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Identification of *Beach Carrying Capacity* and Sedimentation-Based *Nourishment* Impacts at Ancol Beach Jakarta

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Abstract

Purpose. This study aims to analyze the *carrying capacity of Ancol Beach, Jakarta, in relation to the sediment nourishment strategy* as an effort to maintain the stability of coastal tourism areas.

Method. The approach used is qualitative descriptive, using the literature study method, namely by collecting and analyzing secondary data from scientific journals, research reports, and related publications. The analysis was conducted by examining the five main dimensions of carrying capacity: *Physical Carrying Capacity* (PCC), *Ecological Carrying Capacity* (ECC), *Social Carrying Capacity* (SCC), *Management Capacity* (MCC), and *Facility Carrying Capacity* (FCC).

Results. The findings in this study confirm that the interaction among the dimensions of carrying capacity is complex and that they affect one another. High dependence on *meeting needs* makes management quality a key factor in maintaining a balance between tourism utilization and environmental sustainability.

Conclusion. An integrated, adaptive, and data-based management strategy is needed to ensure the sustainability of Ancol Beach as a coastal tourism destination.

Keywords: carrying capacity, sediment nourishment, artificial beach, coastal tourism, Ancol Beach

INTRODUCTION

Coastal tourism is one of the strategic sectors in tourism development because it offers abundant natural attractions and makes a significant economic contribution. However, high

utilization intensity often puts pressure on the coastal environment, physically, ecologically, and socially. In this context, the concept of carrying capacity is important as an analytical tool to ensure that the use of tourist areas remains within tolerable limits, without causing environmental degradation or reducing the quality of the tourist experience.

The concept of tourism carrying capacity is not limited to physical capacity (Physical Carrying Capacity) but also includes ecological (*Ecological Carrying Capacity*), social (*Social Carrying Capacity*), managerial (*Management Capacity*), and facilities (*Facility Carrying Capacity*). These five dimensions interact with one another and form a complex system that determines the sustainability of tourist destinations. An imbalance in one dimension can trigger a chain reaction in the other, so a holistic approach is needed to manage it.

Ancol Beach was chosen as the study location because it has unique characteristics compared to natural beaches in general. This beach is an artificial beach that relies heavily on human intervention, especially through the practice of sediment nourishment (the addition of sediment/sand). Unlike natural beaches, which receive sediment from geomorphological processes such as river flows and wave dynamics, Ancol Beach lacks such a natural supply system, so the stability of its coastline is largely determined by the quality and continuity of sediment management.

In addition, Ancol Beach is one of Indonesia's coastal tourist destinations with very high visitor numbers, especially on weekends and during holiday seasons. The high number of visitors makes Ancol Beach a prime example of mass tourism in urban coastal areas. These conditions place significant pressure on space capacity, environmental quality, and tourist comfort, making it a relevant location for a comprehensive study of the concept of carrying capacity.

Another reason for choosing Ancol Beach is its heavy reliance on sediment nourishment strategies to maintain the area's sustainability. This practice not only helps maintain the beach's area and shape but also has direct implications for ecological aspects, such as water quality and marine life. Errors in the selection of sediment types, placement times, and material distribution can have significant negative impacts, such as increased water turbidity and disturbance to the aquatic ecosystem. Thus, Ancol Beach is an ideal case study for analyzing the relationship between beach carrying capacity and sediment-fulfillment strategies. This study is expected to provide a deeper understanding of how interactions among physical, ecological, social, and managerial aspects determine the sustainability of coastal tourist destinations, and to contribute

to the formulation of more effective and sustainable management strategies.

The study of the carrying capacity of coastal tourism generally examines the area's physical capacity, tourist comfort, environmental quality, and managers' ability to maintain destination sustainability. In the context of Ancol Beach, this article presents a carrying capacity analysis across five main dimensions: Physical Carrying Capacity (PCC), Ecological Carrying Capacity (ECC), Social Carrying Capacity (SCC), Management Capacity (MCC), and Facility Carrying Capacity (FCC).

