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Article

Optimizing tourist flows through operative carrying capacity assessment: The case of Bakkhali coastal tourism, W.B., India

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Abstract: Carrying capacity assessment of nature-based tourist destinations is important for keeping the consumption of natural resources and anthropogenic pollution levels within environmentally safe and sustainable limits. With the mostly rural character of such destinations, the local community's well-being also needs to be prioritized. Exposure to natural hazards and climate crises have further exacerbated concerns about the long-term sustainability of these locations. The interrelationship between tourism intensity and its impacts clearly reflects Butler's Tourism Area Life Cycle model of 1980. The 'elements of capacity' and their 'critical range' mark a significant threshold in the model that leads us to the concept of carrying capacity. The capacity may be physical, spatial, ecological, environmental, social, economic, management, and governance, among others. This is also linked with the quality of the touristic experience and satisfaction. In this context, aiming to understand the optimum level of tourist traffic flow in Bakkhali, one of the popular beach destinations of the deltaic island system of the Indian Sundarbans, this study assesses its visitor carrying capacity at three levels—physical, real, and effective. It also briefly introduces the idea of 'operative' carrying capacity at the fourth level. The study is based on tourist data until 2019 and adopts the well-established methodological framework of carrying capacity assessment applied widely in several settings. The result suggests that tourism operations at Bakkhali may optimally handle 2040 visitors per day, which may be stretched to a maximum of 2267 visitors per day. This may be used as baseline information for sustainable coastal tourism policy framing in the long term while planning for tourism management and infrastructure development in the Sundarban region in immediate terms.

Keywords: beach tourism; carrying capacity; limiting factors; operative carrying capacity; sustainability

1. Introduction

The World Tourism Organization (UNWTO), a United Nations specialized agency, defines tourism as *'a social, cultural and economic phenomenon which entails the movement of people to countries or places outside their usual environment for personal or business/professional purposes. These people are called visitors (which may be either tourists or excursionists; residents or non-residents) and tourism has to do with their activities, some of which involve tourism expenditure'*. Tourism involves travelling and staying of people '*outside their usual environment for not more than one consecutive year for leisure, business and other purposes*' and is a sub-set of travel, while visitors are a particular type of traveler moving from one geographic location to another. UNWTO further differentiates between stay-trips and day-trips, classifying visitors as a 'tourist' (or overnight visitor) who opts for an overnight stay or as a 'same-day visitor' (or excursionist).

The tourism sector is known for its significant contribution to a country's economic development and hence plays a vital role in supporting living and livelihood in the places of visit. Tourism activities impact the natural and built environment, as well as the local community, and in turn, also get impacted. The dynamics and complexities between these dimensions influence the various stages of tourism growth and are well-depicted by Butler's theory of 'tourism area life cycle' or TALC [1].

It is interesting to note how these stages correlate with the number of visitations, particularly the development and the stagnation stages where the rates of visitation are reversed. A large number of tourists within a short span marks the development stage, whereas reduced visitations for a prolonged period indicate stagnation. **Figure 1** reinterprets the TALC model to highlight this correlation [2]. The most significant segment of Butler's hypothetical evolution of a tourist area is the post-stagnation stage, when the area can either get rejuvenated by positive strategies and action or can slip into absolute decline through five likelihoods. While E is attributed to catastrophes, B and C are hopeful possibilities where the 'capacity levels' are respected with due consideration, as minor modifications to capacity levels lead to modest growth in tourism (B) and tourism is stabilised by cutting the capacity levels (C). Once the capacity levels are reached or surpassed with passage of time and simultaneous increase of visitors, the attractiveness of a tourist area and consequent visitor experience get negatively affected. Appropriate destination planning and management can effectively reverse this trend and arrest the decline by adjusting the capacity levels even before the stage of stagnation (**Figure 1**).

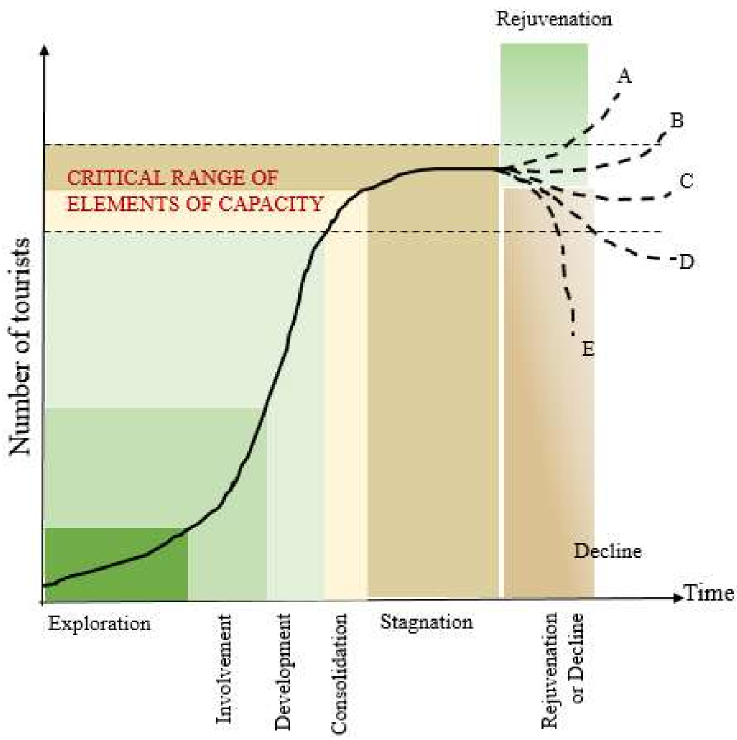

Figure 1. Carrying capacity related to tourism area life cycle [1].

TALC is the seminal model and a forebear of the sustainability concept in tourism. This is where the tourism carrying capacity figures prominently as a tool to assess and understand the threshold of tourism growth for a specific tourist area.

