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Analysis of Tourism Carrying Capacity and Land Carrying Capacity in Nyama Hamlet, Moa Island, Southwest Maluku Regency

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Abstract: Gerdarsi Beach is an undeveloped beach in Nyama Hamlet, Southwest Maluku Island, Indonesia. It features a 1.5 km long white sandy shoreline, coral reefs 100-300 m offshore, lowland topography (0-5 m above sea level), savannah vegetation, and minimal basic infrastructure. With only one manager, this beach serves as a representative case study for research on carrying capacity in remote destinations in Indonesia. The purpose of this study is to calculate tourism carrying capacity (physical carrying capacity, real carrying capacity, and effective carrying capacity). Carrying capacity is used to calculate land capacity, population size, and space per person. A quantitative method was used, with calculations based on Douglass, Vandelli, and Muhammad using Microsoft Excel to calculate the tourism carrying capacity. The research results show that the current tourist arrival rate is 302 people per day, while the physical carrying capacity (PCC) reaches 2,966,860 people per day. The actual carrying capacity (RCC) and effective carrying capacity (ECC) have been exceeded by 302 visits per day, necessitating control through visitor restrictions. The land carrying capacity, with an area of 17.20 km² and a population of 935, is 1.83 ha per person. This study concludes that PCC is still feasible for development, while RCC and ECC need to be remanaged or controlled. The land carrying capacity, with an area of 17.20 km² and a population of 935, is 1.83 ha per person. This study concludes that PCC is still feasible for development, while RCC and ECC need to be remanaged or controlled. The contribution of this research is to provide an integrated management model for PCC, RCC, ECC, and land carrying capacity in the Nyama Hamlet residential area, as well as to provide scientific data for sustainable management planning at the local and international levels.

Keywords: Land capacity; Sustainable development strategy; Tourism carrying capacity

Introduction

The tourism industry is one of the largest and most well-known industries in the world, serving as a key driver of global economic growth. According to the UNWTO Tourism Barometer (January–March 2024), international tourist arrivals to Indonesia increased by 5%, compared to 4% in 2014 and 3% in the pre-pandemic year of 2019. In 2016, the tourism sector contributed approximately USD 7.61 trillion to the global economy, equivalent to 9.8% of global GDP (Fadilla, 2024). Furthermore, Moussa et al. (2025) reported that, according to the World Travel and Tourism Council (WTTC), in 2019 the tourism sector contributed USD 10.3 trillion, equivalent to 10.4% of global GDP, and supported 334 million jobs worldwide. The increasing number of tourists visiting a destination for extended periods, along with various activities such as transportation, souvenirs, food, and accommodation, can significantly increase revenue from the tourism sector.

In the Indonesian context, foreign exchange earnings from tourism were estimated to reach USD 16.7 billion in 2024, with the tourism sector's contribution to national GDP targeted to reach 4.6% in 2025 and 5% in 2029, equivalent to USD 32 billion. However, urban

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tourism in Indonesia has become more popular than rural tourism, posing a challenge for rural destination development. As emphasized by the Minister of Tourism of the Republic of Indonesia at a conference in Saudi Arabia (2024), global tourism development must involve rural tourism, strengthen national capacity, and drive transformation.

Indonesia, as an archipelagic nation, possesses unique cultural and natural attractions from Sabang to Merauke, including diverse ethnic groups, languages, and traditions that attract international tourists. The country's tourism appeal encompasses cultural tourism, religious tourism, educational tourism, and diverse natural attractions. Purba et al. (2024) argue that Indonesia's tourism potential includes underwater ecosystems, beaches, biodiversity, mountains, and tropical rainforests. Sustainable tourism management requires applying seven principles: minimizing physical and social impacts, raising environmental awareness, providing quality experiences, generating financial benefits, driving local economies, respecting local culture, and supporting human rights.

Gerdarsi Beach is a naturally preserved tourist area with potential for various activities, including swimming, boating, snorkeling, and photography. This aligns with Terraferma et al. (2026), who stated that tourist attractions can be enjoyed through photography. However, increasing visitor numbers potentially affect the ecosystem, wildlife, and environmental quality. If environmental quality and attractions successfully attract tourists, they will likely return in the short or long term (Kodariawan et al., 2025). Therefore, maintaining environmental quality requires carrying capacity analysis to prevent over-tourism and negative environmental impacts.

