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Environmental Carrying Capacity and Community-Based Governance of Mangrove Ecotourism in Tomini Bay

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ABSTRACT

Mangrove ecotourism is increasingly promoted as a pathway to reconcile conservation, livelihood diversification, and coastal resilience, yet destination growth often outpaces ecological thresholds, institutional capacity, and community readiness. Building on the literature review in the International Journals and incorporating recent studies compiled in Journals, this article presents an updated integrative review on the role of carrying capacity in sustainable mangrove ecotourism, with strategic implications for Tomini Bay, Indonesia. Using only the uploaded extraction sources, the review synthesizes advances in ecological suitability assessment, physical-real-effective carrying capacity, community participation, governance arrangements, social feasibility, and tourism management innovation across Indonesia and comparable settings. The synthesis shows that carrying capacity should not be treated merely as a visitor quota; it functions as a multidimensional governance instrument linking ecosystem integrity, visitor experience, local welfare, infrastructure limits, and enforcement capacity. Recent studies also reveal a persistent gap between technical suitability analysis and day-to-day management, especially in zoning, monitoring, promotion, digital visitor control, and benefit sharing. For Tomini Bay, the review proposes a conservation-first, community-based, and adaptive-capacity model that combines spatial zoning, phased visitor limits, ecosystem monitoring, participatory governance, and blue-economy livelihood integration. The article contributes a comparative evidence base, a strategic framework, and a research agenda for emerging mangrove destinations.

1. Introduction

Mangrove ecotourism has become one of the most visible expressions of the contemporary blue economy in tropical coastal regions. In policy and practice, it is commonly expected to achieve several goals simultaneously: conserving mangrove ecosystems, diversifying local livelihoods, improving environmental awareness, strengthening coastal identity, and generating a low-impact tourism economy. Yet the very popularity of mangrove destinations creates a central tension. Once accessibility improves and destinations are promoted more aggressively, visitor numbers can exceed ecological tolerance, infrastructure becomes stressed, waste accumulates, and community benefits may be distributed unequally. As a result, the question of carrying capacity has moved from being a technical side issue to becoming a core governance challenge in mangrove ecotourism [1]–[5].

Recent scholarship confirms that the mangrove ecotourism literature has expanded rapidly in both thematic diversity and geographic coverage. Reviews now discuss conservation outcomes, ecosystem services, social entrepreneurship, destination marketing, community-based tourism, policy integration, and institutional collaboration, while also highlighting growing concern over the gap between ecological suitability analysis and everyday management practice [6], [7]. Across many

cases, mangrove ecotourism is not rejected as a development model; instead, the debate has shifted toward how much tourism can be accommodated, under what conditions, through which institutions, and with whose consent and benefit [6]–[10].

This issue is especially relevant for Tomini Bay, a coastal region whose ecological richness and socio-cultural diversity make it highly suitable for conservation-oriented tourism but also highly vulnerable to unmanaged growth. This localization is increasingly supported by emerging INOTERA-linked evidence from Gorontalo and the Bay of Tomini context. Recent studies highlight mangrove species diversity and density in Tomini Bay as essential ecological inputs for zoning and conservation prioritization, while regional assessments of marine tourism potential in Gorontalo reinforce the need to align tourism growth with coastal management strategy and environmental limits [43], [44]. Although the uploaded literature does not provide a large body of Tomini-specific empirical studies, it offers a substantial evidence base from Indonesia and comparable tropical settings that can be used to build a strong conceptual and strategic agenda for Tomini Bay. This is important because emerging destinations often attempt to copy infrastructure or branding models from more mature ecotourism sites before first establishing ecological thresholds, monitoring protocols, and governance arrangements. The consequence is that conservation rhetoric may remain strong while operational control remains weak [6], [8], [11], [12].

The older literature often framed carrying capacity primarily as a physical or numerical limit: how many people can enter a site within a given time without obvious congestion or habitat damage [1], [4]. More recent studies expand that perspective. Carrying capacity is now treated as a multi-layered construct that integrates biophysical suitability, ecological resilience, visitor experience, infrastructure adequacy, community acceptance, managerial capacity, and institutional enforcement [8]–[14]. The transition from a narrow visitor-quota approach to a broader governance framework is one of the most important developments in the recent literature and is central to designing mangrove ecotourism for Tomini Bay.