1.1. Need of the study

Coastal zones are densely populated regions of the world supporting about 60% of the world's population and also vulnerable to multiple natural hazards like storm surges and floods. The land-ocean interface in these zones has a complex ecosystem and experiences intense economic activities such as tourism owing to their rich resource base and aesthetic appeal. The rising anthropogenic pressure threatens the sustainability of these fragile environments [3]. The Indian Sundarbans is one such ecologically rich coastal region in south Bengal (**Figure 2**)—a World Heritage Site inscribed in 1987. It has the world's largest mangrove forests, comprising 55% forest land and 45% wetlands in the form of tidal rivers, creeks, canals, and vast estuarine mouths of the river [4]. Sandy beach is present in a few areas, while large stretches of muddy beach are common in the Sundarbans [3].

Figure 2. Location of the Indian Sundarbans [4].

The sandy beach of Bakkhali is a popular seaside location in one of the inhabited islands of the Indian Sundarbans. The State Government introduced tourism here in 1972, and in the last five decades, it has grown considerably, mainly with private initiatives. Uncontrolled tourism, inadequate planning, and a lack of ecosystem-based management have caused widespread degradation, resulting in a loss of biodiversity and ecosystem services in the Sundarbans [5]. Studies on tourism carrying capacity in the context of the Indian Sundarbans are lacking, and therefore, such an assessment for Bakkhali was felt necessary.

1.2. Aim of the study

Sustainability implies human economy to remain within earth's carrying capacity [6]. Aiming for controlled tourism growth for long-term sustainability of both environment and socio-economic conditions, this paper aims to understand the spatio-physical threshold of tourist population that may be supported by the Bakkhali tourist area within the sustainable limits. This leads to the assessment of its carrying capacity to guide/develop a plan of action for optimizing tourist traffic flow to the site.

1.3. Methodology

The methodology involves a literature review, field visits, and primary and secondary data collection. Literature review consists of two tracks: one, tourism theory covering the tourism life cycle, sustainability, and carrying capacity (CC), and second, studies on the tourism site, its development history, abiotic, built, and tourism profiles, and related challenges. These are discussed in sections 2 and 3, respectively. Tourism data and field surveys constitute the primary study. The methodology flow diagram is given in **Figure 3**.

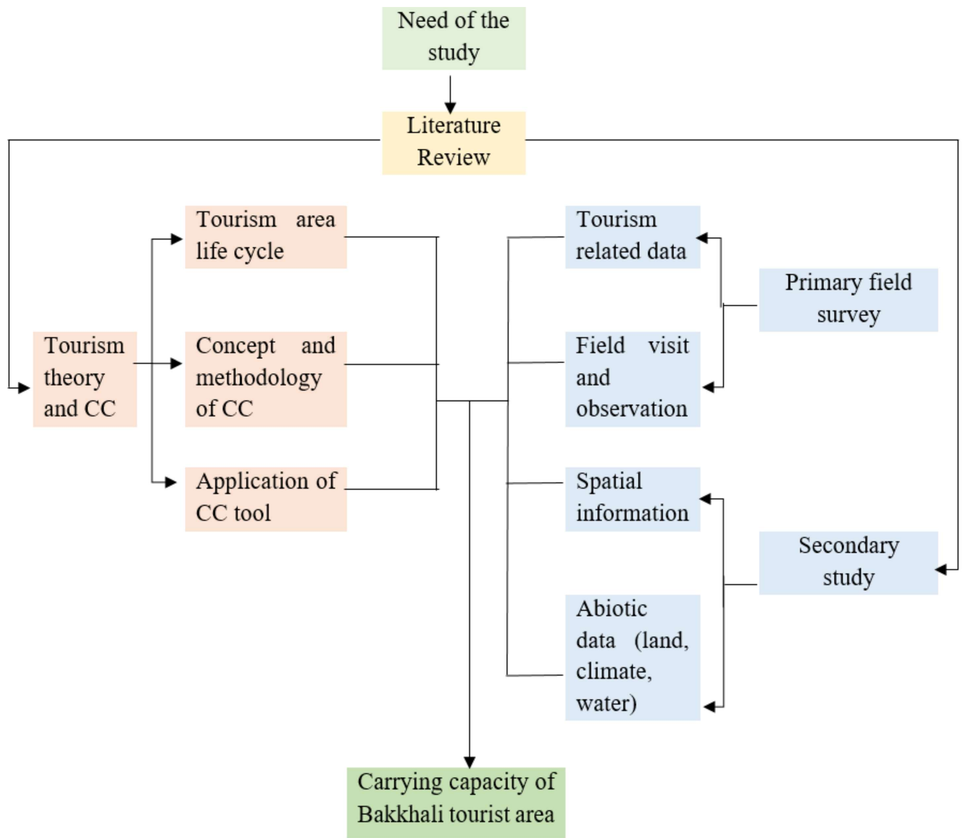

Figure 3. Research methodology.

2. Carrying capacity

2.1. Carrying capacity—Definition and dimensions

A year after the concept of 'tourism area life cycle' emerged, we find the United Nations World Tourism Organization defining the carrying capacity of a tourist resort as *'The maximum number of people that may visit a tourist destination at the same time, without causing destruction of the physical, economic, socio-cultural environment and an unacceptable decrease in the quality of visitors' satisfaction'* [7,8]. This definition is echoed by McNeely and Thorsell [9] when they described carrying capacity as '*the maximum level of visitors use an area can accommodate with high levels of satisfaction for visitors and few negative impacts on resources*'. UNEP puts an emphasis on environment and defines carrying capacity as '*The maximum number of users which can be sustained by a natural or manmade resource without* *endangering the character and quality of that resource at a sustained resource productivity over time'* [10]. The concept of capacity emerges from the concerns of the sustenance of fragile ecosystems in the face of accelerated anthropocentric activities and anthropogenic load. This is particularly critical to coastal environments, as these have finite resources and capacity and therefore should be central to coastal management initiatives [10]. Exceeded limits of capacity in peripheral destinations negatively affect visitor expectations, community wellbeing, and the natural environmental system [11]. Hunter [12] identified four different types of carrying capacity: physical, psychological (or perceptual), social, and economic carrying capacity. MacLeod and Cooper [13] have classified the capacity types in a slightly different manner: physical, ecological, social, and economic, with corresponding focal themes. Tourism carrying capacity is instrumental in the planning and management of tourism growth and to limit tourist flows [14]. Quicoy and Briones [15] view carrying capacity as an ecotourism tool having interdependent stakeholders from the tourism industry, community/local authorities, and environmental supporters. Tourism carrying capacity should not be viewed as a fixed framework but as a supportive tool for tourism management, with its assessment and implementation being a part of the tourism development planning process [16]. The concept is also an integral aspect of addressing the long-term sustainability of tourism sites [17].