The concept of tourism carrying capacity, initially developed in 1940 for cargo ship load calculations (Sayre, 2008), has evolved into a crucial tool for destination management. According to Nurrahma et al. (2021), tourist area management must consider three main factors: physical carrying capacity (PCC), real carrying capacity (RCC), and effective carrying capacity (ECC). This concept assesses the extent to which tourist destinations can support visitor activities and evaluates environmental impacts, enabling managers to regulate area utilization (Zulfikar et al., 2024). Carrying capacity analysis determines maximum visitor numbers and provides solutions for areas approaching their limits, including visitor restrictions (Lutfiyanti, 2024). Consequently, analyzing tourist area carrying capacity is essential for determining sustainable management strategies and identifying vulnerable areas (Hadiyanti et al., 2024). Calculating carrying capacity provides managers with effective management and development strategies while reducing environmental threats (Fecker et al., 2026). Zacarias (2020) emphasizes that carrying capacity is not absolute or fixed but subject to change due to climate change, environmental damage, visitor types, and natural disasters. Therefore, resilience concepts are necessary to address future threats (Sun & Shang, 2020). Sangkota et al. (2023) suggest real-time monitoring to prevent negative impacts in tourist areas, enabling timely intervention when environmental degradation occurs.

Physical carrying capacity (PCC) represents the maximum number of tourist visits to a specific area, adjusted to existing physical conditions before negative impacts occur. Physical infrastructure, including parking spaces, road width, public toilets, and waste management systems, supports tourist needs (Parmawati et al., 2020). Additionally, clean water availability determines tourist capacity at any given time (Setyandhinavia et al., 2025).

Real carrying capacity (RCC) refers to the maximum visitor numbers considering actual conditions, ecosystem status (soil, air, flora, and fauna), and existing resources without causing negative impacts. Wildlife disturbance must be managed to prevent tourist activities from affecting animals in tourist areas (Madania et al., 2025). Determining safe distances between tourists and wildlife requires bio-logging methods. Carrying capacity encompasses both tourism and non-tourism activities, including environmental damage in picnic areas, coral reef degradation from snorkeling, and noise pollution from vehicles (Öztürk et al., 2026). In the context of climate change, actual carrying capacity requires continuous monitoring to assess erosion rates and prevent threats to tourists, particularly children swimming in coastal areas (Mulyana, 2026).

Effective carrying capacity (ECC) represents the maximum visitor numbers at specific times, considering PCC, RCC, and management capacity relative to tourist area size. Despite increasing visitor interest, limited management capacity often determines tourist area degradation (Miccini et al., 2026). In the carrying capacity hierarchy, ECC serves as the specific acceptable peak. While PCC and RCC may accommodate large visitor numbers, ECC becomes the determining factor for acceptance or rejection, directly affecting destination management (Stobdan & Mantok, 2026). Wati et al. (2023) argue that established management systems mediate between environmental boundaries, functioning as practical applications of carrying capacity implementation. Thus, physical carrying capacity (PCC), real carrying capacity (RCC), and effective carrying capacity (ECC) are used to analyze the carrying capacity of a tourist area. Based on the book recommended by Parmawati et al. (2022), it is revealed that to calculate the

physical carrying capacity, real carrying capacity, and effective carrying capacity in a tourist area

The research's strengths lie in three aspects. First, this study focuses on tourism carrying capacity (physical carrying capacity, real carrying capacity, effective carrying capacity) within the Gerdarsi Beach tourism area and land carrying capacity in Nyama Hamlet within a single analytical framework on a remote island in eastern Indonesia, an approach that is very limited to be analyzed and applied in Southwest Maluku. Second, this study provides the first empirical evidence and data for Nyama Hamlet that has never been studied (tourism management based on tourism carrying capacity). Third, this study combines several correction factors such as vegetation diversity, animal diversity, slope gradient, rainfall, soil sensitivity, and wave events and analyses related to manager capacity and provides recommendations for managers needed based on area size and correction factors.

The research conducted at the Gerdarsi Beach tourist destination is the right step, for several logical reasons. (1) The current number of visits by visitors is 302 per day, while the real carrying capacity and effective carrying capacity are 0 (exceeded). These results indicate an urgent need for intervention in the management of tourist destinations. (2) The Southwest Maluku Regency Government currently lacks accurate data (scientific data) in the development to the sustainable management stage by considering the tourism carrying capacity on Moa Island. (3) Without a carrying capacity analysis, tourism will not be controlled with the number of visits increasing significantly in a month, even per year, thus having an impact on the quality of the environment (destination area). (4) The results of this analysis can be one of the recommendations and implementations that can be applied in the development to the management stage of tourist destinations by considering the tourism carrying capacity on the remote islands of eastern Indonesia in facing tourism development.

Based on the above background, this study aims to analyze the carrying capacity of the Gerdarsi Beach tourist area, including physical carrying capacity (PCC), real carrying capacity (RCC), effective carrying capacity (ECC), and land carrying capacity, in order to support sustainable tourism management and determine the extent of land carrying capacity in Nyama Hamlet.

