Cifuentes (1992).

a) Physical Carrying Capacity (PCC)
The PCC calculation is following the calculation below:

\[ PCC = A \times \frac{1}{B} \times Rf \]  \hspace{1cm} (2.1)

where:

- \( A \) = Ecotourism section area
- \( B \) = Sufficient area for the visitors to achieve satisfaction in the tourism place. For example, the need for swimming is 27 m², picnic is 65 m² and camp is 90 m².
- \( Rf \) = Daily visitor rotation factor

b) Real Carrying Capacity (RCC)
The RCC calculation is following the calculation below:

\[ RCC = PCC \times \left( \frac{100-PH}{100} \right) \times \left( \frac{100-PF}{100} \right) \times \ldots \times \left( \frac{100-Pn}{100} \right) \]  \hspace{1cm} (2.2)

where:

- \( Fn \) = The n correction factor with the n component data
\[ Fn = \frac{M_n}{M_t} \times 100\% \]

Alternatively, by using the calculation of correction factor \((Fn)\) [17]:

\[ Fn = 1 - \left( \frac{M_n}{M_t} \right) \]  

(2.3)

where:

- \(M_n\) = Real condition on calculated \(Fn\) variable
- \(M_t\) = Maximum on \(Fn\) variable

The determination of \(M_t\) is accordingly to each correction factor, as shown in Table 1.

**Table 1.** Correction factor.

| No | Variable              | \(M_t\) |
|----|-----------------------|---------|
| 1  | Rainfall index        | 7       |
| 2  | Soil sensitivity index| 75      |
| 3  | Slope index           | 100     |

Source: Lucyanti [17]

c. **Effective Carrying Capacity (ECC)**

The ECC calculation is following the calculation below:

\[ ECC = RCC \times FM \]

Where

\[ FM = \frac{R_n}{R_t} \times 100\% \]  

(2.4)

Note:

- \(R_n\) = The current stakeholder
- \(R_t\) = The ideal stakeholder provision

3. **Results and discussion**

3.1 **Location study**

Kutuh Village land utilization is about 999.57 Ha for dry land and 918.35 Ha, 29.72 Ha for public facilities, and 51.50 for the forest. The livelihoods of the local community in Kutuh Village are dominantly in the medium and large industrial sector with 1,072 people as employees of private companies, service sector consisting of 10 people who are in a hotel and other lodging business owners, 309 people are owners of stalls, restaurants. In comparison, 15 people have a livelihood as hotel and other lodging business workers. The Pandawa Beach Tourism Object area belongs to the Kutuh Village, Kuta Selatan District, Badung Regency, Bali Province. The Pandawa Beach area is managed by the Kutuh Village Indigenous Community called *Bhaga Utsaha Manunggal Desa Adat* (BUMDA).

Pandawa Beach is a beach with a white sandy beach, having 700 meters’ length of coastline and expansive blue sea views. Some tourist attractions have been developed in the Pandawa Beach area, such as 1) Cliff Attractions and Pandawa Statues, 2) White Sand Beach Attractions, 3) Water and Coral Reef Tourism Attractions, 4) Spiritual Tourist Attractions, 5) Attractions Cultural Tourism, 6) Tourism Attraction of Seaweed Farming. The number of visitors from 2013-2017 showed up on 6,801,891 people, or an average of 1,360,378 people per year.

The Pandawa Beach area based on the map of the Master Plan for the Development of the Pandawa Beach Integrated Area is included in the utilization space, which is located adjacent to the Gunung Payung Temple so that this tourist attraction and object is located in a single unit located in Kutuh Village, Badung Regency. The pattern of area management space is divided into 3 (three) management zones, among others: a) Public Space is a space that contains elements of human activities, both closed and open, which are used by everyone and provide opportunities for various activities. b) Tourism or adventure space is a space that is an attraction for everyone to carry out certain activities or visit to enjoy the comfort of that place. c) Accommodation space is a space used to fulfil the need for a place to stay or stay. Based on the land use of the Pandawa Beach tourist area, it is classified into the division of management space zones, as shown in Table 2.
Table 2. Pandawa Beach management zone.