The carrying capacity concept is most applicable in the context of natural protected areas where the visitor numbers can be regulated by the park management to a well-defined physical extent. It is quite challenging to ascertain the threshold of visitors for open-access visitation areas. Also, since no destination or person is identical, the diverse characteristics of the visitors, the hosts (local population), and the visited (destination) impede the process of objective assessment. Perception of visitors plays a significant role in determining the carrying capacity, as qualitative dimensions of attractiveness and satisfaction are subjective. Thus, carrying capacity appraisal involves both qualitative and quantitative approaches.

Carrying capacity in tourism involves three overlapping terms: tourist carrying capacity, tourism carrying capacity, and visitor carrying capacity. From the UNWTO glossary of tourism terms [18], these may be understood as below:

1) Tourist carrying capacity: Tourists undertake over-night stays in the tourist area. Hence, such carrying capacity studies would consider only the overnight visitors.

2) Visitor carrying capacity: Visitors include both tourists and excursionists, i.e., day-trippers. Hence, this study has a larger scope and considers all visitors.

3) Tourism carrying capacity: Tourism involves activities of visitors. Thus, the capacity of the tourist area to support all such activities comes under its purview, expressed in the number of people as per the UNWTO definition.

Cifuentes and Ceballos-Lascurain developed the methodology [19,20] based on which carrying capacity studies have been conducted by several scholars world-wide, as follows:

$$\text{Physical Carrying Capacity} = \frac{\text{Area used by tourists (say, swimming area)}}{\text{Average Individual Standard}}$$

$$\text{Rotation Coefficient} = \frac{\text{No. of daily hours area open to tourists}}{\text{Average time of visit}}$$

The total number of allowable daily visits is then determined by:

Total daily visits (maximum) = Carrying Capacity × Rotation Coefficient

The physical carrying capacity is further calibrated in a top-down process through real carrying capacity and effective carrying capacity (**Figure 4**) by accounting for the local constraints and management capacity [19–21]. Additionally, a concept of 'operative carrying capacity' has been introduced in this paper.

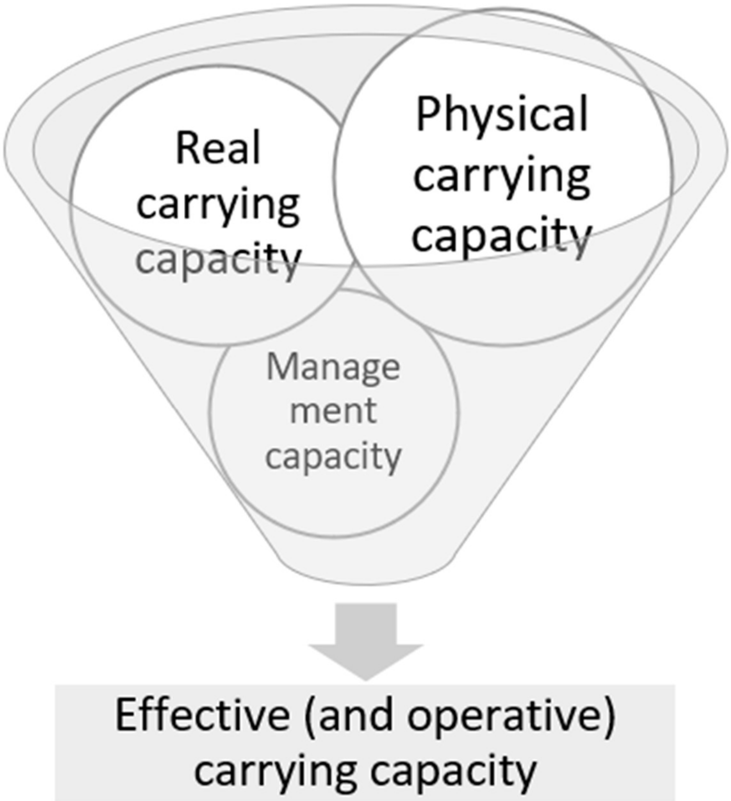

Figure 4. Interconnected top-down process of carrying capacity assessment.

The current paper has applied the physical carrying capacity (CC) assessment tool for finding the optimum number of visitors in the context of Bakkhali, the study area.

2.2. Carrying capacity assessment: Precedent studies

The deterioration in the tourist areas' environmental quality with increased footfall and intensity is seldom addressed in tourism potential studies and propositions. It is prudent to plan for controlled tourism growth from the very inception of tourism development, especially in nature-based destinations, to ensure overall sustainability. The World Tourism Organization defines sustainable tourism as "tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, and the environment and host communities". In the 2030 Agenda for Sustainable Development, the importance of sustainable tourism is highlighted in SDG target 12.b [22].

Sustainable tourism for coastal areas is closely related to coastal zone management, which in turn uses Carrying Capacity Assessment (CCA) as a necessary tool for formulating tourism development and management plans [7]. A tourism carrying capacity study as a part of the planning process has been presented in the report on European tourism destinations [23]. Zacarias et al. [21] focused on Praia de Faro of Portugal and assessed its physico-ecological carrying capacity for coastal management. It suggests applying the physico-ecological carrying capacity concept for ecosystem management and the socio-cultural carrying capacity for tourists and beach users.

Some applied research on carrying capacity estimation for controlled tourism in specific geographical locations include Fuka-Matrouh-Egypt [24], the Natural Reserve Mombacho Volcano-Granada and the Natural Reserve Datanl-El Diablo, Jinotega, Nicaragua [25], the Greek islands of Kalymnos, Kos, and Rhodes [26], Phong Nha-Ke Bang and Dong Hoi, Quang Binh Province, Vietnam [27], the Purbeck section of the Dorset and East Devon Coast [28], Calatagan, Batangas, Phlippines [15], South Andaman Island beaches, India [29], and the Town of Mali Lošinj under both normal and recent pandemic conditions [30].