Method

This study was conducted to analyze the tourism carrying capacity of Gerdarsi Beach and the land carrying capacity of Nyama Hamlet as a reference for tourism area management and land carrying capacity management, which were deliberately chosen because (1) Gerdarsi Beach has potential attractions that can be developed, but there is still minimal involvement from the management, and (2) to determine the extent to which the carrying capacity in Nyama Hamlet is being used appropriately, effectively, and sustainably.

This study uses a direct field observation approach to observe the reality within the research location so that researchers are able to identify problems occurring within the research location Ardiyanti et al. (2025) with the interaction between tourists and the local community. The method used in this study is quantitative based on the calculation of tourism carrying capacity using Microsoft Excel (Douglass, 1975; Vandelli, & Muhammad, 2009). For a clearer picture of the research location, it will be attached in the form of Figure 1 as follows.

Figure 1. Map of the Gerdarsi Beach research area location

This research was conducted at Gerdarsi Beach, Nyama Hamlet, Moa Island, Southwest Maluku Regency from July 16 to August 16, 2025. This research involved all individuals and institutions participating in the management of the Gerdarsi Beach tourist area. Meanwhile, the target is limited to stakeholders, including (1) the head of Nyama Hamlet, (2) tourist visits, and (3) the manager of the Gerdasi Beach tourist area. The sample for quantitative data was taken from the entire Gerdasi Beach tourist area to calculate the RCC, PCC, and ECC. Meanwhile, the carrying capacity is analyzed using boundaries taken directly from the Nyama Hamlet office. The instruments and measurements used in this study employed a measuring tape to measure physical carrying capacity (PCC) based on area for tourism activities such as swimming, boating, picnicking, and camping, while soil type and scores were measured using a 3-in-1 soil meter.

The initial step was to collect data in the Gerdarsi Beach tourist area through observation and direct observation to identify existing physical conditions (Ghorbani & Pamucar, 2025). Primary data was obtained through observation and direct measurement related to the total area of the tourist area using GPS. Tourist

visitation data and area boundaries were obtained directly from the Nyama Hamlet office. The software used in this study was Microsoft Excel as the basis for calculating PCC, RCC, and ECC, while land carrying capacity was calculated using commonly used formulas. Meanwhile, details regarding land carrying capacity in 2025 will be presented in the form of the following map.

Figure 2. Map of Nyama Hamlet settlement area

Regarding data analysis, to be more specific in calculating physical carrying capacity (PCC), real carrying capacity (RCC), effective carrying capacity (ECC), and land carrying capacity, the following calculation formulas will be attached.

Physical Carrying Capacity

Physical carrying capacity, commonly referred to as PCC, is the maximum number of tourists that can physically be accommodated in a given area. The formula used to calculate physical carrying capacity is:

$$PCC = A\ x\ 1\ /\ B\ x\ R \quad (1)$$

Description:
PCC =Physical Carrying Capacity
A =Existing Tourism Area
B =Area Used by Tourists
Rf =Rotation Factor

Meanwhile, the formula used to calculate the area required by tourists (one tourist)

$$B = v\ /\ a \quad (2)$$

Description:
v =1 Tourist is Worth 1
a = Area Size for Tourism Activities

Real Carrying Capacity

Real carrying capacity, commonly referred to as RCC, refers to the maximum number of visitors that a tourist area can realistically accommodate, taking into account the correction factor. The correction factor referred to here is the physical condition of the tourist area. The formula used to calculate real carrying capacity is:

$$Cfn = 1 - (Mn\ /\ Mt) \quad (3)$$

Description:
Cfn =Correction Factor Ke-n
Mn =Actual Condition of Variable fn
Mt =Batas Maximum variable fn

Meanwhile, the formula used to calculate the real carrying capacity (RCC) is:

$$RCC = PCC\ x\ Cf_1\ x\ Cf_2\ x\ Cf_3\ x\ \ldots\ldots x\ Cf_n \quad (4)$$

Description:
RCC =Real Carrying Capacity
PCC =Physical Carrying Capacity
MC =Management Capacity

Effective Carrying Capacity

Effective carrying capacity, commonly referred to as ECC, is the maximum number of tourists or visitors that can visit while still taking into account management capacity factors. The formula used to calculate effective carrying capacity is:

$$ECC = RCC\ x\ MC \quad (5)$$

Description:
ECC = Effective carrying capacity
RCC =Real Carrying Capacity
MC =Management Capacity