Previous research has placed carrying capacity as an instrument to control the number of tourists. However, this article places Ancol Beach as a special case because it is an artificial beach whose stability depends heavily on human intervention through sediment nourishment. Thus, the carrying capacity of the beach is understood not only in terms of the number of visitors but also in terms of the relationship among tourism pressure, sediment stability, water quality, facilities, and management capacity.

Research Gap

Most coastal tourism carrying capacity studies still focus on natural beaches and predominantly discuss the physical or social aspects of tourism. Studies that specifically link beach carrying capacity to sediment nourishment practices on artificial beaches remain limited.

In addition, previous research has not explained much about how the addition of sediment can have a double impact: on the one hand, increasing coastal area and space capacity, but on the other hand, it can increase water turbidity and disrupt coastal ecosystems.

Thus, the main gap in this article is the lack of integrative studies linking physical, ecological, social, managerial, and facility dimensions to sediment management strategies in artificial coastal tourism destinations.

Novelty

The novelty of this article lies in its use of a multidimensional approach to analyze the carrying capacity of Ancol Beach, an artificial beach, based on sedimentation. This article not only calculates or describes tourism capacity but also links it to the sustainability of sediment nourishment, an important factor in maintaining regional stability.

The main novelty can be formulated as follows:

This study offers an integrative analysis framework for beach carrying capacity based on sediment nourishment on artificial beaches, combining five dimensions of carrying

capacity—PCC, ECC, SCC, MCC, and FCC—to explain the relationship among tourism pressure, sediment stability, environmental quality, and the sustainability of Ancol Beach management.

METHODS

This study uses a descriptive qualitative approach and a library research method to analyze beach carrying capacity and the impact of sediment nourishment on the sustainability of the Ancol Beach tourist area in Jakarta. This approach was chosen because the research focuses on synthesizing and interpreting relevant scientific sources to understand the relationship between coastal carrying capacity and sediment management strategies.

Location and Object of Study

The object of the research is the tourist area of Ancol Beach, North Jakarta, which is an artificial beach with high levels of tourist visits and dependence on the sediment nourishment program as an effort to maintain coastline stability. The location was selected purposively because Ancol Beach has unique characteristics compared to other natural beaches, particularly regarding sediment management and high tourism pressure.

Data Source

The study used secondary data obtained from:

1. National and international scientific articles that discuss carrying capacity, coastal tourism, sedimentation, and sediment nourishment.
2. Technical report and management documents for the Ancol Beach area.
3. Statistical data on tourist visits and coastal environmental conditions.
4. Documents from international organizations such as the World Tourism Organization (UNWTO) related to sustainability indicators of tourist destinations.
5. The results of previous research on the quality of the waters and sedimentation characteristics of Ancol Beach.

Data Collection Techniques

Data collection is carried out through several stages:

1. Literature Identification: Collect relevant references through scientific databases such as Scopus, Google Scholar, ScienceDirect, and accredited national journals.

2. Literature Selection Literature is selected based on the suitability of the theme, year of publication, credibility of the source, and relevance to the carrying capacity of coastal tourism and sediment nourishment.
3. Data Extraction: The information obtained from each source is classified based on research variables and carrying capacity indicators.
4. Documentation: All data is compiled in the form of a synthesis matrix to facilitate the process of analysis and interpretation.

Variables and Indicators of Analysis

The analysis was carried out based on the five main dimensions *of beach carrying capacity* as developed by Cifuentes (1992), Coccossis and Mexa (2004), and UNWTO (2004), namely:

Dimensions	Key Indicators
Physical Carrying Capacity (PCC)	Beach area, tourist density, space capacity
Ecological Carrying Capacity (ECC)	Water quality, Total Suspended Solid (TSS), coastal ecosystem conditions
Social Carrying Capacity (SCC)	Perception of density, tourist comfort, quality of travel experience
Management Capacity (MCC)	Number of officers, waste management system, supervision capacity
Facility Carrying Capacity (FCC)	Availability of facilities, distribution of facilities, quality of service

In addition, the sediment *nourishment aspect* is analyzed based on sediment characteristics, the frequency of sediment addition, and its impact on the physical and ecological conditions of coastal areas.

