J. of Adv. Res. in Sustainable Tourism Management and Destination Development
Volume 1, Issue 2 - 2025, Pg. No. 23-29
Peer Reviewed Journal

Review Article

Tourism Carrying Capacity Revisited: Innovative Tools for Visitor Management in High-Pressure Destinations

Priya Nair[1], Meera Singh[2]

[1,2]Students, Department of Tourism Studies, Indira Gandhi National Open University (IGNOU), New Delhi, India

I N F O

Corresponding Author :
Priya Nair, Department of Tourism Studies, Indira Gandhi National Open University (IGNOU), New Delhi, India
E-mail Id:
nairpriya58@gmail.com
Orcid Id:
https://orcid.org/0009-0003-5115-7649
How to cite this article:
Nair P, Singh M, Tourism Carrying Capacity Revisited: Innovative Tools for Visitor Management in High-Pressure Destinations. *J Adv Res Sustain Tour Manag Destin Dev 2025; 2(1): 23-29.*

Date of Submission: 2025-11-25
Date of Acceptance: 2025-12-20

A B S T R A C T

Tourism carrying capacity (TCC) has long been a central concept in sustainable destination management, offering a systematic approach to determining the limits of acceptable visitor use. However, rapid tourism growth, climate change, overtourism, and digital disruption have placed unprecedented pressure on destinations, highlighting the need to revisit traditional carrying capacity frameworks. This review synthesises developments in TCC theory, evaluates contemporary challenges, and examines emerging tools—including geospatial technologies, real-time monitoring, AI-driven analytics, and participatory management models—that are reshaping visitor management in high-pressure destinations. The paper argues for a shift from static carrying capacity calculations toward dynamic, adaptive, and data-informed management systems.

Keywords: Tourism Carrying Capacity; Sustainable Destination Management; Visitor Management; Overtourism; Real-Time Monitoring; Geospatial Technologies

Introduction

The concept of tourism carrying capacity (TCC) emerged in the 1970s as destinations increasingly faced concerns over overcrowding, environmental degradation, and socio-cultural tensions associated with rapid tourism growth.[1] Initially, TCC provided a systematic framework for identifying the maximum number of visitors that a destination or site could accommodate without causing irreversible damage to natural resources, compromising visitor experiences, or negatively affecting the host community's quality of life.[2] Early models largely focused on static calculations, emphasising ecological thresholds, infrastructure limits, and social tolerance levels as measurable determinants of carrying capacity.

Over time, however, the tourism landscape has undergone significant transformations. Accelerated tourism demand, fuelled by globalisation and the rise of low-cost transportation, has intensified pressure on popular destinations, leading to phenomena such as overtourism and seasonally concentrated visitor flows.[3] Simultaneously, climate change has introduced new vulnerabilities, including extreme weather events, coastal erosion, and shifts in biodiversity, which challenge the ecological assumptions underpinning traditional TCC models.[4] Social and cultural dynamics have also evolved, as host communities increasingly demand participatory decision-making and equitable distribution of tourism benefits, highlighting the need for more socially responsive approaches to visitor management.[5]

Technological advances further complicate and enhance TCC implementation. The proliferation of geospatial technologies, big data analytics, real-time monitoring systems, and artificial intelligence enables destinations to collect, process,

and interpret visitor data on an unprecedented scale.[6] These tools allow for dynamic assessments of visitor flows, instantaneous identification of congestion points, and adaptive management strategies that were previously unattainable through traditional static models. Moreover, participatory management approaches—engaging local communities, businesses, and tourists themselves—have emerged as essential mechanisms to ensure that carrying capacity assessments reflect not only environmental and infrastructural thresholds but also social and cultural acceptability.[7]

In light of these developments, revisiting the concept of tourism carrying capacity is both timely and necessary. Static, one-size-fits-all calculations are no longer sufficient to manage the complex and rapidly changing dynamics of contemporary tourism destinations. Instead, modern TCC frameworks must embrace adaptive, data-informed approaches that integrate technological innovations, stakeholder participation, and multidimensional indicators of sustainability. This review seeks to synthesise theoretical advancements, examine contemporary challenges, and explore emerging tools and methodologies that are reshaping visitor management practices in high-pressure destinations. By doing so, it aims to provide insights for policymakers, planners, and tourism managers seeking to balance destination resilience, visitor satisfaction, and community well-being in the era of overtourism and climate uncertainty.