Land Carrying Capacity

Land carrying capacity is the ability of an area of land or environment to support a certain population at a given time. If the population in an area exceeds the land carrying capacity, an imbalance or negative impact will occur. Conversely, if the carrying capacity of the land dominates the population size, then there will be no environmental damage or conflict within the community. Kumara et al. (2026) emphasizing that the assessment of carrying capacity aims to strengthen landscape conservation management in Danau Sentarum from a sustainable water use perspective. To ensure that the land in an area remains controlled and free from damage, it is necessary to conduct an analysis of the carrying capacity of the land to determine and find out how much population the land can support in an area. Therefore, a formula is needed to calculate the carrying capacity of the land.

$$A = L / P \quad (6)$$

Description:
A = Land Carrying Capacity
L = Land Area (ha)
P = Population Size (People)

Result and Discussion

Nyama Hamlet Profile

Nyama Hamlet is part of Klis Village, Moa Lakor Subdistrict, Southwest Maluku Regency (MBD). More specifically, Nyama Hamlet is located at coordinates 127°59'10.1 E and 8°14'43.2 S. Based on its physical characteristics, Nyama Hamlet is dominated by expanses of white sand located on low-lying land. Its location is very strategic, as it is flanked by several islands such as Lakor Island (east), Letti Island (west), Australia (south), and the Banda Sea (north). Based on the characteristics of Nyama Hamlet, the characteristics of livelihoods, religion, and language in Nyama Hamlet are presented in Table 1.

Table 1. Demographic profile of Nyama Hamlet

Aspect	Category	Population	Percentage (%)
Population	Cumulative	935	100%
Age group	Children	381	40.70%
	Adult	410	43.90%
	Elderly	144	15.40%
Religion	Christian	-	100%
Language	Local language	-	90%
	Indonesian	-	10%
Livelihood	Farming	-	90%
	Livestock	-	5%
	State apparatus	-	2%
	Business	-	3%

The results in the table above show that children are aged 0-17 years, adults are aged 18-59 years, and the elderly are aged 60 years and above. As for the main occupations of the local community in Nyama Hamlet, they are a mixture of farming and raising livestock, owning small businesses (micro enterprises), and also farming. In addition, agriculture is one of the main occupations of the local community in Nyama Hamlet, who use the land for farming. From a plantation perspective, the main crops cultivated include coconut (a long-term crop) and mango. Meanwhile, in terms of food crops, the community grows corn, sweet potatoes, red beans, white beans, peanuts, and various other local commodities. The types of fruits that are also cultivated include bananas and mangoes, along with a variety of other fruits grown by the local community.

In terms of governance, Nyama Hamlet is currently under the full authority of the Hamlet Head, who performs administrative and governmental functions. The hamlet is planned to be expanded into a definitive village in 2026. Meanwhile, the Saniri Head plays a role in managing communal land owned by the local community. In the agriculture and livestock sector, farmer and livestock groups have been formed and regularly receive guidance from the Agriculture Office and Livestock Office. The education provided covers sustainable farming and livestock management practices. In terms of infrastructure, conditions in Nyama Hamlet are still very poor and difficult to access, as shown in Table 2.

Table 2. Infrastructure availability in Nyama Hamlet

Availability	Basic facilities	Total amount
Total amount	SD Kristen Nyama	1
	TK Glori Nyama	1
Health	Sub-health center	1
Place of worship	Church	1
Clean water sources	Dug well	7
Government	Village head office	1

Overview of the Research Location

Gerdarsi Beach is one of the beaches located on the coast of Nyama Hamlet, which is located on Moa Island in Southwest Maluku Regency (MBD). Gerdarsi Beach is known for its natural resources and attractions that draw tourists to the area. Tourists can enjoy activities such as swimming, boating, picnicking, and camping during their visit. In addition, there is a long white sand beach within the Gerdarsi Beach area that adds to the appeal of this area. For more specific information regarding natural potential and attractions, please refer to the coordinates between 128°00'46.2"E and 8°15'23.0" S. More specific details of the Gerdarsi Beach tourist area will be attached in the form of map-based images for each activity that tourists can do during their visit:

Figure 3. Tourist Activities at Gerdarsi beach

A spatial analysis was conducted to delineate and calculate the area of tourist activity zones at Gerdarsi Beach using Google Earth Pro (Image ©2026

CNES/Airbus). This analysis identified and measured three primary zones: a swimming area (28.06 m²), a picnicking area (263.25 m²), and a camping area (339 m²) (Figure 1). Boating was excluded from this mapping as no facilities or boats are currently available for tourists in the area. This spatial data serves as a foundational tool for informing future development and management policies for the Gerdarsi Beach tourism area.

Access to the Gerdarsi Beach Tourism Area typically begins from the center of Tiakur, with a distance of approximately 25.11 km and a travel time of about two hours. The area offers a diverse range of natural attractions, including expansive stretches of fine white sand, vast green savannas, and a marine ecosystem featuring clear blue waters and well-preserved coral reefs, which are ideal for activities such as snorkeling.