Data Analysis Techniques

Data analysis was carried out using content analysis and comparative descriptive analysis through the following stages:

1. Data Reduction: Selecting information relevant to the concept of carrying capacity and sediment nourishment.

2. Data Categorization: Group findings based on five dimensions of coastal carrying capacity.
3. Intervariable Relationship Analysis: Identify the relationship between PCC, ECC, SCC, MCC, and FCC with sediment nourishment implementation.
4. Synthesis and Interpretation: Develop a conceptual model of the relationship between sediment management strategies and the sustainability of the carrying capacity of coastal tourism areas.
5. Conclusion: Concluding the condition of the carrying capacity of Ancol Beach and its implications for sustainable coastal tourism management.

Research Analysis Framework

The research flow is carried out through stages:

Literature Study → Identification of Carrying Capacity Dimensions → Secondary Data Collection → PCC, ECC, SCC, MCC, and FCC Analysis → Sediment Nourishment Impact Analysis → Interdimensional Relationship Synthesis → Sustainable Management Recommendations.

DISCUSSION

Physical Carrying Capacity (PCC)

Physical Carrying Capacity (PCC) at Ancol Beach indicates fairly high pressure on the physical space, especially during *peak season*. According to standard

outdoor recreation planning by Coccossis and Mexa (2004), the ideal space needs of tourists range from 5–10 m² per person to create comfortable conditions. However, based on empirical data, the density in some areas of Ancol Beach can be as low as 3 m² per person, which falls into the very dense category.

This condition indicates that the area's physical capacity has often been exceeded, with implications for reduced tourist comfort and increased pressure on the coastal environment, including sand compaction and reduced effective areas for use.

The calculation of Physical *Carrying Capacity (PCC)* at Ancol Beach is conducted under three tourist density scenarios: ideal, medium, and dense. The area used in the calculation is 209,000 m², assuming 4 visitor rotations per day.

In an ideal scenario, the comfort standard is set at 10 m² per person. By this standard,

the maximum capacity that can be accommodated at one time is 20,900 people, and if you consider 4 times rotation, the total daily capacity reaches 83,600 people. This scenario illustrates the tourist conditions that are comfortable and not too crowded.

In the medium scenario, the standard space per person is reduced to 5 m². As a result, the capacity at one time increased to 41,800 people, and the daily capacity reached 167,200 people. This condition reflects a level of density that is still tolerable, but it is beginning to reduce tourists' comfort.

Meanwhile, in dense scenarios, the standard space is only 2 m² per person. Under these conditions, the capacity increased significantly to 104,500 people at one time and 418,000 people per day. This scenario shows very congested conditions and has the potential to reduce the quality of the tourism experience and have an impact on the environment.

Ecological Carrying Capacity (ECC)

Ecological Carrying Capacity (ECC) at Ancol Beach is greatly influenced by environmental quality, especially seawater quality. One of the main indicators used is *turbidity,* measured by *Total Suspended Solids (TSS).*

Research by Adittio (2017) shows that the TSS value in Ancol Beach ranges from 33 to 266 mg/L. Based on the general classification, the value indicates water conditions from somewhat turbid to very turbid. This indicates that the ecological pressure in this region is quite high, caused by tourism activities, artificial sedimentation (nourishment), and waste from human activities. Thus, the ECC at Ancol Beach is sensitive to minor changes in sedimentation patterns, so improper management can directly impact coastal ecosystems.

Social Carrying Capacity (SCC)

Social Carrying Capacity (SCC) is related to tourists' perception of density and comfort. According to Vaske (2008), the concept of perceived crowding is the main indicator for measuring SCC, where density is measured not only objectively but also based on individual perception.

Shelby and Heberlein (1986) added that when the number of visitors exceeds the limit of social tolerance, the quality of the tourist experience will decrease. In the context of Ancol Beach, the high number of tourists often creates the perception of "crowded" and "uncomfortable", even though physical space is still available. This shows that SCC depends not only on the number of visitors but also on tourists' expectations and experiences.

Management Capacity (MCC)

Management Capacity (MCC) reflects managers' ability to manage, control, and maintain the quality of tourist areas. At Ancol Beach, there are indications that management capacity remains limited, especially during surges in visitors. According to the concept put forward by Cifuentes (1992), management capacity must be proportional to the burden borne by the region. When the number of visitors far exceeds the management capacity, the system will not run optimally.