The Evolution of Tourism Carrying Capacity

Tourism carrying capacity (TCC) has undergone significant conceptual development since its inception, reflecting the increasing complexity of tourism systems and the multidimensional pressures faced by destinations. The evolution of TCC illustrates a shift from narrow ecological concerns to more holistic frameworks that integrate environmental, social, and economic considerations.

Early Definitions and Conceptual Foundations

The concept of carrying capacity originated in ecological sciences, where it described the maximum population of a species that an ecosystem could sustain without degradation. Applied to tourism, the idea initially focused on environmental limits and thresholds of resource degradation, emphasising the avoidance of irreversible ecological impacts.[4] Early assessments were largely quantitative, relying on measures such as trail erosion, vegetation loss, or facility utilisation rates to determine acceptable visitor numbers.

As the tourism industry grew, researchers recognised that environmental considerations alone were insufficient. Tourism carrying capacity expanded to include physical, ecological, social, and perceptual dimensions.[4] Physical capacity addressed infrastructural constraints, such as accommodation, parking, and transport facilities. Ecological capacity considered the resilience of natural systems to visitor pressure. Social and perceptual capacity examined visitor experience quality and local community tolerance for tourism activities. This multidimensional approach highlighted that sustainable destination management requires balancing environmental integrity, visitor satisfaction, and host community well-being.

Seminal contributions by Mathieson and Wall.[5] emphasised the need to consider tourism as a socio-ecological system, where environmental, economic, and cultural factors interact dynamically. The United Nations World Tourism Organization (UNWTO) further reinforced this perspective by advocating integrated approaches to managing destination use, including monitoring visitor flows, evaluating social carrying capacity, and ensuring community involvement in planning.[6] These foundational works set the stage for contemporary TCC frameworks, which increasingly integrate multidisciplinary insights from geography, sociology, environmental science, and economics.

Limitations of Traditional Approaches

Despite their conceptual contributions, traditional TCC approaches have been widely criticised for their rigidity and limited applicability in dynamic tourism contexts. Key limitations include:

- **Static Thresholds**: Traditional TCC models often assume fixed limits for visitor numbers. However, real-world conditions fluctuate due to seasonality, climate variability, and unforeseen disruptions such as natural disasters or pandemics. Static thresholds are therefore unable to capture the temporal dynamics of tourism pressure.[7]
- **Data Limitations**: Early TCC assessments relied on limited empirical data and basic observational methods. Accurate estimation of visitor numbers, distribution patterns, and environmental impacts was challenging, particularly in regions with informal tourism infrastructure or multiple user groups.[7]
- **Complex Socio-Cultural Factors**: Social carrying capacity, including community tolerance, cultural preservation, and visitor experience quality, is inherently difficult to quantify. Traditional models often oversimplified these factors, leading to recommendations that may not reflect the nuanced realities of host communities.[7]
- **Political and Economic Pressures**: Destination managers frequently face pressures to maximise short-term economic returns. These pressures can result in exceeding recommended visitor thresholds, particularly in high-demand destinations reliant on tourism for local livelihoods, undermining sustainability objectives.[7]

Collectively, these limitations underscore the need for more dynamic, adaptive, and data-informed TCC frameworks. Modern visitor management strategies increasingly emphasise continuous monitoring, scenario planning, and stakeholder participation to account for environmental variability, technological changes, and socio-economic complexities. By moving beyond static, one-size-fits-all models, destinations can better balance tourism growth with environmental protection and community well-being.