Based on research conducted from July 16 to August 16, 2025, the average number of tourist visits to Gerdarsi Beach was 302 people per day, with peak visitation occurring on weekends. Given the total area of 14,530,971 m² (1,453 ha), this translates to approximately 48,116 m² (or 4.81 ha) per visitor, based on the average daily visitation rate. Despite its significant potential, Gerdarsi Beach remains undeveloped by the local government, preserving its natural charm and making it particularly appealing to tourists seeking unspoiled landscapes and tranquility (Southwest Maluku Tourism Office, 2022).

However, there are several problems that are often faced by the Gerdarsi Beach Tourism Area, including: 1) Litter is scattered due to tourist activities that still lack awareness of the preservation of the area. This directly reduces the attractiveness of tourism and lowers the quality of the environment. 2) Unsustainable fishing practices carried out by the local community of Nyama Hamlet and neighboring villages. These activities involve damaging coral reefs, which are fish habitats, resulting in a decline in catch yields and pollution of the marine ecosystem. 3) Uncontrolled tourist visits every day have a negative impact on the sustainability of the ecosystem within the Gerdarsi Beach tourist area. 4) The lack of tourism area managers, with only one person in charge, makes this area vulnerable to environmental degradation. In addition, the lack of research on the carrying capacity of the area has led to uncontrolled visits and exacerbated damage within the tourism area (Parmawati et al., 2023).

The area of land and land use are factors that local communities in Nyama Hamlet take into account when carrying out various activities. Through this spatial analysis, the administrative boundaries of Nyama Hamlet, the distribution of used and unused land, and key facilities are visualized in Figure 4. According to the delineation of this map, the total land area in Nyama Hamlet used for analysis is 17.20 ha.

Figure 4. Administrative map and land Use in Nyama Hamlet

The total land area, when compared to the population of 935 people, results in a land carrying capacity ratio of 1.84 hectares per individual. This result shows that, based on the available space, the level of pressure on the Nyama Hamlet community is still very low. However, based on the map provided in Figure 1 for facilities such as schools, churches, and the Nyama Hamlet hall, there is still land available for sustainable development. Wardani et al. (2023) which analyzes the limits of the carrying capacity of the available land in Banda Aceh until 2029 with a population of 291,940 people, while the current population is 268,370 people, meaning that the land area in Banda Aceh still supports the activities of the existing population for the current period, but needs to be re-analyzed to avoid threats in 2029.

The Potential and Challenges of Gerdarsi Beach Tourism

Gerdarsi Beach is known for its natural attractions and potential that can be developed sustainably. Physically, Gerdarsi Beach offers attractions such as natural landscapes, including a coastline within the tourist area that is still very natural, with a coastline that has physical conditions such as a beach with savanna expanses that are more dominant when viewed based on the existing reality. Of course, this potential and appeal can offer opportunities for every visitor to engage in various activities that provide a range of services from nature, such as wildlife, vegetation, and landscapes (Parmawati & Hardyansah, 2022). Meanwhile, the marine ecosystem of Gerdarsi Beach is a valuable asset, characterized by its coral reef diversity and various rockfish species found there. In addition, this marine ecosystem is promising enough to establish policies in planning for sustainable management. The combination of the appeal of Gerdarsi Beach and the potential of the marine ecosystem is one of the potentials to attract

tourists who enjoy nature tourism, such as diving, boating, camping, and observing wildlife and vegetation within the tourist area (Parmawati et al., 2017). In addition, community participation in the management of tourism areas based on sustainable management is very much needed by the media in providing various resources needed by visitors and capable of providing benefits in increasing the income of local communities and controlling the tourism area (Muslih et al., 2023). Gerdarsi Beach is famous for its vast area and is still very natural or has not been developed at all. The location of Gerdarsi Beach is more than 2 hours away from the city center of Tiakur, so this area is far from noise and has the potential to attract tourists who love tranquility. Ulfy et al. (2026) emphasizing that the potential and attractiveness of a destination area determine the visits and quality of visitors.

The potential and appeal of the Gerdarsi Beach tourist area face significant challenges in terms of management, especially when it comes to development. The most pressing challenge is uncontrolled visitor activity, which is not restricted by the management and directly reduces the appeal of the Gerdarsi Beach tourist area through uncontrollable environmental damage. Based on the results of research by Anisti et al. (2025), it was revealed that environmental damage occurs not only due to an increase in the number of visitors but also due to a lack of awareness among tourists, especially on the part of managers, in maintaining cleanliness within the tourist area.