The metrics and parameters that we use in this study based on the precedent literature are:

Physical carrying capacity of beach area is one tourist per 200 m^2 (50 users per ha of coastal zone), and for swimming in the sea, it is one tourist per 8 m^2 [24].

The beach capacity of 200 m^2/tourist has been adopted considering (a) ecological fragility of the coast—a habitat of the shore crabs *Ocypode macrocera* [31], their population decreasing due to increased tourism activities [32], (b) the beach use is concentrated along the shoreline in a linear manner, as much of the beach width is occupied by vending stalls, and (c) generous space for kids to run around as most tourists visit as families.

For assessing the real and effective carrying capacities, correction factors include local impediments affecting the physical carrying capacity, including climatic, abiotic, and spatial factors like monsoon months, strong winds, excessive sun-shine, cyclonic events, beach quality, sea water, beach area availability, and other related site-specific information [27,29].

3. The study area

Bakkhali Beach (21°33′32″N, 88°15′59″E) is located in the village Amrabati, Namkhana Block, Kakdwip sub-division, district South 24 Parganas in the Indian State of West Bengal (**Figure 5**). Tourism was initiated here when a government tourist lodge was set up on the eastern bank of a creek named Bakkhali (**Figure 6a**) in 1972. The convex-shaped sea-facing beach acquired its name from this creek [33]. It is 122 km south of the administrative centre of Kolkata, the capital city of West Bengal. The Namkhana Island is bordered by the Saptamukhi River on the east, Muri Ganga River on the west, Hatania-Doania River on the north, and overlooks the Bay of Bengal on the south. Its three smaller islands, namely Frazerganj, Fredrick Island, and Henry Island, are in the vicinity of Bakkhali (**Figure 6b**). The number of residents in the village is 6675 [34].

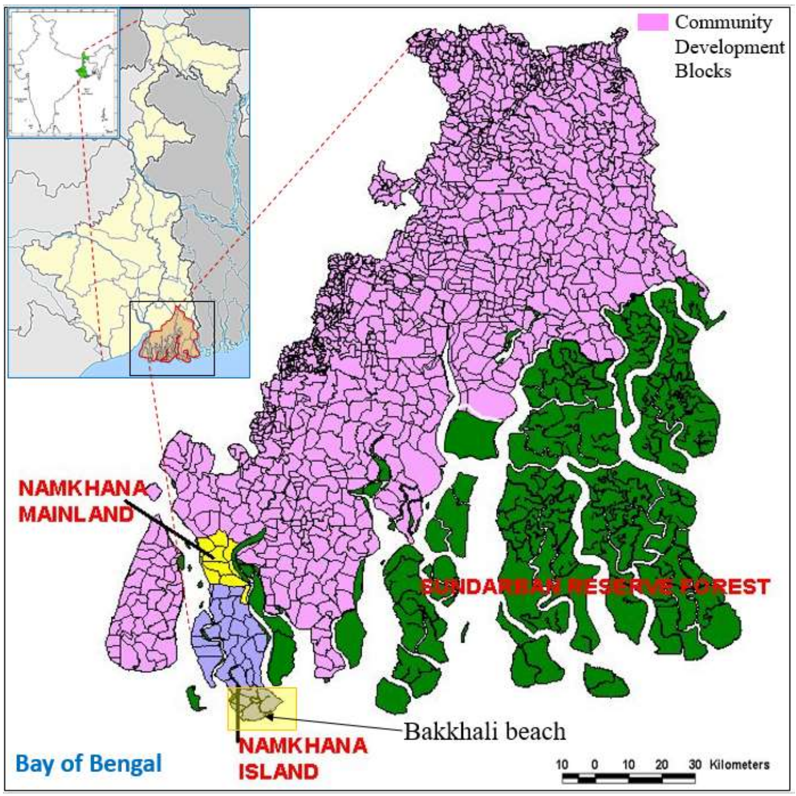

Figure 5. Location of Bakkhali in the Indian Sundarban region.

(a) (b)

Figure 6. (a) Bakkhali creek and adjacent forests (part) in 1906–1907, 1920–1921 [35]; **(b)** Bakkhali beach (central part) of the Namkhana Island's convex sea front [36].

3.1. Abiotic characteristics of Bakkhali coastal region

The coastal areas of Sundarban are susceptible and vulnerable to flooding, erosion, overwash dynamics, shoreline retreat, and habitat loss at the sea face and the mouths of tidal rivers and estuaries [37]. High-intensity storms, changing directions of approach to the low-lying beaches, increased evaporation rate in dry periods, and shortage of fresh water supply further aggravate the damage to the beaches, sand dunes, and mangroves [37]. Bakkhali beach face is nearly flat with a gentle seaward slope with MSL 1.50 m to 3.30 m and width varying between 150 m and 500 m [38]. Bakkhali experiences two predominant wind systems—the southwesterly in the summer and northeasterly in the winter, with wind velocity of 15–50 km/h and average minimum velocity of 10 km/h, respectively [39]. Cyclonic events are common in the Sundarbans due to frequent low pressure zone formation on the Bay of Bengal [40], and Bakkhali is no exception. Cyclones accompanied with heavy rainfall and wind velocities reaching up to 120 km/hour are recurrent. These also cause significant damage to the beaches within a very short period by eroding and redepositing the sands [39].

The Bakkhali coast is affected by erosion and accretion [39,41]. The erosion in Bakkhali has been so severe that the sand cover of Bakkhali sea beach has been removed, exposing the older alluvium with the formation of clay balls [42].

The coastal areas are also exposed to surface solar UV radiation [43]. Further, the coastal water quality gets affected due to anthropogenic inputs from land-based sources like domestic and agricultural wastes [44]. With close to 1000 tourists per day visiting the beach, it is obvious that tourism activities add to this load.

