

Visitor Carrying Capacity in Natural Areas: Challenges and New Perspectives from Bhitarkanika National Park, Odisha, India

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Abstract

There have been remarkable developments in nature tourism around the world. It creates an opportunity but also poses a challenge when it comes to the conservation of natural habitats in protected areas. In India, specifically on the eastern coastal belt of Odisha state lays the globally significant habitat of Bhitarkanika mangroves. Increasing tourism pressure is putting Bhitarkanika National Park, one of the few places with a diverse array of flora and fauna under threat in the world today. In this research, we explore the challenges faced by Bhitarkanika National Park when it comes to carrying capacity and sustainable tourism management. A qualitative descriptive analysis method is employed based on secondary sources such as government documents, statistics, management guidelines, and scholarly articles. The findings of this research point out visitor growth, ecological sensitivity, disturbances caused by tourists to saltwater crocodiles and other birds, poor infrastructure facilities, and climatic changes as the challenges Bhitarkanika is facing now. Some of the management recommendations include zoning, digital monitoring, community-based ecotourism, seasonal regulations, and sustainable infrastructure development.

Keywords: Carrying capacity; ecotourism; mangrove ecosystem; sustainable tourism; protected areas; visitor management; Bhitarkanika

1.0 Introduction

The rise of nature-based tourism has led to an increasing number of tourists visiting protected natural areas like national parks, wildlife reserves, and Ramsar sites each year (Buckley, 2012; Balmford et al., 2015). These sites provide a chance to see animals in their natural environments, engage in recreational activities, learn about the environment, and experience the local culture. Despite the many benefits associated with protected areas, there have been many challenges posed by the growth of tourism in terms of negative environmental impacts (Newsome et al., 2013; Eagles et al., 2002).

On the one hand, these protected areas have to attract tourists to generate revenues for the country's development as well as conservation funding. On the other hand, it should be kept in

mind that protected areas need to minimize the impact of tourism on the ecosystem to preserve its biodiversity (Spenceley, 2008; Bushell & Eagles, 2007). This particular challenge becomes even more evident when talking about developing nations, where national parks play a crucial role in the economic development of the region (Mbaiwa, 2015; Snyman, 2014). Otherwise, the results may turn out to be harmful for the environment.

There is an extensive adoption of the concept of visitor carrying capacity as a framework for addressing the above concerns. Visitor carrying capacity is defined as the level at which visitor activity may take place without resulting in any adverse ecological impacts, reduced satisfaction by visitors, or social disruption among the local community (Manning, 2011; Coccossis & Mexa, 2004). Despite having been borrowed from the field of wildlife biology and range management, there has been extensive use of the concept within tourism since the late 1980s (Shelby & Heberlein, 1986; McCool & Lime, 2001).

1.1 The Concept of Carrying Capacity in Tourism

The term carrying capacity is widely used in ecology for describing the largest number of individuals of a species which a habitat is able to support indefinitely given its resources (Malthus, 1798; Odum, 1971). The notion started being applied to outdoor recreation and wilderness management during the 1960s and 1970s by resource and recreation managers (Wagar, 1964; Lime & Stankey, 1971). Such application of the term to recreation was justified due to the limited capacity of nature to handle visitors without crossing ecological or socio-cultural limits (Manning, 2007).

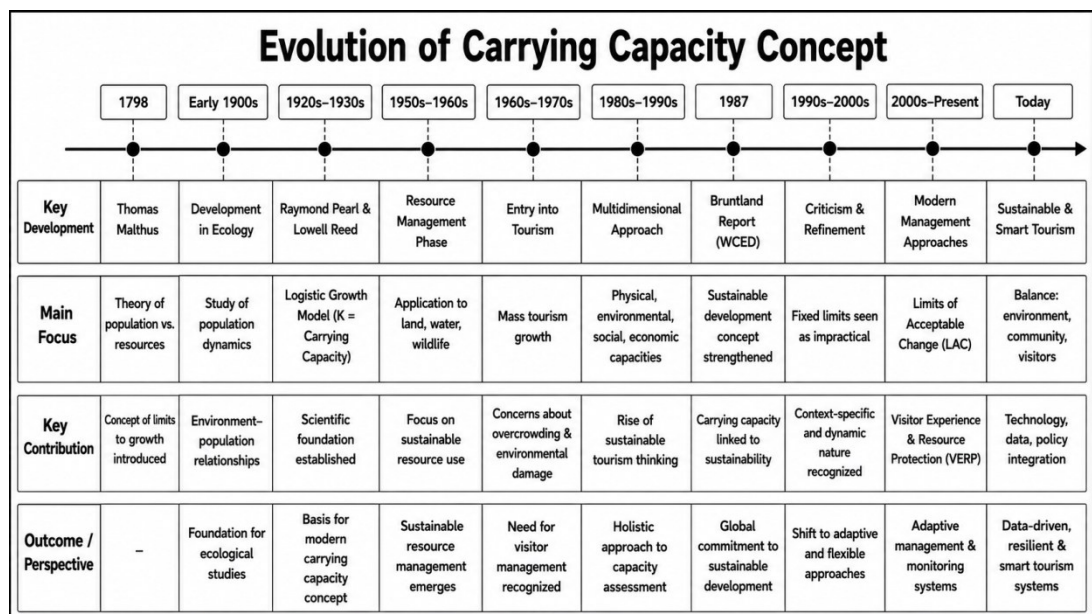
Academic literature commonly identifies the following four dimensions of tourism carrying capacity (Coccossis & Mexa, 2004; Papageorgiou & Brotherton, 1999):

1. Physical carrying capacity entails the maximum spatial capacity of the facilities, including parking, trails, accommodation, among others. This type of capacity is easier to measure, although it is the least restrictive (Hammit & Cole, 1998).
2. Ecological carrying capacity is linked to the capacity thresholds of the environment, including the vegetation, soils, water sources, wildlife, among others. Crossing the limits leads to permanent destruction of the environment through activities like trail erosion, loss of vegetation, polluting water sources, displacing wildlife, among others (Buckley, 2004; Cole, 2004).
3. Social carrying capacity involves satisfaction of visitors and host community members. Social carrying capacity is crossed when the impacts of crowding and noise affect the satisfaction levels of the tourists or cause frustration of the host communities (Manning et al., 1996; Shelby et al., 1983).
4. Managerial carrying capacity is associated with the ability of the park management to control visitor behavior and maintain the infrastructure. Low budget, inadequate workforce, among

others, may impair managerial capacity despite other carrying capacities being underutilized (Getzner et al., 2020; McCool & Lime, 2001).