Table 1. Types of Tourism Carrying Capacity

Carrying Capacity Type	Description	Key Indicators
Physical Capacity	Maximum number of visitors that physical space can contain	Space availability, infrastructure limits
Environmental/Ecological	Threshold beyond which ecological damage occurs	Soil erosion, wildlife disturbance, pollution
Social Capacity	Level of tourism acceptable to host communities	Resident attitudes, crowding tolerance
Psychological/Perceptual	Visitor's subjective crowding tolerance	Satisfaction levels, perception surveys
Economic Capacity	Tourism level compatible with sustaining local economies	Income distribution, employment benefits
Managerial Capacity	Destination's ability to manage visitor flows	Policy strength, staffing, monitoring systems

Contemporary Challenges in High-Pressure Destinations

High-pressure destinations—those experiencing concentrated tourist flows relative to their ecological, social, or infrastructural capacity—face a range of complex challenges that undermine sustainable management. The rapid growth of global tourism, combined with environmental fragility, urbanisation, and digital trends, has intensified pressures on many iconic and emerging destinations.

Overtourism and Urban Congestion

Overtourism has emerged as one of the most visible challenges in popular urban destinations. Cities such as Venice, Barcelona, and Amsterdam exemplify the socio-cultural and infrastructural strain caused by excessive visitation.[8] In these cities, high tourist density contributes to overcrowded streets, public transport congestion, and inflated housing costs, often displacing local residents and reducing quality of life. Cultural authenticity is also threatened, as commercialised experiences replace traditional community practices and local identities. The challenge is compounded by the seasonal concentration of tourism, where peaks overwhelm infrastructure and exacerbate resident–visitor conflicts. Addressing overtourism requires not only visitor number management but also spatial planning, temporal distribution strategies, and community engagement to balance economic benefits with social sustainability.

Environmental Vulnerability

Natural areas of high ecological or aesthetic value are particularly sensitive to visitor pressure. Coral reefs, protected forests, alpine environments, and fragile coastal ecosystems face degradation through trampling, pollution, wildlife disturbance, and resource overuse.[9] For example, hiking trails in alpine regions experience soil erosion and vegetation loss under heavy foot traffic, while coral reefs suffer from snorkelling- and diving-related damage. Environmental vulnerability is further amplified by climate change, which intensifies stressors such as rising temperatures, sea-level rise, and extreme weather events. High-pressure destinations therefore require management strategies that integrate environmental monitoring, risk assessment, and mitigation measures, ensuring that visitor use does not exceed ecological thresholds.

Digital Visibility and Instant Tourism

The rise of social media and digital platforms has transformed tourism patterns, creating what is often termed "instant tourism".[10] Previously unknown or remote destinations can rapidly gain popularity through viral content, leading to sudden surges in visitor numbers that overwhelm local infrastructure, services, and management systems. This phenomenon challenges traditional TCC models, which are generally based on predictable visitation patterns, and highlights the need for real-time monitoring and adaptive management. Destinations must now consider not only physical and ecological limits but also digital exposure and its influence on visitor distribution. Strategies such as timed

entry systems, visitor quotas, and online communication of peak times have become increasingly important to manage these digitally driven flows effectively.

Interconnected Nature of Challenges

These challenges are often interconnected: overtourism exacerbates environmental degradation, while digital visibility accelerates visitor spikes that intensify congestion and ecological pressures. High-pressure destinations must therefore adopt holistic and adaptive management strategies, combining spatial planning, technological tools, policy interventions, and community participation. Understanding the multi-dimensional nature of these pressures is critical for developing sustainable visitor management approaches that safeguard both the destination's resources and the well-being of local residents.

Innovative Tools for Visitor Management

Advances in technology and participatory governance have enabled destinations to adopt more dynamic and adaptive approaches to managing visitor flows. These tools enhance the effectiveness of tourism carrying capacity frameworks by providing data-driven insights, predictive capabilities, and community involvement in decision-making. The integration of such innovations allows high-pressure destinations to balance visitor satisfaction, environmental conservation, and socio-cultural well-being.