3.2. Built characteristics of Bakkhali tourism

The tourist accommodations are built on both sides of the major thoroughfare leading to the beach in a typical ‘ribbon development’ pattern common to the Asian countries. The majority of the hotels have very little foreground in the front and therefore create a picture of chaos and confusion. The lodgings are two to three stories high and boast highly urbanized facades (**Figure 7**). The West Bengal Tourism Development Corporation Ltd. (WBTDCL) has also refurbished and expanded its tourist accommodation—the Bakkhali tourist lodge, a single-storey cottage cluster—into multi-storey blocks, renaming it Balutot Tourism Property, Bakkhali [45]. Our field survey carried out in 2019–2020 revealed about 27 tourist accommodation establishments with a total built-up area of 16,574 m^2 and 1705 bed capacity.

Figure 7. Some of the tourist lodges in Bakkhali (Bakkhali-Frezerganj Hoteliers Welfare Association).

The Gangasagar Bakkhali Development Authority (GBDA), constituted in June 2013 [46], is also planning to expand the tourism activities through a guided day-tourism journey from Frazerganj Fishing Harbour to Jambu Island and Benuban in collaboration with the Forest, Tourism, Fisheries, and Transport Departments. This substantiates the importance of conducting a carrying capacity assessment to inform where to draw the line.

3.3. Tourism scenario at Bakkhali

The tourist volume was 259,696 in 2018 (source: Tourism Department), and the month-wise break up of its tourist overnights is given in **Figure 8**. Tourist footfall in the Bakkhali-Fraserganj region has been reported to be 62,288 in 2001 to 190,030 in 2015 [47]. This indicates an annual growth of 14.65% in tourist volume till 2015 and 12.22% till 2018.

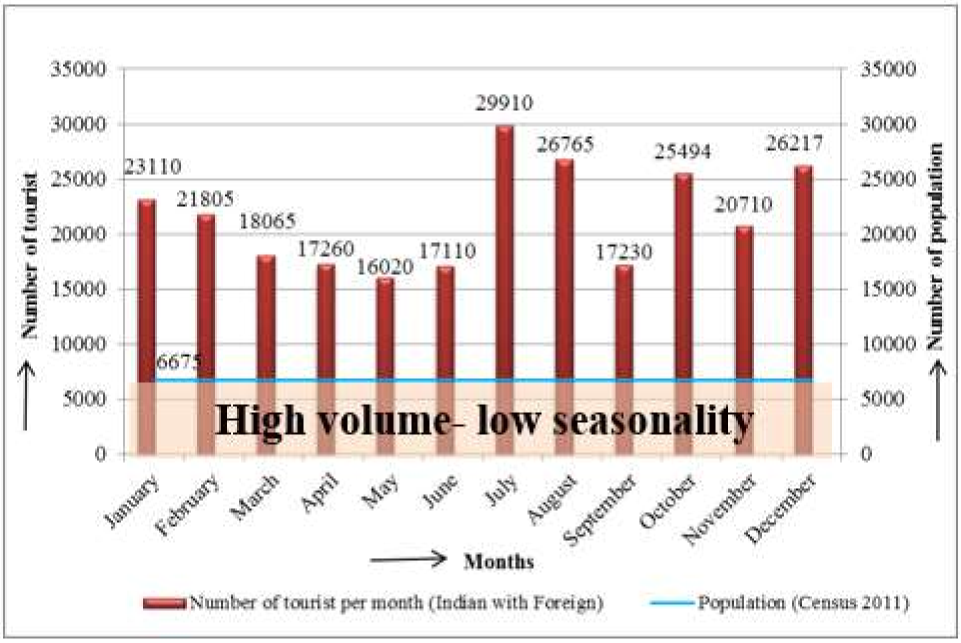

Figure 8. Month-wise break-up of tourist overnights in 2018 at Bakkhali (source: Tourism Department).

Our primary survey of 368 tourist respondents regarding their purpose of visit is indicated in **Figure 9**, and the sea beach stands out as the main reason for visiting Bakkhali.

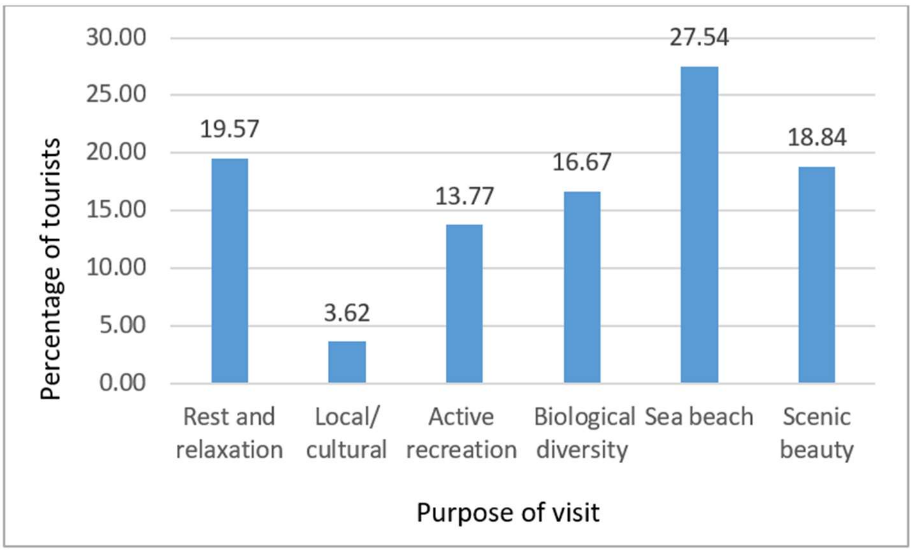

Figure 9. Tourist preferences and purpose of visiting Bakkhali (source: Authors' survey).