These factors are not mutually exclusive but interrelate in complex ways. In one scenario, insufficient management capability (such as shortage of rangers) will result in violation of ecological carrying capacity (such as feeding of wildlife by tourists) (Eagles et al., 2002).

Figure: 1 Evolution of carrying capacity till date



(Source: Author's Compilation by using collected secondary data from different sources)

In India, wildlife tourism and ecotourism have increased greatly during the past twenty years due to higher disposable incomes, better transport connectivity, and aggressive marketing campaigns undertaken by the states' tourism authorities (Karanth et al., 2012; Sekhar, 2003). The national parks of Ranthambore, Jim Corbett, Kaziranga, and Sundarbans have become world-famous tourist sites for both domestic and foreign tourists (Sinha et al., 2012; Dutta, 2017). Yet, there have been shortcomings in managing the tourist influx, such as overcrowding, trespassing, disturbances to wildlife, and poor infrastructure (Karanth & DeFries, 2011; Chatterjee & Saikia, 2018).

One such example that has gained international recognition due to its mangrove forests and rich biodiversity, along with a large number of saltwater crocodiles (*Crocodylus porosus*), is Bhitarkanika National Park located within the deltaic zone of Odisha State, Eastern India

(Singh, 2019; Pattnaik et al., 2017). However, despite being ecologically important, Bhitarkanika National Park has not garnered as much academic attention in regards to carrying capacity of tourists visiting the park as other well-renowned national parks such as Sundarbans (Ghosh et al., 2018). This poses a problem since the national park experiences increasing pressures from visitors and faces ecological threats due to its location in a mangrove habitat (Upadhyay et al., 2002; Badola & Hussain, 2005).

1.2 Carrying Capacity in Protected Areas

Protected areas (which include national parks, wildlife sanctuaries, and Ramsar wetlands) need strict visitor control owing to their high ecological sensitivity and their obligations for biodiversity conservation (Dudley, 2008; IUCN, 2016). Over the last three decades, there have been many reported cases of adverse effects resulting from excessive tourism in protected areas (refer to Table 1).

Table 1: Documented Impacts of Excessive Tourism in Protected Areas

Impact category	Specific examples	Representative studies
Vegetation damage	Trail widening, root exposure, loss of ground cover	Marion & Leung (2001); Kiss et al. (2005)
Soil compaction	Reduced water infiltration, increased runoff	Hammitt & Cole (1998); Liddle (1997)
Wildlife disturbance	Altered foraging, breeding failure, habitat abandonment	Buckley (2012); Steven et al. (2011)
Water pollution	Nutrient enrichment, turbidity, fecal contamination	Hadwen et al. (2007); Pickering & Hill (2007)
Noise pollution	Disturbance to birds and mammals	Barber et al. (2010); Shannon et al. (2016)
Litter and waste	Visual blight, wildlife ingestion	Newsome et al. (2013); O'Reilly (1986)

Many of these parks have implemented visitor management plans that help mitigate these effects. In the U.S., the National Park Service utilizes the Visitor Experience and Resource Protection (VERP) model, which helps determine threshold levels for carrying capacity (Manning, 2011; Hof et al., 1994). Additionally, the Limits of Acceptable Change (LAC) planning system, created specifically for managing wilderness areas, sets desired conditions and uses indicators to trigger interventions (Stankey et al., 1985; McCool, 2007). On the European continent, the Tourism Carrying Capacity Assessment (TCCA) technique has been employed in coastal and mountain conservation regions (Coccossis & Mexa, 2004; Zacarias et al., 2011).

1.3 Ecotourism and Sustainable Tourism

Ecotourism has become a sustainable option for mass tourism, described as "travel to natural destinations that protects the environment, enhances the quality of life for local people, and incorporates educational components" (TIES, 2015, p. 1). Some of the fundamental tenets of



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ecotourism involve low environmental impact, cultural sensitivity, economic incentives for hosts, and environmental consciousness (Weaver, 2008; Fennell, 2020).

A well-managed ecotourism model can contribute significantly to the protected area in the following ways:

- The financial resources required for managing and preserving parks can be acquired through ecotourism (Balmford et al., 2009; Spenceley, 2008).
- Ecotourism can create alternative livelihood opportunities, thereby discouraging destructive practices such as logging and poaching (Mbaiwa, 2015; Snyman, 2014).
- Sustainable habitats can be established through ecotourism (Buckley, 2010).
- Public awareness and advocacy can be created through environmental education (Ballantyne & Packer, 2011).

Nonetheless, ecotourism itself cannot ensure sustainability. In the absence of proper planning and management mechanisms, ecotourism can have a negative impact on natural resources (Buckley, 2012; Newsome et al., 2013). Indeed, ecotourism practices that are not sustainable have been referred to as "greenwashing," a term used by some researchers to describe unsustainable tourism operations that claim to be ecotourism (Fennell, 2020; Honey, 2008).

The research questions that will be addressed in this study are:

- 1) Trends in tourism growth and tourist visits in Bhitarkanika National Park.
- 2) The environmental, managerial, and socio-economic issues affecting tourist carrying capacity in Bhitarkanika National Park.
- 3) Sustainable approaches towards managing the pressures of tourism within the national park.