This review therefore has five objectives. First, it updates the earlier literature base in turis2 by incorporating recent studies from nego2. Second, it synthesizes how carrying capacity is conceptualized and operationalized in mangrove ecotourism research. Third, it compares recent evidence on ecological suitability, community participation, socio-economic feasibility, governance, and destination management. Fourth, it identifies the main limitations in the current literature. Fifth, it translates these lessons into a strategic agenda for Tomini Bay. The central argument advanced here is that carrying capacity in mangrove ecotourism should be understood not as a single maximum number of visitors, but as an adaptive governance instrument that aligns ecological thresholds with community rights, institutional capability, visitor management, and long-term coastal resilience [1], [6], [8], [9], [15].

2. Review Basis and Analytical Orientation

This article is an integrative review constructed exclusively from the uploaded literature extraction files, namely the prior review source base in turis2 and the more recent additions in nego2. No new references have been added from the web. The resulting evidence base is heavily centered on Indonesia, but it also includes comparative cases from Malaysia and broader international reviews, allowing both contextual specificity and conceptual generalization. Because the source set is dominated by journal articles and conference proceedings focused on mangrove ecotourism, suitability assessment, social feasibility, and governance, the review is particularly well suited for identifying convergences and contradictions in operational models [6]–[18].

The analytical lens used in this article combines four strands of literature. The first is the classic tourism carrying-capacity tradition, which emphasizes limits to visitor use and physical space allocation [1], [4]. The second is the mangrove ecotourism and coastal management literature, which emphasizes ecosystem services, habitat suitability, local participation, and conservation-linked development [5], [6], [8], [15], [16]. The third is the community-based and governance literature, which examines collaboration, participation, readiness, stakeholder coordination, and institutional

roles [18]–[24]. The fourth is the recent innovation literature on digital visitor management, branding, infrastructure design, policy integration, social entrepreneurship, and gendered environmental governance [25]–[42].

To make the evidence analytically useful for Tomini Bay, the review organizes the literature into six recurring dimensions:

1. Biophysical suitability: mangrove density, species diversity, thickness, tides, wildlife, accessibility, and ecological condition. 2. Tourism carrying capacity: physical, real, effective, and site-specific operational carrying-capacity estimates. 3. Community dimension: perceptions, participation, willingness to pay, livelihood outcomes, readiness, and social acceptance. 4. Governance and institutions: collaboration, policy integration, zoning, legal responsibility, and actor coordination. 5. Visitor management: route design, infrastructure, branding, promotion, digital control, interpretation, and safety. 6. Strategic implications: what the evidence suggests for new or emerging mangrove destinations such as Tomini Bay.

This structure is important because the literature repeatedly shows that ecotourism failure rarely originates in one dimension alone. Destinations may be ecologically suitable but institutionally weak; socially supported but poorly monitored; heavily promoted but operationally underprepared; or economically promising but ecologically overexposed [8]–[14], [19]–[21], [25], [30], [31]. Carrying capacity becomes meaningful only when these dimensions are interpreted together.

3. Conceptualizing Carrying Capacity in Mangrove Ecotourism

The foundational literature defines carrying capacity as the level of use an area can sustain without unacceptable ecological degradation, declining visitor satisfaction, or deterioration in management performance [1]–[4]. In mangrove ecotourism, however, this concept is more complex than in many terrestrial tourism settings because visitor movement is constrained by tides, boardwalks, river channels, sediment conditions, fragile roots, wildlife sensitivity, and restoration zones. Mangrove tourism therefore requires capacity calculations that are closely tied to habitat morphology and management logistics [5], [8]–[14].