For example, the ratio of janitors to visitors during peak season is significantly unequal, which has the potential to reduce the quality of the environment and services. The information shows that management capacity consists of several main components, namely human resource (HR) capacity, waste management, and supporting facilities. These three components are interrelated in determining the effectiveness of tourism area management.

During peak season, the amount of waste produced can reach around 1 ton (1.000 kg) per day. Meanwhile, the number of daily cleaners is around 30 people and can increase to 50 people under certain conditions. This data shows that there is significant pressure on the waste management system as visitor numbers increase

In the analytical interpretation section, it is shown that when the number of visitors reaches 85,000, the gross ratio of officers to visitors is about 1:2,833. This ratio indicates that each officer has to handle a heavy workload, so the management system may not run optimally. This is in line with the principle stated by Cifuentes (1992): if the load exceeds capacity, the system will not function effectively. The conclusion of the picture is that management capacity is very limited during peak season, so it is necessary to increase staffing, improve waste management efficiency, and optimize facilities to maintain environmental quality and enhance the tourist experience.

Facility Carrying Capacity (FCC)

Facility Carrying Capacity (FCC) is related to the facility's ability to serve the number of visitors. In general, Ancol Beach has comprehensive facilities, such as toilets, places of worship, dining areas, and internal transportation. However, according to the UNWTO's perspective, the capacity of facilities is determined not only by quantity but also by quality and distribution. At Ancol Beach, there are several obstacles, such as uneven distribution of

facilities, a lack of shaded areas, and limited access at certain points. This shows that even though the number of facilities is adequate, the quality and distribution still need improvement.

The Relationship of Carrying Capacity with Sediment Nourishment

As an artificial beach, Ancol Beach relies heavily on *sediment nourishment* strategies to maintain shoreline stability. According to Clark (1996), the high dependence on human intervention in the esisir system requires a high management capacity. *Nourishment* has a two-sided impact. On the one hand, the addition of sediment can increase beach area and decrease tourist density (increasing PCC and SCC). However, if not done appropriately, it can increase water turbidity and damage the seafloor ecosystem (lowering the ECC). Therefore, the quality of nourishment planning and implementation is a key factor in maintaining the balance of coastal carrying capacity.

CONCLUSION

Based on the analysis, it can be concluded that the carrying capacity of Ancol Beach is a complex, multidimensional system formed by the interaction among physical, ecological, social, managerial, and facility aspects. The five dimensions do not stand alone but dynamically influence one another in determining the level of sustainability of coastal tourism areas. Furthermore, this study emphasizes that sediment nourishment is a key element in maintaining the stability of Ancol Beach as an artificial beach. The high dependence on the *fulfillment of needs* makes the success of sediment management a determining factor in maintaining a balance between tourism utilization and environmental sustainability. On the one hand, nourishment can increase space capacity and reduce density; on the other hand, errors in its implementation can have significant ecological impacts. Thus, it can be emphasized that the sustainability of Ancol Beach is highly determined by the ability to integrate all dimensions of carrying capacity into an adaptive, planned, and data-based management system. A partial approach is no longer adequate, so an integrated management strategy is needed to accommodate tourism dynamics, artificial beach characteristics, and the associated ecological risks.

Suggestions

Managers need to implement a system for controlling the number of tourists based on the results of carrying capacity calculations, especially *Physical Carrying Capacity* (PCC) and *Social Carrying Capacity* (SCC). This can be done by limiting daily visitor quotas, using

booking systems, or differentiating ticket prices during peak periods to reduce overcrowding. To maintain Ecological Carrying Capacity (ECC), efforts are needed to improve environmental quality, including more effective waste management, oversight of activities that could pollute waters, and routine monitoring of water quality (e.g., TSS parameters). In addition, education for tourists related to environmentally friendly behavior also needs to be improved. Managers need to increase *Management Capacity* (MCC) through increasing the number and quality of human resources, especially during *peak seasons*. In addition, an integrated, technology-based monitoring system is needed to track the condition of the area in real time, so that responses to problems can be carried out quickly and precisely.

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