1.4 Objectives of this research are:

1. Analyzing tourism development and trend of visitors at Bhitarkanika National Park on the basis of secondary information for the period from 2015 to 2024.
2. Determining environmental and management issues associated with carrying capacity of visitors by means of thematic analysis of relevant literature.
3. Considering sustainable tourism approaches for handling visitor pressure at the national park site.

1.5 Gaps in the Literature for Bhitarkanika National Park

Despite much research into carrying capacity at the global level, there are still many shortcomings regarding studies conducted specifically for some protected areas, especially those in developing nations (Eagles, 2014; Snyman, 2014). For example, while there have been studies done about Bhitarkanika National Park's ecology and biodiversity (Singh, 2019; Pattnaik et al., 2017; Upadhyay et al., 2002), there are hardly any studies conducted about visitor



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carrying capacity, visitor management, and the socio-economic tradeoffs involved in tourism development within the park.

Previous research conducted in other places with mangroves, such as the Sundarbans in India and Bangladesh (Ghosh et al., 2018; Dutta, 2017) and Everglades in the United States (Jacobson & Robles, 1992), showed that mangroves are highly susceptible to being damaged through trampling, boat wakes, and pollution. Therefore, it can be inferred that the same issues could affect Bhitarkanika. However, site-specific research needs to be conducted.

This project will bridge these gaps by conducting an analysis of carrying capacity issues in Bhitarkanika for the first time, analyzing existing literature, and recommending appropriate visitor management strategies.

2.0 Materials and Methods

2.1 Research Design

This study utilizes the qualitative and descriptive approach to research design, employing mainly secondary data sources. The appropriateness of this method stems from the exploratory nature of the research questions posed, coupled with the absence of primary data from visitors gathered by the park management (Creswell & Poth, 2018). Through the process of qualitative secondary analysis, researchers are able to derive new insights through the synthesis of available information (Johnston, 2014).

2.2 Study Area

2.2.1 Geographic Location and Context

Bhitarkanika National Park is situated in Kendrapara district of Odisha state in eastern India, at around 150 km distance from the state capital city of Bhubaneswar (Odisha Forest Department, 2023). This national park is situated within the deltaic area created by the confluence of three rivers, namely, Brahmani, Baitarani, and Dhamra, and their drainage into the Bay of Bengal (Pattnaik et al., 2017). The geographic coordinates of Bhitarkanika National Park are 20°30' to 20°50' N and 86°45' to 87°05' E (Singh, 2019).

The national park has an official land area of 145 square kilometers (56 square miles), and the broader Bhitarkanika Wildlife Sanctuary consists of 672 square kilometers (259 square miles) of land. This sanctuary was elevated to the status of a national park in the year 1998 under the provisions of Wildlife Protection Act, 1972 (Chadha & Kar, 1999).

2.2.2 Ecological Significance

Bhitarkanika is considered to be one of the most important mangrove forests both in India and throughout the world (Selvam et al., 2004; Kathiresan & Rajendran, 2005). The park comprises

about 74 species of mangroves and associate species that constitute more than 50% of the total number of Indian mangrove species (Singh, 2019; Gopal & Chauhan, 2006).

The significance of the Bhitarkanika ecosystem for nature conservation can be demonstrated by several international and national designations, such as:

- Ramsar site (Wetland of International Importance), designated in 2002 (Ramsar Site No. 1205) (Ramsar Convention Secretariat, 2023)
- Important Bird and Biodiversity Area (IBA) (Islam & Rahmani, 2004)
- World Network of Biosphere Reserves (UNESCO, 2014)
- Critical Wildlife Habitat according to Indian regulations (Ministry of Environment, Forest and Climate Change, 2015)

Bhitarkanika is especially famous for the high number of saltwater crocodiles (*Crocodylus porosus*) living in its waters – the number of individuals constitutes one of the largest populations of this species in India (Chadha & Kar, 1999; Whitaker & Whitaker, 2019). As reported by an annual census of the Odisha Forest Department, the number of saltwater crocodiles in Bhitarkanika totaled about 1,760 in 2023, with some specimens exceeding six meters

- **Mammals:** Spotted deer (*Axis axis*), wild boar (*Sus scrofa*), smooth-coated otter (*Lutrogale perspicillata*), fishing cat (*Prionailurus viverrinus*), and leopards (*Panthera pardus*) (Pattnaik et al., 2017; Singh, 2019).
- **Reptiles:** Indian python (*Python molurus*), water monitor lizard (*Varanus salvator*), king cobra (*Ophiophagus hannah*), and various species of marine turtles (Chadha & Kar, 1999).
- **Birds:** More than 320 species of birds, both resident and migratory, including aquatic birds like the Asian openbill stork (*Anastomus oscitans*), black-headed ibis (*Threskiornis melanocephalus*).

2.2.3 Tourism Activities and Infrastructure

Tourism in Bhitarkanika revolves around water activities such as cruising along the mangrove channels via boats (Odisha Tourism, 2023). Some of the tourism activities that tourists engage in here include:

- Boat cruises that take about 1-3 hours along the water channels lined with mangroves, where tourists can view crocodiles, birds, and other wild animals
- Bird-watching from watch towers and hides, especially during the migratory period in winter (Nov-Feb)
- Photography of wildlife species with special boat trips for photographers
- Nature interpretation tours conducted by Forest Department personnel and guides

- A visit to the crocodile breeding and interpretation center at Dangamal (Odisha Forest Department, 2023).

The tourism infrastructure in the national park is purposely kept minimal to limit its ecological impact (Badola & Hussain, 2005). There is accommodation at rest houses owned by the Forest Department in Dangamal, Gupti, and other places, and some privately-owned eco-lodges at the park boundary (Odisha Tourism, 2023). Visitors can drive to the park from Bhubaneswar (~4 hours) or take trains to nearby stations like Bhadrak and Cuttack (Singh, 2019).