The above charts and our field survey reveal the following:

a) The monthly tourist arrival is 2–4 times higher than the local population.

b) The destination is characterized by high volume, low seasonality tourism.

c) Annual average tourist flow is 711 tourists per day, and peak tourist flow is 965 tourists per day in the month of July 2018.

d) A clear majority of tourists arrive at the weekend and stay over night.

e) About 50% of tourists spend one night, 42% two nights, and the rest more than two nights.

f) Half of the tourists surveyed are repeat visitors and have visited Bakkhali at least thrice.

g) The main draw for visitors is the sea beach, followed by people visiting for leisure, natural qualities, and opportunities to observe biological diversity.

h) The local people go to the beach in connection to their livelihoods, such as fishing, vending, attending their shops, and the like, varying in their spatial and temporal distribution.

4. Carrying Capacity Assessment (CCA) for Bakkhali

CCA begins with enumeration of spatio-physical data, as given in **Table 1**.

Table 1. Spatial information used for assessment of carrying capacity.

Tourist areas	Value	Remarks
Bakkhali beach area	614,089 m^2	Calculated from Google Earth
Picnic spot	53,371 m^2	
Beach length	4.164 km	Calculated from Google Earth
Sea-bathing/swimming area: 5 m into the sea for the entire length of the beach = (4164 × 5)	20,820 m^2	Computed

While assessing the Physical Carrying Capacity (PCC) for Bakkhali, the beach area and the picnic spot areas have only been considered as the 'effective area', especially as PCC is not merely the tourists' spatial density but a measure of acceptable crowding in a specific location of tourist interest.

Physical Carrying Capacity or PCC is expressed as:

$$PCC = A \times D \times Rf$$

where,

A = effective area (in m^2) available for use by a tourist, i.e., the Bakkhali beach area and the picnic spot area. This has been calculated directly from Google Earth (**Table 1**) and is:

Beach area: 614,089 m^2

Sea-bathing/swimming area = 20,820 m^2

Picnic area: 53,371 m^2

D = tourist density in this case would be of two types:

Beach area: one tourist per 200 m^2 [24]

Swimming in the sea: one tourist per 8 m^2 [24]

Picnic area: Considering ten picnickers per group, each group would need a 200 m^2 area for comfortable sitting and play activities. Hence, tourist density would be 20

m^2 per tourist.

Rf = rotation factor, i.e., the number of times these visits are possible to be undertaken within a specific duration, i.e., the daily permissible visiting hours, and is given by:

Rf = visiting hours/average trip time.

Similar to D, Rf will also be of three types corresponding to D:

Beach area:

Since Bakkhali Beach is the main attraction, tourists spend substantial time on the beach, considered to be 3 hours on average. The total time available for beachgoers is from sun-rise to sun-set, which is an annual average of 12 hours. Hence, Rf = (12/3) = 4.

Swimming in the sea:

On average, tourists spend about 1.5 hours actively engaging with the sea from morning to noon till lunch time, i.e., about 6 hours. Hence, Rf = (6/1.5) = 4.

Picnic spot:

Picnicking normally starts at 11 a.m. and continues till 4 p.m., covering the lunch hours. The same group continues for the said five hours. Thus, Rf = 5/5 = 1.

The physical carrying capacity of Bakkhali has been assessed based on these three different types of tourist areas and is given below in the successive **Tables 2–4**:

Table 2. Calculation of Physical Carrying Capacity (PCC) for beach.

Beach area in m^2	**Tourist density = One tourist per 200 m^2 (in person/ m^2)**	**Rotation factor**	**PCC = A × D × Rf (no. of tourists per day)**
A	D	Rf	D
614089	0.005 (1/200 m^2)	4	12282

Table 3. Calculation of Physical Carrying Capacity (PCC) for sea.

Beach area in m^2	**Tourist density = One tourist per 8 m^2 (in person/ m^2)**	**Rotation factor**	**PCC = A × D × Rf (no. of tourists per day)**
A	D	Rf	D
20820	0.125 (1/8 m^2)	4	10410

Table 4. Calculation of Physical Carrying Capacity (PCC) for picnic spot.

Picnic spot area in m^2	**Tourist density = One tourist per 10 m^2 (in person/ m^2)**	**Rotation factor**	**PCC = A × D × Rf (no. of tourists per day)**
A	D	Rf	D
53371	0.05 (1/20 m^2)	1	2668

4.1. Real carrying capacity

RCC is the maximum number of tourists, derived from PCC but moderated according to the destination's limitations (local, physical, or environmental conditions and management's capability). It is given by:

$$RCC = PCC \times (Cf_1 \times Cf_2 \times Cf_3 \times \ldots Cf_n)$$

where: "*Cf_i (corrective factors or limiting factors) are factors having negative impact on tourism activities and assessed by limiting threshold which is used for identifying* *the impact level of a factor"*

The corrective factor can be determined by: $Cf_1 = (1 - M_1/M_t)$.
where M1: limiting magnitude of variable 1; Mt: total magnitude of variable.

These factors depend on the tourism activities and local conditions of the site, especially unfavourable climatic factors such as heavy downpours, gusty winds, unbearable solar exposure, coastal storms, etc.

High rainfall, strong winds, excessive sunshine, cyclones, and beach quality are the limiting factors for the Bakkhali coast.

Rainfall (Cf_1):

Bakkhali experiences heavy rainfall in the months of July and August to the tune of nearly 500 mm. August also has the highest number of rainy days at 27.6 days [48]. Thus, the limiting magnitude for this climatic factor will be (30 + 31 + 31 + 30) = 122 days out of 365 days in a year.

$$Cf_1 = 1 - (122/365) = 1 - 0.33 = 0.67$$

Strong winds (Cf_2):

The windiest month in Bakkhali is July, with an average wind speed of 16.9 mph (27.2 km/h), closely followed by June [49]. The calmest month is November, with an average wind speed of 8.2 mph (13.3 km/h). Hence, both June and July with high speed winds have been considered.

$$Cf_2 = 1 - (61/365) = 1 - 0.17 = 0.83$$

Excessive sunshine (Cf_3):

Day temperature at Bakkhali is highest in May, although March has the maximum sun hours. A combination of high day temperature and sun-shine hours can be observed from March to June. Additionally, with the south-facing beach, the Ultra Violet load is also very high during the noon when the solar zenith angle is maximum [43]. Hence, the noon hours (12 noon to 3 pm) during March to June may be considered a limiting factor for the tourists. Thus, the magnitude of the variable is (31 + 30 + 31 + 30) days × 3 h = 366 h. The total magnitude is 365 days × 12 h = 4380 h.