Geospatial Technologies (GIS, GPS, Remote Sensing)

Geospatial technologies—including Geographic Information Systems (GIS), Global Positioning Systems (GPS), and remote sensing—have become indispensable in contemporary visitor management. GIS allows managers to map visitor flows, analyze spatial patterns, and identify congestion hotspots, while remote sensing provides real-time data on ecological changes, vegetation cover, and landscape degradation.[11] GPS-based tracking of tourists enhances understanding of movement patterns across trails, parks, and urban districts, informing trail design, zoning decisions, and infrastructure placement. For example, alpine and coastal destinations have successfully used GIS-based models to redistribute visitor flows, reducing environmental impact and enhancing the overall experience. These technologies enable continuous monitoring of both ecological and social dimensions of carrying capacity, supporting adaptive management practices.

Real-Time Monitoring Systems

Smart destination technologies, including sensors, mobile signal tracking, and CCTV analytics, provide managers with the ability to monitor visitor density in real time.[12] This capability is especially valuable in heritage sites, theme parks, and urban attractions where daily fluctuations in visitation are significant. Real-time data allow managers to implement immediate interventions—such as redirecting flows, opening alternative routes, or adjusting staffing levels—thereby preventing overcrowding, preserving infrastructure, and improving visitor satisfaction. Furthermore, continuous monitoring facilitates data collection over time, informing long-term planning and infrastructure investments.

AI and Predictive Analytics

Artificial intelligence (AI) and predictive analytics provide destinations with powerful tools for forecasting visitor surges and potential pressure points.[13] By analyzing booking patterns, mobility trends, weather conditions, and social media activity, AI models can anticipate periods of high visitation, enabling proactive management strategies. For example, predictive algorithms can recommend optimal staffing, ticketing policies, or temporary closures to mitigate congestion. These systems also allow destinations to simulate multiple scenarios, testing the potential impacts of different interventions on visitor distribution, resource use, and environmental outcomes.

Carrying Capacity Decision-Support Models

Modern decision-support models integrate environmental indicators, visitor satisfaction data, and stakeholder feedback to generate adaptive carrying capacity thresholds.[14] Unlike traditional static approaches, frameworks such as Limits of Acceptable Change (LAC) and Visitor Experience and Resource Protection (VERP) prioritise continuous monitoring of impacts rather than focusing solely on numerical visitor limits. These models allow managers to adjust policies in response to evolving conditions, such as seasonal variations, climate events, or sudden popularity surges, ensuring that ecological, social, and experiential quality thresholds are maintained.

Participatory Governance and Community-Based Tools

Effective visitor management increasingly involves local communities in planning and decision-making processes. Participatory governance models and community-based tourism initiatives enhance social carrying capacity by incorporating resident perspectives into tourism policies.[15] Engaging local stakeholders helps identify potential conflicts, preserve cultural heritage, and promote equitable distribution of tourism benefits. Community participation also strengthens compliance with management measures and fosters stewardship of natural and cultural resources.

Digital Visitor Management Interfaces

Digital interfaces, such as online reservation systems, timed-entry permits, and mobile applications, are becoming standard tools for guiding visitor behaviour and managing congestion.[16] These systems allow destinations to smooth

visitor distribution across time and space, directing tourists to less crowded areas or off-peak periods. They also provide real-time information to visitors, enhancing experience quality while reducing pressure on sensitive sites. For example, apps can suggest alternative trails, display current crowding levels, or allow advance booking of limited-capacity attractions. By integrating these digital tools with predictive analytics and participatory governance, destinations can implement fully adaptive, data-informed visitor management strategies.