2.3 Data Source

Secondary data were sourced from:

1. **Governmental records:** Yearly tourism figures provided by the Odisha Tourism Department (2015-2024), management strategies formulated by the Odisha Forest Department (2010-2023), and policies related to ecotourism developed by the Ministry of Tourism, Government of India.
2. **Scholarly publications:** Scientific journals indexed on Scopus, Web of Science, and Google Scholar, using keywords such as "Bhitarkanika," "mangrove tourism," "carrying capacity," and "visitor management."
3. **External databases:** Information sheets on Ramsar wetlands (Ramsar Sites Information Service, 2023), documentation from the UNESCO World Heritage Centre, and data on protected areas compiled by the IUCN.
4. **Press coverage and gray literature:** Archives of local newspapers (e.g., The Hindu, Times of India – Odisha Edition), reports published by NGOs (e.g., WWF-India, Wildlife Trust of India), and web pages of tourism agencies.

The total number of papers analyzed amounted to 85, out of which 62 met the inclusion criteria of (a) directly discussing Bhitarkanika or comparable mangroves, (b) being written between 2000 and 2024, and (c) being available in English or Odia (with translation).

2.4 Data Analysis

Thematic analysis was conducted based on the methodology of Braun and Clarke (2006) consisting of six steps, namely: (1) familiarization with data, (2) creating initial codes, (3) searching for themes, (4) review of themes, (5) defining and naming themes, and (6) writing up the report. The program NVivo 14 was employed in order to code and generate themes.

Five themes emerged during the process of analysis, which include: (1) trends in tourism growth, (2) ecosystem sensitivity, (3) management constraints, (4) disturbance of wildlife, and (5) impacts of climate change.

2.5 Limitations

The current study suffers from many limitations, some of which are common in secondary data analysis studies. The first limitation is that official statistics for visitors may not be complete or consistent since different methods are used in counting, and there might be underestimations in

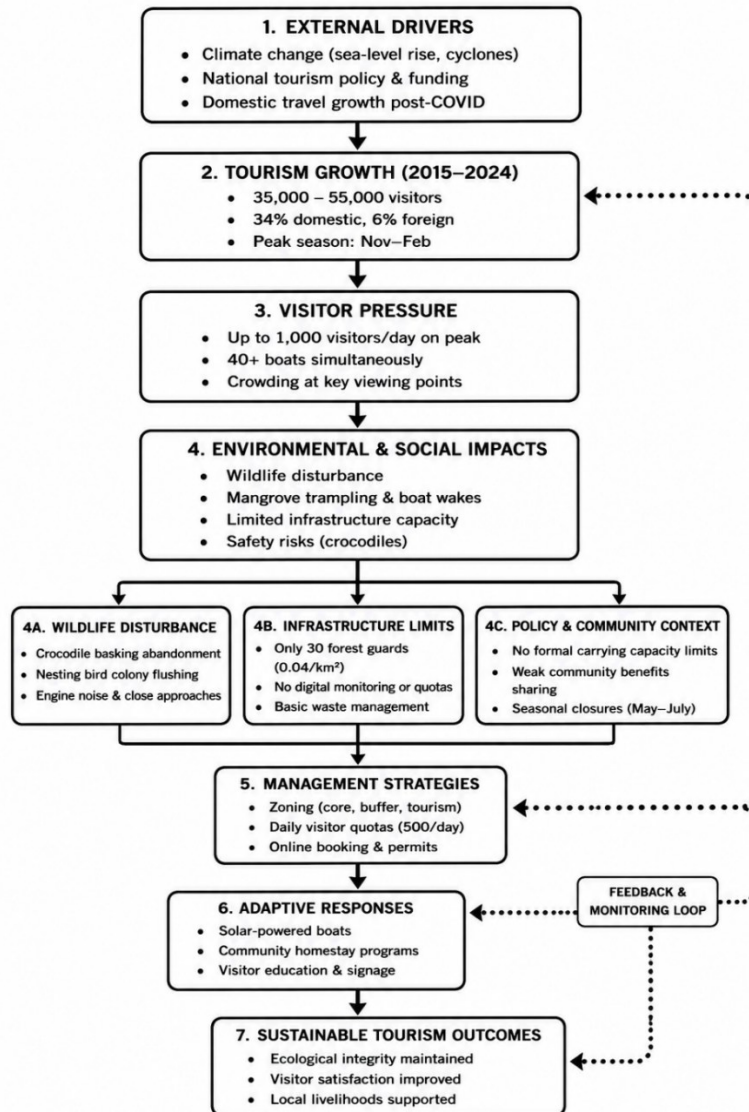
the statistics. Another limitation is the lack of primary data on tourists' behavior and impacts on the environment.

2.6 Conceptual Framework

The proposed conceptual model (see Figure 1), based on a review of the literature and preliminary analysis, connects tourism development, environmental effects, managerial action, and sustainable tourism benefits. The proposed conceptual model is influenced by systems theory and adaptive management approach (Holling, 1978; Pahl-Wostl, 2009).

Figure 1: Conceptual Framework for Visitor Carrying Capacity Management

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The key variables in the framework are:

- Volume of visitors: The main source of pressure, dependent on seasonal variations, availability, and promotion.
- Limits of infrastructure: Physical constraints posed by trails, boats, parking facilities, and lodging.
- Disturbance of wildlife: Changes in behavior and population caused by human activity.



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- Level of community involvement: The degree to which local communities are involved in tourism planning and benefits.
- Tourism management actions: Zoning, limiting quotas, permitting, enforcement, and educational initiatives.
- Sustainability impacts of tourism: Ecological stability, tourist satisfaction, and well-being of host communities.

This model stresses the importance of adaptive management, the process that includes planning, execution, monitoring, and evaluation (Manning, 2011).