| No | Utilization (Public Zone) | Area (m²) |
|----|----------------------------|-----------|
| 1  | City Hall                  | 2,420.83  |
| 2  | Gazebo                     | 1,573.03  |
| 3  | Park                       | 230,843.85|
| 4  | Restaurant                 | 11,260.39 |
| 5  | Toilet                     | 2,428.03  |
|    | **Total**                  | **248,626.14** |

| No | Utilization (Tourism Zone) | Area (m²) |
|----|----------------------------|-----------|
| 1  | Kecak Dance Attraction     | 7.19      |
| 2  | Information Center         | 533.76    |
| 3  | Temple Area                | 2,420.83  |
| 4  | Beach                      | 23,989.93 |
| 5  | Savana                     | 153,486.93|
| 6  | Garden                     | 34,946.63 |
|    | **Total**                  | **215,385.28** |

| No | Utilization (Accommodation) | Area (m²) |
|----|----------------------------|-----------|
| 1  | Accommodation              | 5,155.69  |
|    | **Total**                  | **5,155.69** |

3.2 Environmental carrying capacity at Pandawa Beach area before the pandemic COVID-19

3.2.1 Physical carrying capacity/PCC. The calculation of the environmental carrying capacity of the Pandawa Beach Tourism Object area is carried out in 3 (three) management rooms, namely public space, tourist space and accommodation space. Previously, the calculation was determined for the duration of the visit, and the survey results conducted to the respondents gave the average duration of the visit was 3.5 hours. So the rotation factor can be calculated as follows:

\[
\text{Rotation factor (Rf)} = \frac{\text{Operation hours}}{\text{Average on staying}} = \frac{9}{3.5} = 2.86
\]

Table 3. Physical Carrying Capacity/PCC of Pandawa Beach.

| Zone            | Area = A (m²) | Comfortable sufficient area = B (m²) | Rotation factor = Rf (hour) | Physical Carrying Capacity (visitor/day) |
|-----------------|---------------|--------------------------------------|-----------------------------|----------------------------------------|
| Public Zone     | 248,526.14    | 65                                   | 2.86                        | 10,924                                 |
| Tourism Zone    | 215,385.28    | 65                                   | 2.86                        | 9,467                                  |
| Accommodation   | 5,155.69      | 65                                   | 2.86                        | 277                                    |
| **Totals**      | **469,067.11**|                                      |                             | **20,668**                            |

According to the calculations in Table 1, the value of 20,618 visitors/day is the highest number of visitors who can physically visit the Pandawa Beach tourist area every day while still getting a good level of satisfaction. While the actual number of visitors is an average of 3,727 visitors/day, it is still lower of the value of the calculated physical carrying capacity. The value of B is determined according to research from the calculation of area provided for a tourist to remain satisfied [17].
3.2.2 Real carrying capacity/RCC. The results showed that the Pandawa Beach area shows biophysical terms that are considered as limiting factors for environmental carrying capacity, including rainfall (Cf₁) and soil erosivity (Cf₂). Calculation of the correction factor using the RCC equation and the results are as follows:

According to the rainfall in 2007-2016, it is found that the rainfall index is as follows:
Rainfall index = 1/(∑wet : ∑dry) = 1/(79/32)) = 0.4051

The rainfall index is determined as M rain. To calculate the Cf₁, it is used the formula below:
Cf₁ = 1 – (M rainy/Mt) = 1 – (0.4051/7) = 0.9421

Erodibility is the sensitivity of the soil due to erosions risk in the Pandawa Beach Area. According to the rainfall station at Pecatu, the erodibility in this area is about 0.02888. So, it determines the correction factors for erosivity Cf² is 0.9711.

| Zone          | Cf₁  | Cf₂  | Visitor/day | Visitor/day |
|---------------|------|------|-------------|-------------|
| Public Zone   | 0.9421 | 0.9711 | 10,924      | 9,995       |
| Tourism Zone  | 0.9421 | 0.9711 | 9,467       | 8,662       |
| Accommodation Zone | 0.9421 | 0.9711 | 277         | 207         |
| Totals        | 0.9421 | 0.9711 | 20,668      | 18,864      |

Table 4. Real Carrying Capacity/RCC in Pandawa Beach area.