Table 2.Traditional vs. Modern Visitor Management Approaches

Characteristic	Traditional Approaches	Modern Approaches
Nature of Limits	Fixed numerical thresholds	Adaptive, real-time thresholds
Data Use	Periodic surveys, manual counts	IoT sensors, AI analytics, GPS data
Management Focus	Reactive	Predictive and proactive
Spatial Management	Basic zoning	Dynamic spatial modeling (GIS)
Community Role	Limited	Strong community co-management
Monitoring Frequency	Seasonal or annual	Continuous, real-time
Policy Flexibility	Low	High—data-driven adjustments

Integrating Carrying Capacity with Sustainable Destination Management

Effectively managing tourism in high-pressure destinations requires moving beyond static numerical thresholds toward a holistic integration of carrying capacity concepts within broader sustainable destination management frameworks. Such integration ensures that environmental integrity, visitor satisfaction, and community well-being are simultaneously considered, enabling destinations to achieve long-term resilience and sustainability.

Adaptive Management

Adaptive management frameworks treat carrying capacity not as a fixed number but as a dynamic threshold that evolves in response to changing conditions, data inputs, and stakeholder feedback.[17] This approach emphasises continuous monitoring of environmental, social, and infrastructural indicators, allowing managers to adjust visitor limits, zoning arrangements, and operational policies in near real time. For example, alpine ski resorts increasingly adjust trail access and lift capacities based on snow conditions and real-time visitation data, while coastal parks may temporarily restrict access to fragile dunes following extreme weather events. Adaptive management also relies on structured stakeholder collaboration, incorporating insights from local communities, businesses, and tourists to ensure that thresholds reflect socio-cultural acceptability and economic realities. By embedding flexibility into carrying capacity implementation, destinations can respond to unexpected surges, seasonal variability, and climate-induced disruptions while maintaining ecological and social sustainability.

Multi-Criteria Approaches

Contemporary carrying capacity models adopt multi-criteria approaches that integrate ecological, social, and economic dimensions into comprehensive management strategies.[18] Ecological indicators may include habitat quality, biodiversity integrity, or trail erosion, while socio-cultural tolerance levels account for resident acceptance, visitor satisfaction, and cultural preservation. Economic objectives consider tourism revenue, employment generation, and local business sustainability. By combining these dimensions, managers can develop destination-specific thresholds that reflect local contexts and stakeholder priorities. Multi-criteria models also enable scenario analysis, allowing planners to evaluate trade-offs between competing objectives, such as maximising visitor numbers versus preserving cultural heritage or protecting sensitive ecosystems. This integrated approach fosters more nuanced decision-making compared to traditional single-factor carrying capacity calculations.

Policy and Governance Implications

Embedding carrying capacity principles into formal policy and governance frameworks is essential for sustainable destination management.[19] Governments and destination management organisations increasingly incorporate carrying capacity considerations into tourism development plans, zoning regulations, and environmental impact assessments. Effective governance requires transparent communication with stakeholders, political commitment to long-term sustainability goals, and mechanisms to enforce regulations. For example, urban centres facing overtourism may implement timed-entry policies for popular landmarks, restrict short-term rental licences in residential neighbourhoods, or establish buffer zones to protect sensitive heritage sites. Similarly, protected natural areas may enforce visitor quotas or seasonal closures based on environmental monitoring data. Strong governance ensures that carrying capacity management is not merely a technical exercise but a coordinated strategy that aligns environmental conservation, community well-being, and tourism development objectives.

Table 3.Innovative Visitor Management Tools: Functions and Applications

Tool/Technology	Core Function	Applications in Destinations
GIS Mapping	Spatial analysis	Hotspot identification, zoning
Remote Sensing	Environmental monitoring	Vegetation loss, shoreline changes
GPS Tracking	Visitor movement analysis	Trail design, congestion mapping
IoT Sensors	Real-time crowd detection	Entry control at heritage sites
Mobile Network Data	Visitor density analysis	Urban crowd management
AI Forecasting Models	Predict visitor surges	Event management, resource planning
Digital Permitting Systems	Controlled access	National parks, World Heritage Sites
Mobile Visitor Apps	Real-time guidance	Route suggestions, timed entry
Participatory Platforms	Community involvement	Resident feedback, co-management

Conclusion

Tourism carrying capacity (TCC) continues to serve as a fundamental framework for understanding and managing visitor impacts in high-pressure destinations. Historically, TCC provided critical insights into the limits of sustainable use, helping planners and managers prevent environmental degradation, maintain visitor satisfaction, and protect community well-being. However, the rapid evolution of global tourism—including rising visitor numbers, the proliferation of social media, climate change, and changing tourist behaviours—has revealed the limitations of traditional, static carrying capacity models.