3.0 Discussions

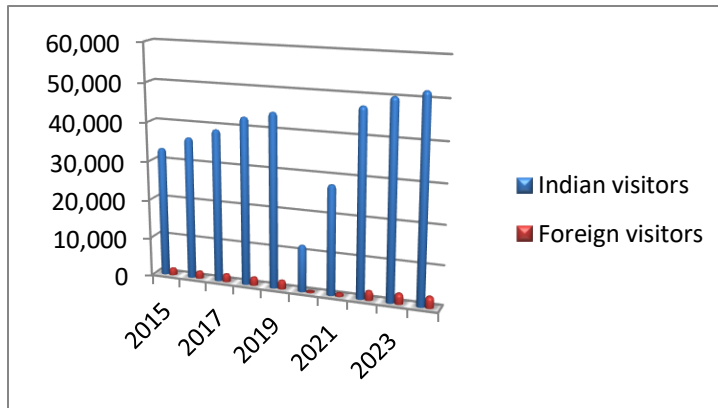
The number of tourists visiting Bhitarkanika has been increasing consistently since the past ten years due to better road connections and aggressive marketing strategies employed by Odisha Tourism. The following table (Table 2) depicts the projected growth in the number of tourists from the year 2015 to 2024 according to records of the Odisha Forest Department.

Table 2: Estimated Annual Visitor Arrivals in Bhitarkanika National Park (2015–2024)

Year	Indian visitors	Foreign visitors	Total visitors	Annual change (%)
2015	33,200	1,800	35,000	—
2016	36,500	1,900	38,400	+9.7
2017	39,100	2,100	41,200	+7.3
2018	42,800	2,200	45,000	+9.2
2019	44,500	2,300	46,800	+4.0
2020	12,000	300	12,300	-73.7 (COVID-19)
2021	28,000	800	28,800	+134.1
2022	47,500	2,500	50,000	+73.6
2023	50,200	2,800	53,000	+6.0
2024*	52,000	3,000	55,000	+3.8

Source : Odisha Forest department

Graph: 1. Indian and foreign tourist visited the park



Source: Odisha Forest Department annual reports (2015–2023); 2024 figures are projected based on first six months.

* **Note:** Foreign visitors formed around 5-6% of all arrivals prior to the COVID outbreak, recovering back to the same figure by 2024.

Several key points can be identified here. First, Bhitarkanika saw tourism nearly doubling in terms of the number of annual visitors (from 35,000 in 2015 to almost 55,000 in 2024). The growth rate ($\approx 5.8\%$ per annum, excluding the pandemic period) matches the nationwide trends in less-visited PAs (Karanth & DeFries, 2011).

Second, India-based tourism dominates, with domestic tourists forming 94-95% of all arrivals. The foreign visitor segment remains a minority but stable at 5-6%, representing mostly Europeans (Germany, France, UK) and Southeast Asians (Odisha Tourism, 2023).

Third, the COVID-19 pandemic hit hard in 2020 (tourism declined by -73.7%) but was soon recovered in 2021-2022 after which visitor volumes surpassed the pre-pandemic figures in 2023. Finally, seasonality is evident. Tourist traffic is highest between November and February (post-monsoon and winter), which provides pleasant weather conditions along with migratory birds. The monsoon season (July-September) records very low tourist traffic, considering there is extensive rainfall, floods, and closure of the park (Odisha Forest Department, 2023). The summer season (March-May) is hot and humid; however, tourists visit the park to witness crocodiles.

The number of tourists visiting Bhitarkanika is lower compared to other Indian conservation parks. For instance, Sundarbans National Park (West Bengal) receives approximately 120,000-150,000 visitors per year (Dutta, 2017), whereas Jim Corbett National Park (Uttarakhand)

attracts more than 500,000 tourists per annum (Sinha et al., 2012). Nonetheless, Bhitarkanika's reduced land size (145 sq. km vs. 1,330 sq. km of Sundarbans) and vulnerable ecosystems can result in overcrowding during peak seasons.

The current research contributes to the theoretical discourse on visitor carrying capacity and sustainable tourism in protected areas. Firstly, the research shows that visitor carrying capacity is not a single, objective quantity but rather a subjective and dynamic concept (Manning, 2011; McCool & Lime, 2001). The acceptable level of visitor use in Bhitarkanika is contingent upon the management's choice of trade-offs between various alternatives, for instance, between optimizing tourism revenues and minimizing disturbances to animals. This aligns with the paradigmatic shift from carrying capacity as a scientific truth to a value-based tool for planning and management (Coccossis & Mexa, 2004).

Secondly, the research underscores the interdependency of the four types of carrying capacity (physical, ecological, social, managerial). Physical limitations of infrastructure in Bhitarkanika limit managerial capacity (for instance, there are not enough guards to enforce regulations), which then limits ecological carrying capacity (regulations are not enforced, boats speed up near crocodiles). Not many studies explore the relationships between the carrying capacity dimensions (Getzner et al., 2020).

Thirdly, the results shed light on an area of study that has received limited attention despite the popularity of tourism among mangroves, compared to terrestrial tourism and coral reef tourism (Ghosh et al., 2018; Duke et al., 2007). There are similarities between Bhitarkanika and other mangrove parks – susceptibility to tides, crocodile safety concerns – but the park also has distinct characteristics (lower visitor population, higher number of domestic tourists).

These recommendations have practical and applicable significance to both park managers and policy makers. The practical significance of the paper includes the following:

1. Immediate measures (0–6 months): Introduction of online booking system to restrict visitors at 500 per day; posting of code of conduct signboards; and training of boat drivers in wildlife-safe driving.
2. Short-term measures (6–18 months): Creation of zoning map through community consultation; introduction of homestay certification scheme; commencement of visitor satisfaction survey.
3. Medium-term measures (18–36 months): Purchase of solar-powered boats; building of boardwalks and construction of interpretation center; introduction of a revenue sharing framework.
4. Long-term measures (3–5 years): Carrying capacity analysis using ecological indicators; adoption of adaptive management process; and obtaining a Ramsar advisory mission.



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Sources of funds for all the above-mentioned measures include the National Ecotourism Board (as suggested under India's new National Green Tribunal guidelines) and state government budget allocations, as well as global agencies like GEF.