The lack of awareness among tourists about tourism area management is still very low, because almost 95% of tourists litter in areas they have already visited, which affects the RCC and ECC, so that other visitors who want to travel are affected by the litter in the tourist area. Sutrisno et al. (2025) found that integrated waste management can reduce tourist quality and pollute the tourist area environment, as well as increase air pollution, which disrupts the activities and comfort of every visitor. The management, consisting of only one person, does not provide trash bins nor does it provide a policy for visitors to take home the trash they produce during their visit. This practice certainly makes visitors who want to return less interested due to the lack of management in the Gerdarsi Beach tourist area. Therefore, when visiting a tourist area, management capacity must be considered (Parmawati et al., 2018).

Potential and Challenges of the Local Community of Nyama Hamlet in Terms of Land Carrying Capacity

Nyama Hamlet is known as a hamlet located in lowlands and has enormous natural resource potential, especially for agriculture and livestock farming. By 2025, around 90% of the local community in Nyama Hamlet will still rely on nature for farming. The agricultural potential of the local community in Nyama Hamlet relies on very fertile soil, which is always cultivated using a mixed farming system that varies according to the types of crops that the local community wants to grow, such as corn, sweet potatoes, beans, and various other local crops. This diversity of crops is not only focused on providing food security but also on providing long-term food security.

There are challenges that are often faced by the local community of Nyama Hamlet in meeting their daily needs. The main challenge they often face is their dependence on high rainfall. If rainfall is high in a given year, the local community's harvest income will increase and they will obtain very satisfactory results and sufficient food stocks for one year for some of the local community. However, if rainfall is low, the results obtained will of course only last for a few months (5 months). The results of research by Wahyuni et al. (2026) show that most of the rainfall in Kalimantan in September 2020 was caused by high-intensity easterly winds and an increase in sea surface temperature. resulting in high rainfall conditions caused by the easterly wind disturbance, which influenced the rapid increase in food productivity in 2020. The availability of land that is still very supportive of the farming activities of the local community in Nyama Hamlet is a very supportive potential, but the community's dependence on high and low rainfall (prolonged drought) is one of the challenges that the local community in Nyama Hamlet always faces.

Carrying Capacity Analysis

Tourism carrying capacity calculation is one of the techniques or methods used to measure a tourist destination area with the aim of obtaining more accurate results that can be applied to the area in order to avoid damaging its appeal and avoiding various threats that may occur in the future. There are three methods that have been applied in calculating the carrying capacity of a tourist area, including: physical carrying capacity (PCC), real carrying capacity (RCC), and effective carrying capacity (ECC), which have been modified by Sobhani et al. (2022) to calculate the carrying capacity of tourist areas, as follows:

Physical Carrying Capacity

Physical carrying capacity (PCC) is the physical condition of the Gerdarsi Beach tourist area. Based on prevailing theory, physical carrying capacity is the maximum number of tourists or visitors that can visit a tourist area, but must take into account the physical conditions or available space in the tourist area. Thus, (Swandayani & Sulastri, 2025) reported that while 54.7% of tourists considered the yard plants diverse, all respondents (100%) supported the development of the

village as a tourism area and emphasized the need for better facilities and accessibility. The following table shows the total area and various activities carried out by tourists during their visit.

Table 3. Physical carrying capacity of Gerdarsi Beach

Variable	Gerdarsi Beach	Total area
Area size	-	14,530,971 m²
Tourist activities	Swimming	28.06 m²
	Boating	37.12 m²
	Picnicking	253.25 m²
	Camping	339.00 m²
Operating hours	-	24 hours
Time required for tourists	-	5 hours

To calculate the physical carrying capacity of tourism using the standard calculation of the area of tourist areas based on Douglass (1975) and modified by (Wati et al., 2023), which was implemented in the research results at Gerdarsi Beach, is as follows:

$$PCC = A\ x\ 1\ /\ B\ x\ Rf$$

$$= 14.530.371\ x\ \frac{1}{23.5}\ x\ 4.8$$

$$=14.530.971\ x\ 0{,}042553\ x\ 4{,}8$$

$$= 2.966.860$$

Based on the results of calculating the physical carrying capacity of tourism at Gerdarsi Beach in relation to area size, tourist activity, operating hours, and the amount of time visitors need, calculations using Microsoft Excel show that Gerdarsi Beach can accommodate 2,966,860 tourists per day. Furthermore, the value of one tourist based on the total area within the Gerdarsi Beach tourist area is 23.5 m². The total area of the region was obtained by measuring the length multiplied by the width of the area, thus obtaining the total area of Gerdarsi Beach.