Table 4 shows the actual carrying capacity of the Pandawa Beach tourist attraction area of 18,864 visitors/day so that the estimated number of visits per month that are accepted is 565,927 visitors/month or 6,885,444 per year. This value is still higher the actual value of the current visitors, namely over five years (2013-2017). The average visit per month is 113,365 visitors/month or 1,360,378 visitors/year, so that the visitors can be optimized.

3.2.3 Effective carrying capacity/ECC. The adequate carrying capacity (ECC) is influenced by the management capacity (Management Capacity) of the management officer, in this case, the staff from the BUMDA Desa Adat Kutuh, as the management of the Pandawa Beach tourist attraction area where the total number of staff is 61 people. However, based on interviews with the management manager, the staff who work effectively every day in the field are 61 people, but ideally, the staff needed in the management of the Pandawa Beach Tourism Area is 300 people so that the management capacity value is calculated according to the ECC equation giving the results of the MC value: MC = Rn/Rt x 100%

Rn is the number of current management officers as many as 61 people, and Rt is the ideal number of management officers needed as many as 300 people. So the results of the calculation to find the MC value are:
MC = 61/300 x 100% = 20.33 %.

| Zone          | RCC (Visitor/day) | MC (%) | ECC (Visitor/day) |
|---------------|-------------------|--------|-------------------|
| Public Zone   | 9,995             | 20.33  | 2,032             |
| Tourism Zone  | 8,662             | 20.33  | 1,761             |
| Accommodation Zone | 207       | 20.33  | 42                |
| Totals        | 18,864            | 20.33  | 3,836             |

Table 5. Effective Carrying Capacity/ECC in Pandawa Beach area.
Table 3 shows the officers who are able to serve the visitors for daily incoming where the current average number of visits is 3,727 visitors/day, and in the future, the number of visitors can be optimized by 2.83%. However, optimizing the number of visitors, both based on the value of actual carrying capacity and adequate carrying capacity, must be followed by optimizing the capacity of management officers up to 100%. So, increasing the management officer’s capacity is necessary to analyze the workload, which can be influenced by several factors, including the legal basis, policies, regulations, financing, equipment, infrastructures and facilities to minimize the lack of management performance, especially during the high season of the visitor where the visitors may exceed the calculated carrying capacity.

3.3 Optimisation strategies of the carrying capacity towards sustainable development
The results of the Internal Factors (IF) analysis showed a value of 3.083, while the value of External Factors (EF) was 3.024 and based on the IF and EF matrices, it was in cell 1 (Table 5).

Table 6. SWOT matrix.

| Total of EFAS Value | Strong | Average | Weak |
|---------------------|--------|---------|------|
| 4.0 strong          | 3.083  | 2.0     | 1.0  |
| 3.024 average       | Grow and Develop (concentration through vertical integration) | Grow and develop (concentration through horizontal integration) | Keep and maintain (rotating growth) |
| 2.0 weak            | Grow and Develop (pause) | Keep and maintain (strategy does not change) | Harvest and divestment (areas run out or sell out vigilance) |
| 1.0                 | Keep and maintain (diversification and concentration) | Harvest and divestment (conglomerate diversification) | Harvest and divestment (liquidation) |

According to the results of the SWOT Matrix, which has been described in Table 5 and the results of the calculation of the adequate carrying capacity (ECC) in the Pandawa Beach Area, the number of tourist visits can still be optimised by 109 visitors/day or 3,262 visitors/month. Based on this, several alternative strategies for optimising carrying capacity for sustainable development are:

1. Maintain and improve the management system based on community carrying capacity. The current management of the Pandawa Beach area is based on local communities where Bhaga Utsaha Manunggal Desa Adat has appropriately managed the Pandawa Beach Tourist Attraction Business unit (BUMDA) Desa Kutuh under the supervision and support of the Government, institutions and community organizations. The manager should provide supporting facilities, provision skills and language training for workers and communities involved in the activities of the Pandawa beach area.