3.1 Comparison with Other Protected Areas

The issues in Bhitarkanika and possible resolutions can be seen as reflective of experiences at other protected areas. For instance:

- Sundarbans (India/Bangladesh): Faced similar problems regarding the conservation of crocodiles, vulnerability of mangroves, and challenges of engaging local communities (Dutta, 2017; Ghosh et al., 2018). The Sundarbans receives relatively more visitors annually (120,000/yr) and have developed a thriving tourism industry.
- Everglades National Park (USA): Successfully introduced zoning, visitor capitations, and limitations on motorboat activities to conserve fragile estuaries (Jacobson & Robles, 1992; Leung et al., 2018).
- Similipal National Park (Orissa, India): Similar to Bhitarkanika in terms of infrastructure issues but has practiced community-based ecotourism with some success (Dash & Jena, 2019). Bhitarkanika has the advantage of being less visited than these comparators, allowing proactive rather than reactive management

4. Findings

4.1 Problems in Managing Visitor Carrying Capacity

The theme-based analysis revealed seven major problems that affect visitor carrying capacity in Bhitarkanika National Park. They are described below, along with the relevant literature.

4.1.1 Wildlife Disturbance Due to Tourist Activities

There could be several ways in which tourist activities, especially boat safaris, can disturb wildlife in the park. For instance, the saltwater crocodile, which is the flagship species in Bhitarkanika, is susceptible to disturbance due to noise, sudden movement, and proximity to its basking sites (Whitaker & Whitaker, 2019). Research carried out in similar crocodile habitats in Australia and Southeast Asia suggests that boat disturbance can lead to crocodiles abandoning basking sites and changing their feeding behavior (Webb & Manolis, 2014; Brien et al., 2013).

Bird colonies in Bhitarkanika, which include nesting herons, egrets, storks, and kingfishers, may be disturbed while in the breeding period between November and March. Disturbance of such birds due to approaching through boats or walking might result in flushing of the birds from their nest sites. As a result, their eggs and offspring would face threats to survival and heat (Steven et al., 2011). In worse cases, disturbance may lead to desertion of the colony (Buckley, 2012).

Seasonal closing of some areas when the crocodiles are reproducing between May and July and when birds are nesting has been put in place by the Odisha Forest Department. Unfortunately, some tourists violate such a restriction (wildlife trust of India, 2021)

4.1.2 Fragile Mangrove Ecosystem

Mangrove systems are highly vulnerable due to their unique adaptation to tidal fluctuations, low biodiversity, and slow rates of regeneration (Kathiresan & Rajendran, 2005; Duke et al., 2007). Mangroves contribute significantly to environmental sustainability through coastal protection, carbon absorption, fish breeding, and filtering of polluted waters (Barbier et al., 2011; Alongi, 2015). Tourism-induced disturbances affecting mangroves in Bhitarkanika include:

- **Trampling and vegetation disturbance:** Visitors participating in organized tours could step on the shoots of mangroves, hindering natural regeneration (Marion & Leung, 2001).
- **Crevice formation:** The high speed of water vessels creates a crevice effect along creek edges, causing erosion, cutting off mangrove roots, and raising turbidity levels (Bauer et al., 2020).
- **Anchor impacts:** The lack of regulations regarding anchor placement leads to root damage and sediment dislodgment (Duke et al., 2007).
- **Pollutants and garbage:** Plastic packaging, food waste, and oil leaks from boats contribute to water degradation and affect fauna (Newsome et al., 2013).
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A study by Ghosh et al. (2018) on the impact of boat density on mangroves in the Sundarbans indicated that higher traffic density corresponded to an increased rate of mangrove tree death and reduced sapling establishment. No equivalent studies have been conducted in Bhitarkanika.

4.1.3 Impacts of Climate Change and Sea-Level Rise

Mangrove systems worldwide face the threat of extinction due to climate change (Alongi, 2015; Duke et al., 2007). Specific climate impacts on mangroves include:

- **Rising sea level:** Adaptation through migration is possible for mangroves when space permits, but urban expansion and construction of embankments restrict such adaptation (Gilman et al., 2008).
- **Cyclones and storm surges:** The area is cyclone-prone, as was evidenced by the severe destruction of mangroves following the 1999 Odisha super-cyclone (Upadhyay et al., 2002). Projections suggest increasing frequency and intensity of storms in the Bay of Bengal (Knutson et al., 2010).
- **Changes in salinity:** Freshwater inflow from upstream dams and the sea-level rise might lead to high levels of salinity in soils beyond the limits of tolerance of mangroves (Kathiresan & Rajendran, 2005).



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- Warmer temperatures: Higher temperatures could influence the species' composition and reduce reproduction rates (Duke et al., 2007).

The effects of climate change interact with those of tourism in complicated ways. Stressed mangroves become more susceptible to damage from foot traffic or wakes. On the other hand, the effects of climate change might change the availability of wildlife and therefore visitor interest (Scott et al., 2012).

4.1.4 Limited Infrastructure and Management Capacity

The Bhitarkanika site suffers from several infrastructure and capacity challenges, making it difficult to manage tourists effectively (Odisha Forest Department, 2023). They include:

- Few patrol rangers: The park lacks sufficient forest guards to cover its 672 sq km of sanctuary area, hence inadequate enforcement of visitor policies (Wildlife Trust of India, 2021).
- No automated visitor management system: There is no automated visitor tracking technology, such as counters, CCTV cameras, and online permits. Visitors' data depend on ticket sales, which may not reflect the exact number.
- Low-quality waste management: Lack of adequate waste handling facilities in the park results in waste accumulation (Badola & Hussain, 2005).
- Low quality interpretation center: Poorly designed signage, brochures, and visitor centers reduce visitors' learning through ecotourism (Singh, 2019).

Table 3 compares Bhitarkanika's infrastructure indicators to recommended standards for protected areas.