Real Carrying Capacity

The carrying capacity (RCC) is the maximum number of visitors or tourists that can visit a tourist destination area, taking into account the correction factor (CF) without causing high risk environmental damage. Several correction factors have been analyzed in accordance with the recommendation book (Parmawati et al., 2022), which contains Cf_1 animal diversity representing all species diversity on land, Cf_2vegetation diversity representing plant species within the tourist area, Cf_3 land slope, Cf_4 rainfall, Cf_5 soil sensitivity, Cf_6 water body cover, Cf_7 forest cover, Cf_8 high wave events.

There are several correction factors that were not included in this study, such as forest cover and water body cover, because these correction factors are not located within the Gerdarsi Beach tourist area. Meanwhile, to calculate the correction factor (CF), the following is used:

$$PCC = RCC\ x\ Cf_1\ x\ Cf_2\ x\ Cf_3\ x\ Cf_4\ x\ Cf_5\ x\ Cf_6\ x\ Cf_7$$
$$= 2.966.860\ x\ 0\ x\ 0{,}5542\ x\ 1\ x\ 0{,}1576\ x\ 0{,}55\ x\ 0{,}8333$$
$$\approx 0$$

Based on the results of the actual carrying capacity (RCC) calculations from the data collected in the research area, Gerdasi Beach has exceeded its actual carrying capacity, or has exceeded the capacity of the tourist environment. The number of tourist visits per day, at 302 per day, is already at the threshold based on the actual carrying capacity (RCC). In addition, corrective factors such as vegetation diversity, animal diversity, land slope, rainfall, soil sensitivity, and high waves manifest a much lower maximum number of tourists when compared to physical carrying capacity (PCC). This exceeded actual carrying capacity serves as a warning or signal that will certainly affect the quality of vegetation and wildlife, which will ultimately damage the attractiveness of the Gerdarsi Beach tourist area.

For more details based on the results of the actual carrying capacity analysis, a table based on the data collection results in the Gerdarsi Beach tourist area is attached in Table 4.

Table 4. Vegetation and Animal Diversity Gerdarsi Beach

Analysis indicator	Analysis results	Total
Vegetation Diversity	Vrostweed	9
	Tocalote	59
	Oldman's cap	38
	Tamanu	362
	Cyperus tenellus	18
	Fimbristylis	42
	Swamp rosemary	16
	Cordylanthus Ridigus	5
	White clover	13
	Horse whip	8
	Coriander leaves	12

	Coriander leaves	3
	Solamun Viarum	11
	Jonghe	52
	Total vegetation diversity	648
Animal diversity	Cow	18
	Horse	53
	Goat	187
	Buffalo	278
	Total animal Diversity	536
Land slope	Steep Track Length	1940 m
	Total trail length	1940 m
	Steep land area	209 m^2
	Total land area	1.45E + 08 m^2
Rainfall (2015-2024)	2015	169
	2016	158
	2017	240
	2018	209
	2019	187
	2020	209
	2021	231
	2022	185
	2023	200
	2024	218
	Total rainy days	2.264
Soil type and sensitivity	Brown forest soil	45
High wave event	January and February	2

Effective Carrying Capacity

Effective carrying capacity (ECC) is an estimate of the maximum number of visitors that can be accommodated in a tourist area in a day, taking into account the physical conditions or physical carrying capacity within the tourist area and, most importantly, its management capacity. This concept involves the number of managers available and the number of managers needed to manage the tourist area.

One of the main keys to calculating effective carrying capacity is management capacity, so that management capacity correlates with how many visitors or tourists can be served. To significantly increase visitation numbers, community involvement and participation from the local government are needed in creating planning agendas for destination development, such as facilities and basic infrastructure to support tourism activities (Zai at al., 2025). Through sustainable management in the Gerdarsi Beach tourism area, the formula for calculating management capacity (MC) is as follows:

$$ECC = RCC\ x\ MC = 1\ x\ 10\ \approx 10$$

Based on the analysis of effective carrying capacity (ECC), there is currently one manager overseeing the Gerdarsi Beach tourist area. Meanwhile, calculations show that a management capacity (MC) of 10 people is needed to manage the Gerdarsi Beach tourist area.

After completing the calculations based on physical carrying capacity, actual carrying capacity, and effective carrying capacity, the results are calculated in the following table:

Table 5. Carrying capacity results of Gerdarsi Beach

Carrying Capacity	Number of tourist visits	
Physical carrying capacity	2.966. 860	Not yet exceeded
Real carrying capacity	0	Has been exceeded
Effective carrying capacity	0	Has been exceeded

The calculation results covering three main points, namely physical carrying capacity (PCC), real carrying capacity (RCC), and effective carrying capacity (ECC), show different results. Whereas the physical carrying capacity (PCC) is based on the number of daily visits, which is 302 tourists, the final result of the physical carrying capacity calculation in the Gerdarsi Beach tourist area is able to accommodate 2,966,860 tourists for one day of visits. Kewuren et al. (2026) at Mangunan Forest Resort, Bantul Regency, also show differences between PCC, RCC, and ECC, but with different statuses. All three destinations at Mangunan Forest Resort (Puncak Becici, Hutan Pinus Sari, and Seribu Batu Songgo Langit) operate below their respective ECC limits, with the highest ECC value of 1,478 people/day at Hutan Pinus Sari and the lowest at 597 people/day at