2. Preserving the preservation of resources and ecosystems in the coastal area begins with increasing public awareness and tourists not to litter, maintaining flora and fauna ecosystems in tourist areas, using tourism facilities and infrastructure as well as possible. The manager as a provider of tourism facilities and infrastructure to complete the required facilities such as increasing the number of trash bins by arranging the placement of trash bins so that they are easily accessible by tourists, providing information signs for each preserved tourist area.
3. Increase tourism promotion, especially the delivery of information about existing and new activities to increase market share. Before promoting tourism areas, the first thing that must be known is the current market conditions to know what tourism products and services are in demand by the market. Current promotions at Pandawa Beach are still famous for the Pandawa Statue icon and its beautiful sea charm; promotions for new areas such as coral reef conservation activities and snorkeling are further expanded to have many choices of other tourist activities.

4. Develop the potential of new tourist areas and tourist activities in the Pandawa Beach tourist area to avoid high visits and avoid the level of boredom of tourists to revisit the Pandawa Beach tourist area. Viral tourist activity on Pandawa Beach is playing canoes because playing canoes can see the clear seawater and views of the Pandawa cliffs from the sea. When conditions are high, the supply of canoes cannot cover all tourists, so other tourist activities are needed in the Pandawa Beach tourist area. Some tourism activities that can be developed are the development of an underwater park area that has been decorated with coral reefs and the addition of Pandawa swing facilities with a beautiful sea background.

5. Establish tour packages and tourist attractions in the Pandawa Beach Area, managed by the management team and Travel Agents. The tour packages offered can be determined according to the market segment, the determination of tourist locations is determined by the wishes of tourists, which is balanced with offers from travel agents regarding the conditions and times of tourist visits to tourist sites.

6. Increased education and information by managers for the public and tourists about the Pandawa Beach tourist area in preserving the environment and the ecosystem in it, cleanliness and beauty of the tourist area. The sustainability of tourism activities in the future depends on resources and the environmental state in the tourism area. Maintaining the existence of tourist areas is not only the manager's responsibility but the cooperation of all parties, namely the community and tourists. Providing education and information about the condition of tourist areas can be done in various ways, such as installing information boards that contain an overview of the condition of the tourist area, installing invitation boards to protect the environment, giving directions to tour leaders to guide the conditions and history of tourist areas to tourists before doing tourism activities.

7. Prepare the management team and local workforce in tourism through training activities to create a professional management team and workforce. Before developing the Pandawa Beach tourist area, the residents of Kutuh Village worked as fishermen and seaweed farmers. Since this area has become a tourist attraction, many people use it as a tourism sector to increase income through business in the tourism or as a side job. Tourism activities on Pandawa Beach require readiness from various aspects, one of which is a professional workforce. The workforce requires special skills in meeting the needs of tourists, such as sufficient knowledge and information about the tourist areas of Pandawa Beach and Kutuh Village.

4. Conclusion
The actual number of visitors in the Pandawa Beach tourist area, Kutuh village, is an average of 3,727 visitors/day, so it is still very far below the calculated physical carrying capacity value of 20,618 visitors/day. While the actual carrying capacity value is 18,864 visitors/day makes estimation number of visitors per month that can be received is 565,927 visitors/month, which means this value is higher the actual value of the current number of visitors over five years (2013-2017) the average visit per month is 113,365 visitors/month so that the number of visitors can still be optimized. According to the adequate carrying capacity, the tourist visit can be optimized by 109 visitors/day. This value means the current 61 officers are able to serve the visitors who come daily, where the average visits is currently 3,727 visitors/day. The strategy of optimizing the carrying capacity of the Pandawa Beach area can be done by adding facilities and infrastructure, increasing the participation of local communities in preserving nature and local culture by utilizing water resources.
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