Table 3: Infrastructure and Management Capacity Indicators

Indicator	Bhitarkanika (actual)	Recommended standard (for similar parks)
Forest guards per km ²	0.04	0.2–0.5 (Eagles et al., 2002)
Visitor monitoring	Manual ticket counts	Digital system with real-time tracking
Waste treatment	None (dump sites only)	Composting and recycling facilities
Interpretation centers	1 small center	3–5 centers with trained naturalists
Boat inspections	Minimal	Regular safety and noise checks

Sources: Odisha Forest Department (2023); Eagles et al. (2002); WWF-India (2019).

4.1.5 Safety Concerns for Visitors

The issue of human-wildlife conflict, especially regarding saltwater crocodiles, is a significant hazard for tourists visiting Bhitarkanika (Whitaker & Whitaker, 2019). Saltwater crocodiles are formidable predators that have caused human deaths in other parts of India, Australia, and Southeast Asia (Webb & Manolis, 2014). The primary hazards are:

- Nearness to the water: Tourists taking boat tours or standing by the riverbank are at risk when crocodiles move towards them or overturn the boats.
- Habituation due to feeding of wild animals: Unauthorized feeding of animals either intentionally or unintentionally may lead to crocodiles being accustomed to human contact, resulting in attacks.
- Signs of warning: Insufficient signs indicating the presence of crocodiles and proper precautions.

According to the Odisha Forest Department, there have been occasional cases where crocodiles have attacked local fishers, but no such attacks have taken place involving tourists yet (Odisha Forest Department, 2023). Nonetheless, the fear of safety could prevent tourists from visiting Bhitarkanika.

4.1.6 Limited Community Engagement and Benefit Sharing

Sustainable tourism necessitates the involvement and cooperation of local communities (Mbaiwa, 2015; Snyman, 2014). But in Bhitarkanika, there is a lack of community involvement. Almost all the tourism proceeds accrue to the Forest Department and certain local boat operators (Badola & Hussain, 2005; Wildlife Trust of India, 2021). Impacts of poor community involvement include:

- Non-involvement in conservation and sustainable tourism: Local communities might not be interested in being part of conservation efforts.
- Some poaching and fishing activities: Local communities resort to these activities since they have no other means of income generation (Singh, 2019).
- Misunderstanding between locals and park authorities: Impositions placed by the park management without compensation may cause resentment (Sekhar, 2003).

Community-based ecotourism projects like homestays and bird tours in the peripheral areas also occur (Odisha Tourism, 2023), but their scope is relatively small.

4.1.7 Lack of Policy Framework for Carrying Capacity

There is a lack of clear policy and legal framework in India for calculating carrying capacity (Ministry of Environment, Forest and Climate Change, 2015). While the Wildlife Protection Act (1972) and the Forest Conservation Act (1980) address biodiversity conservation and habitat protection, they do not have any guidelines for sustainable tourism (Karanth et al., 2012). The National Tourism Policy (2002) talks about ecotourism but does not enforce any policies (Sinha et al., 2012).

As a result, carrying capacity studies are rarely done in protected areas in India, and when they are carried out, they are outdated and not followed (Chatterjee & Saikia, 2018). There are no carrying capacities defined for visitors to Bhitarkanika.

4.2 Visitor Management Strategies

Considering the issues highlighted above and using the experience of other protected areas, we recommend implementing the following eight management strategies for the management of Bhitarkanika National Park.

4.2.1 Zoning Strategy

Zoning has always been recognized as an important method for managing visitors in protected areas (Leung et al., 2018). The proposed zoning strategy for Bhitarkanika National Park should consist of four zones:

- Core Conservation Zone (Prohibited Area): Important breeding habitats of crocodiles, bird colonies, and intact mangroves. Entry allowed to authorized researchers only.
- Limited Access Zone (Permits Required): Natural trail zones where nature observation is possible, but with daily limit on the number of visitors.
- Tourism Zone (Restricted Access): Zones where boat safaris operate along pre-defined routes with certain carrying capacities.
- Periphery Zone (Low Regulation): Zones outside the national park where the local community may run guest houses, eateries, and craft villages.
-

The zoning strategy has already been adopted at mangrove parks like the Great Sandy National Park in Australia and Sundarbans in Bangladesh (Leung et al., 2018; Dutta, 2017).

4.2.2 Visitor Quotas

The imposition of visitor quotas is very important so as to not overburden the site beyond ecological and social carrying capacity limits (Manning, 2011). For Bhitarkanika, we would recommend the following visitor quotas:

- A maximum of 500 visitors per day for safari trips using boats (as compared to 800–1000 visitors on peak days presently)
- Allowing no more than 20 boats at one time on the main safari route (as compared to a maximum of 40 boats currently allowed)
- A maximum of 15 individuals per group for nature walks

Visitor quotas in Kaziranga National Park in Assam and Ranthambore in Rajasthan have proven effective (Sinha et al., 2012).

4.2.3 Visitor Tracking and Online Permission System

A visitor monitoring system will help in collecting data and enforcing rules. The following are suggested:

- The online permit system for boat safaris and permission system (as done in Corbett and Kaziranga)
- Visitor counters at critical checkpoints using infrared or CCTV
- Occupancy display screen at ticket counters and websites

- An app for visitors' feedback and notifications

All such technological advancements have been installed in various protected areas of India through the funding of the World Bank and State Government agencies (Karanth & DeFries, 2011).

4.2.4 Community-Based Ecotourism (CBET)

Improving community involvement is key to ensuring sustainability (Mbaiwa, 2015). The following CBET approaches are suggested:

- Eco-certification homestay scheme: Educate and certify families to run homestays that follow sustainable principles, with booking options through the park's official website.
- Nature guide training: Organize training courses for local people to become certified nature guides (ecology, first aid, languages).
- Handicrafts and food cooperatives: Promote the formation of women self-help groups to manufacture and market crafts and foods compatible with the mangrove ecosystem.
- Revenue sharing arrangement: Dedicate 20-30% of entrance fees to a community development fund for selected projects chosen by the villagers.

Several successful CBET strategies have been implemented at Periyar Tiger Reserve in Kerala and Sundarbans in West Bengal (Sekhar, 2003; Dutta, 2017).