Seribu Batu Songgo Langit. In contrast, our research at Gerdarsi Beach found that both RCC and ECC had been exceeded even though the PCC value was still very high. This difference is mainly due to management capacity factors. At Mangunan Forest Resort, tourism management capacity is sufficient so that the ECC is not exceeded. In contrast, at Gerdarsi Beach, only one manager is available, while the ideal requirement is 10 people, making ECC a major limiting factor. In addition, biophysical factors such as fauna diversity (Cf = 0) and soil sensitivity (Cf = 0.55) also significantly reduced the RCC value, in line with the findings in Mangunan that ecological factors such as herpetofauna diversity, land slope, and soil erodibility influenced the real carrying capacity value.

However, based on the calculations of the actual carrying capacity (RCC) and correction factor (Cf) in the Gerdarsi Beach tourist area, the number of 302 daily visits has exceeded the carrying capacity or is already at the threshold. The results of the calculation of the effective carrying capacity with 1 manager, but the number of managers needed is 10, which has been exceeded. Thus, the daily number of visits of 302 has exceeded the maximum limit of the available space. This result affects the real carrying capacity (RCC) where the Gerdarsi Beach tourist area is dominated by vegetation and wildlife.

Land Carrying Capacity

Land carrying capacity is one of the methods used to calculate the condition of land that supports the activities of all living creatures without any long-term threats. There are several qualities that must be considered in land carrying capacity, namely water quality, air quality, soil quality, land area as a support, and population size. Based on physical carrying capacity calculations. However, this study only analyzes land carrying capacity, population size (souls), and land area, so the commonly used formula is:

$$A = L \,/\, P$$

$$L = 17{,}20\ km^2\ x\ 100\ \ km^2 = 1720$$

$$A = \frac{1720}{935}$$

$$A\ \approx 1{,}83\ ha$$

Based on calculations of land carrying capacity in the Nyama Hamlet area, the land area for one individual or population is 1.83 hectares (ha). This compares to the current standard land carrying capacity of 0.5 ha per person. Thus, quantitatively, the physical land carrying capacity in Nyama Hamlet is sufficient to support the local community at this time. According to Mutpaina et al. (2025), the study found that the land carrying capacity for a population of 1,616,229 people with a total area of 19,799.19 ha is 2.03 hectares per person, which is still considered sufficient to support the activities of each population.

Conclusion

This study analyzes the tourism carrying capacity at Gerdarsi Beach and the land carrying capacity in Nyama Hamlet. The results of the physical carrying capacity (PCC) at Gerdarsi Beach are 2,966,860 visitors per day, far exceeding the actual number of visitors, which is 302 visitors per day. However, the results of the calculation of the real carrying capacity (RCC) from correction factors such as vegetation, fauna, slope, rainfall, soil sensitivity, and wave events have been exceeded with a value of 0. The results of the calculation of the effective carrying capacity (ECC) have also been exceeded (1 manager who manages the Gerdarsi Beach tourist destination and 10 managers are needed). Correction factors and management capacity are the main problems for the management of the Gerdarsi Beach tourist destination based on sustainability. The analysis of land capacity in Nyama Hamlet, with a total land area of 17.20 ha and a population of 935, shows that the land area used per person is 0.5 ha. The land capacity still supports the current population. This study has four major limitations. First, the calculation of maximum tourist numbers is based solely on physical space and operating hours, without considering visitor comfort and density levels. Second, biophysical factors (vegetation, fauna, slope, rainfall, soil sensitivity, and wave events) are measured over a single period (July-August 2025) and do not reflect seasonal variations. Third, management capacity is assessed solely on the number of managers, without evaluating management skills or effectiveness. Fourth, the calculation of land availability still supports population activities without considering land quality, disaster risk, or access to facilities such as schools and clean water availability. Recommendations for further research are: (1) validating the tourism carrying capacity-based management model at Gerdarsi Beach in various seasons (wet and dry) with the aim of capturing temporal dynamics; (2) developing an environment-based tourism monitoring system using real-time sensors for water quality, waste, and visitor density; (3) testing the effectiveness of increasing management capacity from 1 to 10 personnel on increasing environmental carrying capacity; and (4) replicating the use of land carrying capacity in Nyama Hamlet on a sustainable basis to avoid future threats.

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The authors declare that they have no conflicts of interest.

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