$$Cf_3 = 1 - 366/4380 = 1 - 0.08 = 0.92$$

Cyclone (Cf_4):

Bakkhali takes the brunt of the cyclone occurrences originating from the Bay of Bengal. Severe cyclonic events take place mostly during April (Fani), and May (Aila, Amphan, Yaas), affecting normal life in this region [40]. Thus, limiting magnitude is taken as 61 days out of 365 days.

$$Cf_4 = 1 - 61/365 = 1 - 0.17 = 0.83$$

Beach quality (Cf_5):

The quality of the beach and the sea environment contributes to the tourist experience in a major way. Here eight parameters have been considered: (a) on-beach vending activities, (b) beach materials, (c) beach slope, (d) tide action, (e) beach length, (f) beach color, (g) litter, and (h) seawater quality. Except for the first, all the other seven parameters have been adopted from Sridhar et al. [29]. On-beach vending is common on many beaches, with both positive and negative sides to it. While local people get an opportunity to earn, ill-management results in litter and solid waste accumulation. **Table 5** shows the tourists' perception of the beach quality and their level of satisfaction.

Table 5. Limitation assessment of quality and ambience of Bakkhali beach.

on-beach vending activities	beach materials	beach slope	tide action	beach length	beach color	litter	seawater quality	Limiting magnitude
(−)	(+)	(+)	(+)	(+)	(+)	(−)	(+)	(2/8) = 0.25

In case of Bakkhali, on-beach vending and litter contribute negatively, thus

$$Cf_5 = 1 - 2/8 = 1 - 0.25 = 0.75$$

For the picnic spot, the following seven parameters have been considered based on the authors' perceptions: (a) ground cover, (b) sea view, (c) view of surrounding land, (d) tree canopy and overall aesthetics, (e) spaciousness, (f) litter, and (g) tourist amenities/conveniences. Out of these seven, only sea view and spaciousness appear positive. **Table 6** shows the tourists' perception of the picnic spot and their level of satisfaction.

Table 6. Limitation assessment of quality and ambience of picnic spot.

ground cover	sea view	view of surrounding land	tree canopy and overall aesthetics	spaciousness	litter	tourist amenities	Limiting magnitude
(−)	(+)	(−)	(−)	(+)	(−)	(−)	(5/7) = 0.71

$$Cf_{5\ (\text{picnic spot})} = 1 - 5/7 = 1 - 0.71 = 0.29$$

The Real Carrying Capacity (**Table 7**) presents a more realistic number of tourists who may engage in touristic activities at a given point in time in Bakkhali. These figures have to be further rationalized based on the current state of tourism management or management capacity (Mc), a crucial and defining factor for sustainability. Goal 14 of the United Nation's Sustainable Development Goal SDG 17 aims to *"Conserve and sustainably use the oceans, seas and marine resources for sustainable development"* and identifies five ocean emergencies: coastal eutrophication, ocean acidification, ocean warming, including sea-level rise, plastic pollution, and overfishing [22]. The UN Ocean Conference 2022 recognises tourism as one of the major economic activities that depend on a healthy ocean [50]. Ill-managed tourism also contributes to some of the ocean emergencies, particularly pollution. Hence, implementing better coastal waste collection is vital to address marine pollution since 60 to 90 percent of ocean litter is made up of different plastic polymers [50]. The study on beach pollution at Bakkhali [47] found that the micro-litter load was significantly higher than that observed in most other sea beaches of India. Mostly generated through tourism activities, these put the beach infauna at severe risk. Other than this, an overarching sustainability management plan aligned with the Coastal Zone Management Plans (CZMP) and its environmental regulations; capacity building of stakeholders; visitor sensitization; 'green' design, construction, and operation of buildings and infrastructure; and disaster preparedness and emergency response plans need to be urgently prepared by the local and state bodies in charge of tourism. The management capacity has been assessed based on these parameters adapted from the Green Globe International Standard for Sustainable Tourism [51].

Table 7. Calculation of Real Carrying Capacity (RCC).

Tourist area	Physical Carrying Capacity (PCC)	Correction factors					Product of the Cf.s	Real Carrying Capacity (RCC)
		Cf_1	Cf_2	Cf_3	Cf_4	Cf_5		
							CF	(PCC × Cf)
Beach	12282	0.67	0.83	0.92	0.83	0.75	**0.3185**	**3912**
Sea	10410	0.67	0.83	0.92	0.83	0.75	**0.3185**	**3315**
Picnic spot	2668	0.67	0.83	0.92	0.83	0.29	**0.1231**	**328**

Five broad capacity parameters have been shortlisted: (a) sewage treatment facilities; (b) solid waste management; (c) 'green' lodging regulations; (d) capacity building; and (e) tourist sensitization. These are appraised in qualitative terms to arrive at the final score of the current capacity of tourism management at Bakkhali, as observed in our field survey (**Table 8**).

Table 8. Management capacity assessment.

Sewage treatment facilities	Solid waste management	Green lodging regulations	Capacity building	Tourist sensitization	Mc current score
(−)	(−/+)	(−)	(−/+)	(−/+)	(1.5/5) = 0.3

The real carrying capacity further reduces when Mc is applied to obtain the Effective Carrying Capacity, as computed as given in **Table 9**.

Table 9. Calculation of Effective Carrying Capacity (ECC).

Tourist area	Real Carrying Capacity (RCC)	Management Capacity (Mc)	Effective Carrying Capacity (ECC)
	(PCC × Cf)		(RCC × Mc)
Beach	3912	0.3	1174
Sea	3315	0.3	995
Picnic spot	328	0.3	98
		Total	**2267**

Operative Carrying Capacity: However, tourist carrying capacity in terms of only 'tourists' is not enough. The simultaneous and proportional increase of supporting aids for operational tourism, i.e., transportation-related manpower, shopkeepers/vendors, facility providers, and other service staff also need to be factored here, since these additional heads will have a substantial share in consumption of land, energy, water, and bio-resources while contributing to the pollution load. This is the unaccounted 'shadow' of the mainstream tourists. A fourth step, proposed here as 'Operative Carrying Capacity' that considers this support population who may not be part of the host community, needs to be apportioned in the estimated volume.