4.2.5 Sustainable Infrastructure Development

Sustainable development of infrastructure should emphasize reducing ecological footprints and improving visitor experience (Eagles et al., 2002). The following initiatives should be prioritized:

- Use solar-powered boats to limit the effects of fuel and noise pollution (phase-wise installation)
- Use floating docks that can rise and fall with tides and prevent shoreline erosion
- Install eco-toilets at visitor hotspots, which may be used for composting or removal
- Expand the interpretation center through adding interactive displays, dioramas, and audiovisual programs
- Build walkways and hides in sensitive locations to ensure that visitor footprints remain concentrated

These initiatives can be funded by NTCA, Asian Development Bank, or CSR activities of Indian companies (Wildlife Trust of India, 2021).

4.2.6 Environment awareness and visitor education

Providing education regarding appropriate visitor behavior can decrease both deliberate and inadvertent breaches (Ballantyne & Packer, 2011). Some of the measures that can be taken are:



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- Pre-visit education: Sending an email to all online permit recipients with details regarding the code of conduct
- Site awareness: Placing bilingual signs (English-Odia) at entrance points, boat embarking locations, and natural trail areas
- Quarterly training for boat operators on maintaining low speed, not playing loud music, and keeping a safe distance from wildlife
- Campaign for visitor pledge ("I am responsible for Bhitarkanika") with stickers or certificates to those who participate in the program

Research in other national parks indicates that such an approach will result in a reduction in littering by 30-50% and wildlife harassment by 20-40%.

4.2.7 Seasonal Management and Closures

The current seasons of closure should remain intact or even be extended (Odisha Forest Department, 2023):

- May-July: Closure of crocodile nests; reduced safari activities in other areas
- February-April (bird breeding): Restricted access to bird colonies on particular islands
- Monsoon (July-September): Closure of the park during this time

During the peak tourist season (November-January), an extended visiting period of daylight hours can help spread out visitors' arrival times.

4.2.8 Research and Monitoring Program

Data gathering and analysis must occur on an ongoing basis in adaptive management (Holling, 1978). An effective research and monitoring strategy includes:

- Conduct annual carrying capacity review based on ecological indicators (mangrove growth rate, crocodile basking frequency)
- Conduct visitor satisfaction surveys (n=500 per year) to monitor social carrying capacity
- Conduct noise monitoring of boating routes with decibel meters
- Conduct water quality monitoring (fuel hydrocarbons, turbidity, coliform bacteria)

Collaboration with local universities (such as Utkal University and Berhampur University) and research organizations (such as the Wildlife Institute of India) may be beneficial for technical support at a minimal cost (Singh, 2019).

5.0 Conclusion

Bhitarkanika National Park is an extremely rare example of mangrove ecosystems with exceptional importance due to their unique biodiversity. Not only do the mangroves harbour the

largest number of saltwater crocodiles in the country, but they also offer great potential for developing ecotourism in the area.

For the purpose of this paper, the issue of carrying capacity limitations in Bhitarkanika was explored with the use of secondary research and thematic analysis. Major findings of this paper include the following:

1. The number of tourists visiting Bhitarkanika has grown from 35,000 to 55,000 between 2015 and 2024; most of them are domestic tourists (94-95%).
2. The major issues include disturbance of wildlife (especially crocodiles and nesting birds), fragile mangroves, insufficient infrastructure (guards, waste management), safety concerns, insufficient involvement of local communities, and climate changes.
3. There are no carrying capacity restrictions at the moment, and management is mainly reactive, not proactive.

The proposed solutions to this problem lie in adopting a system of adaptive management which involves zoning, visitor quotas per day (500), online monitoring, development of community based ecotourism, development of sustainable infrastructures like solar boats and eco-toilets, education of the visitors, seasonality of tourism, and implementation of a research project.

It is possible to make the Bhitarkanika National Park a model of sustainable mangrove ecotourism, through the implementation of all the above strategies.

In summary, carrying capacity of a visitor number in any natural area is not a definite figure that must be calculated once. It is an on-going effort to negotiate and adapt as well. In order to achieve the success of Bhitarkanika, a combination of political commitment, proper funding, engagement of local communities and scientific studies are vital.

6.0 Implications

6.1 Implications for Theory:

The current research adds value to the sustainable tourism literature through an empirical approach to addressing visitor pressure in the context of mangrove conservation. It supports the notion that carrying capacity is a complex, multi-dimensional construct involving consideration of ecological, social, and managerial aspects.

6.2 Implications for Practice:

Tourism managers and policymakers may implement the suggested approaches to controlling tourist movements to prevent further ecosystem degradation in protected areas. This information may prove useful for coastal protected sites in similar situations related to tourism development.

6.3 Implications for Policy Making:

Forestry and tourism policy-makers must incorporate adaptive management measures such as imposing seasonal limits on tourists' visits, implementing digital control mechanisms, and organizing environmental awareness programs for visitors. Relevant carrying capacity-related legislation must be developed and enforced.

6.4 Limitations and Avenues for Future Research

There are several limitations to this study that highlight avenues for future research. First, the lack of visitor data makes it impossible to determine the extent to which visitors adhere to regulations. Future research could include surveys or direct observation of visitor behaviours.

Second, the effects of the industry on the local ecology need to be evaluated. Quantitative analyses of the health of the mangroves and behaviour of the crocodiles in areas with varying degrees of tourism would provide empirical support for determining carrying capacities.

Third, economic assessment of the costs and benefits of the industry would aid in decision-making processes related to management practices. For instance, what is the financial cost of decreasing boat safaris by 20% compared to the benefits of less wildlife disturbance?

Fourth, adaptation planning to climate change should be incorporated into carrying capacity models. Future projections of sea level rises and frequency of cyclones will have impacts on ecological sensitivity and tourism demand.

Lastly, comparative research across all mangrove parks in India (Sundarbans, Bhitarkanika, Coringa, and Pichavaram) will enable general trends to be identified, leading to context-based solutions.

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