Contemporary destination management requires updated, flexible frameworks that integrate technological innovations, real-time monitoring systems, and adaptive governance structures. Tools such as GIS, GPS tracking, remote sensing, artificial intelligence, and predictive analytics enable managers to assess visitor flows dynamically, identify congestion hotspots, and anticipate surges in demand. Similarly, participatory governance and community-based approaches ensure that local stakeholders are actively involved in decision-making, enhancing social carrying capacity and fostering a sense of ownership over sustainable tourism practices.

The shift toward adaptive, data-driven management offers several advantages. It allows destinations to respond proactively to seasonal fluctuations, sudden spikes in visitation, and climate-related disruptions. It also supports multi-criteria decision-making, balancing environmental, socio-cultural, and economic objectives in ways that traditional one-dimensional models could not. By integrating these innovations with policy frameworks, zoning regulations, and strategic planning, destination managers can achieve a more resilient, sustainable, and socially inclusive tourism system.

Ultimately, the future of sustainable tourism hinges on the ability of destinations to transform carrying capacity from a static number into a dynamic, actionable concept. When effectively implemented, modern TCC frameworks serve not only as tools for managing visitor impacts but also as mechanisms for enhancing destination competitiveness, protecting natural and cultural heritage, and promoting equitable benefits for local communities. As global tourism continues to evolve, ongoing research, technological advancement, and stakeholder collaboration will remain essential for ensuring that tourism development aligns with sustainability goals and long-term destination resilience.

References

1. O'Reilly, A. M. (1986). Tourism carrying capacity: Concept and issues. Tourism Management.
2. Saveriades, A. (2000). Establishing the social tourism carrying capacity for tourist resorts of the East Coast of the Republic of Cyprus. Tourism Management.
3. Peeters, P. et al. (2018). Overtourism: Impact and possible policy responses. Transport & Environment Report.
4. Coccossis, H. (2004). Sustainable tourism and carrying capacity: A new context. UNEP Publications.
5. Mathieson, A., & Wall, G. (1982). Tourism: Economic, Physical and Social Impacts. Longman.
6. UNWTO. (1993). Sustainable Tourism Development: Guide for Local Planners.
7. McCool, S. & Lime, D. (2001). Tourism carrying capacity: Tempting fantasy or useful reality? Journal of Sustainable Tourism.
8. Milano, C., Cheer, J. M., & Novelli, M. (2019). Overtourism and tourismphobia. Tourism Planning & Development.
9. Newsome, D., Moore, S., & Dowling, R. (2012). Natural Area Tourism: Ecology, Impacts and Management. Channel View.

10. Guttentag, D. (2019). Social media-induced tourism demand. Annals of Tourism Research.
11. Shoval, N. & Ahas, R. (2016). The use of tracking technologies in tourism research. Tourism Geographies.
12. Gretzel, U., Sigala, M., Xiang, Z., & Koo, C. (2015). Smart tourism technologies. Electronic Markets.
13. Li, X., et al. (2021). AI-powered visitor forecasting models. Journal of Destination Marketing & Management.
14. Stankey, G. et al. (1985). The Limits of Acceptable Change (LAC) System for Wilderness Planning. USDA.
15. Scheyvens, R. (1999). Community-based tourism and empowerment. Annals of Tourism Research.
16. Hardy, A. et al. (2020). Digital visitor management systems. Journal of Sustainable Tourism.
17. Buckley, R. (2012). Sustainable tourism and adaptive management. Tourism Recreation Research.
18. Saarinen, J. (2006). Traditions of sustainability in tourism studies. Annals of Tourism Research.
19. Dredge, D. & Jamal, T. (2015). Governance, sustainability, and tourism. Journal of Sustainable Tourism.