Going with a reasonable ratio of support heads to tourists as 1:10, the carrying capacity may be further moderated to 90% of the ECC, such that the balance 10% is attributed to the operational aids that would support the tourist volume. The final carrying capacity works out to be 2040 tourists per day with 227 support heads (**Table 10**).

Table 10. Calculation of Operational Carrying Capacity (OCC).

Tourist area	Effective Carrying Capacity (ECC)	Operational Carrying Capacity (OCC)
	(RCC × Mc)	(ECC × 0.9)
Beach	1174	1057
Sea	995	895
Picnic spot	98	88
	2267	**2040**

However, this hypothesis of 10% 'shadow of tourism', i.e., one support head to 10 tourists, is an assumption that requires to be tested through multiple case studies in diverse contexts and hence opens up a fresh avenue for research investigation.

5. Discussions

The bed capacity as surveyed in 2019-'20 was 1705, and considering 100% occupancy, the optimized 'operative' tourist flow per day as found in OCC is 2040. This leaves only a little window for tourism growth under the current tourism management scenario. Tourism development at Bakkhali, therefore, has to be strictly controlled and regulated.

Tourism planners and proponents may disapprove of the idea of 'too many tourists' [52], but events of overtourism underline the need to limit tourist influx [53,54]. Making a distinction between tourist 'flows' and tourist 'flood' underscores sustainable and resilient tourism, particularly for coastal areas in the context of climate change. A robust tourism management plan that is aligned with the coastal zone management plans and capable of critical boundary delineation of tourism growth is the current necessity. Meso-scale steps involving land use planning, formulating specific guidelines and design control rules for the public places and the private hotels, ensuring their construction and operation are environmentally appropriate, and having a strict monitoring system in place are some of the critical management interventions essential for the long-term sustainability of this coastal destination. The role, responsibility, and relationship of different stakeholder groups for sustainable tourism management have been proposed in **Figure 10**.

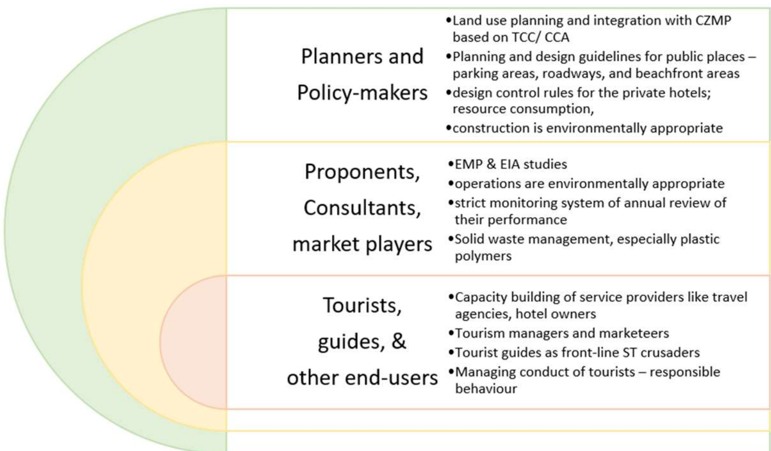

Figure 10. Role, responsibility, and relationship of stakeholder hierarchical groups in Sustainable tourism (ST).

Tourism managers often see growth through a skewed lens and miss the sense of its proportion to the destination capacity. This results in excessive tourist flows causing undesirable conditions such as congestion, environmental pollution, and visual quality deterioration. The cascading effect reduces the natural attractiveness and interferes with the touristic experience. Hence, tourism growth should be in consonance with the destination's carrying capacity to remain within sustainable limits [14]. Focusing only on economic development may be counterproductive in the not-so-long run, and hence, optimizing tourist flows based on carrying capacity assessment is essential.

6. Conclusion

This paper conducted the carrying capacity assessment of the Bakkhali beach of the West Bengal coastal zone in one of the deltaic islands of the Indian Sundarbans. Enduring fifty years of tourism in this remote rural setting, Bakkhali has seen a recent spurt in tourism with investments in infrastructure creation, bringing in private players of varying capacity in the local tourism market. However, the environment is taking the hit in all these economic upsurges. Although the peak tourist traffic per day in 2018 was 965 per day, the level of management is falling short, and it shows in the environmental degradation in the beach and the surrounding area. The tourism administration of Bakkhali should plan and extend appropriate, proactive, and prompt solid waste management services covering sewage treatment plants, gainful reuse of organic waste, and recycling of non-biodegradable waste as an absolute priority. The proliferation of shops, small commercial enterprises, and support infrastructures adds to the load. This may be considered the tourists' *'shadow'*, which undergoes simultaneous growth alongside the tourist population. The current study found that Bakkhali needs to optimize tourist flow to a preferable 2040 tourists per day based on the spatio-physical capacity, climatic constraints, management capacity, and operative factors. The 'operative' carrying capacity concept is introduced in this study to account for the *'shadow'* factor of tourism. Carrying out empirical research on the relationship between tourism and its shadow will lead us to establish a database on the exact nature of this relationship—both qualitative and quantitative. Evaluating the ecological and environmental impacts are the other dimensions that may be carried out in the future for a holistic assessment.

The result obtained through this study intends to inform actors in the tourism sector—policymakers, tourism developers, tourism planners, managers and marketeers, local administrative bodies, tourism promotion proponents, tourism potential identifiers, and the local community—on the optimized limit of tourist traffic in Bakkhali to maintain its natural pristine qualities and ecosystem services for long-term sustainability [54]. Any increase in the number of visitors without an appropriate environmental management plan will add pressure on tourism products, such as lodging facilities, food and beverages, passenger transport, recreation- and -leisure activities, and other services, triggering overconsumption and crossing the sustainable limit.

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