Several recent Indonesian studies demonstrate that carrying capacity is typically operationalized through combinations of suitability analysis and visitor-capacity calculation. Suitability analyses assess whether a site is appropriate for tourism using indicators such as mangrove thickness, species richness, density, tides, associated biota, accessibility, and existing infrastructure [8], [10]–[16]. Carrying-capacity calculations then estimate the number of visitors that can be accommodated per day or per route segment under particular spatial and temporal conditions [9]–[14], [37]–[39]. This two-stage logic is important because a site may be “suitable” in ecological terms but still have a low daily capacity because routes are narrow, supervision is limited, or sensitive habitat patches require exclusion.

The literature also shows growing methodological diversity. Some studies rely on a conventional tourism suitability index coupled with a carrying-capacity formula based on area, time available, route length, and ecological correction factors [8], [10], [11], [15]. Others distinguish between physical carrying capacity (PCC), real carrying capacity (RCC), and effective carrying capacity (ECC), thereby recognizing that raw space calculations must be adjusted for environmental limitations and management capability [9]. Still others integrate a community-based tourism index, SWOT analysis, A’WOT, system dynamics, or theory of planned behavior in order to move from technical assessment to managerial strategy [16], [17], [19], [21], [23], [31], [33].

This methodological expansion is conceptually significant. It suggests that carrying capacity is no longer interpreted as a rigid numerical threshold detached from social and institutional realities. Instead, it is increasingly treated as a decision-support framework. A destination’s effective capacity depends not only on boardwalk length or area size, but also on staffing levels, monitoring intensity, zoning rules, visitor dispersion mechanisms, local compliance, and the ability to adapt during peak periods or ecological disturbance [8], [9], [12], [21], [30], [39], [41]. In practical terms, a destination

with excellent mangrove quality may still have low effective capacity if its management body lacks personnel, waste systems, ticketing controls, or clear operating rules.

A further conceptual lesson from the recent literature is that carrying capacity is not only ecological and managerial; it is also social and political. Studies on community readiness, participation, and governance show that the durability of mangrove ecotourism depends on whether local residents perceive tourism as fair, useful, and compatible with local institutions and values [17], [22]–[24], [29]–[35]. When communities are included only symbolically, tourism may become ecologically branded but socially fragile. Conversely, when residents participate meaningfully in planning, guiding, restoration, and benefit-sharing, capacity is strengthened because compliance, stewardship, and site surveillance improve [15], [18], [22], [23], [31], [32], [34], [35].

For Tomini Bay, these conceptual lessons imply that carrying capacity should be interpreted through at least five linked questions: (1) how much visitation can the mangrove habitat sustain; (2) how much visitation can the infrastructure safely absorb; (3) how much visitation can local institutions supervise and regulate; (4) how much tourism pressure can be accepted without eroding community legitimacy; and (5) how much market growth can be encouraged without undermining the conservation purpose of the destination. The uploaded literature strongly indicates that failure to address all five leads to unstable ecotourism trajectories [6], [8], [9], [18], [23], [30], [31].

4. Ecological Suitability and Biophysical Thresholds

One of the strongest themes in the recent literature is the centrality of ecological suitability as the starting point for ecotourism planning. Studies from Nusa Penida, Bangkalan, Bekasi, Jeneponto, West Lombok, and Pangandaran all affirm that mangrove ecotourism should be grounded in the measurable condition of the ecosystem rather than in tourism demand alone [8]–[14], [37], [38]. Across cases, the indicators used are remarkably consistent: mangrove thickness or width, species composition, stem density, canopy cover, associated fauna, tides, landscape attractiveness, and accessibility.

The Nusa Penida case is especially illustrative because it links ecological suitability directly to conservation-based strategy. Vipriyanti et al. reported a conformity index for tourism of 74.36% and a carrying capacity of 360 visitors per day, then connected these results to recommendations on infrastructure, services, supervision, and stakeholder cooperation [8]. This is important because it demonstrates that a capacity estimate becomes meaningful only when it is translated into management actions. Capacity analysis without operational consequences is analytically elegant but practically weak.

The Pantai Indah Kapuk study adds another important layer by distinguishing PCC, RCC, and ECC [9]. Its findings show that a destination may exceed physical or real limits while still appearing operationally manageable under effective capacity if management interventions are in place. This nuanced interpretation is valuable for Tomini Bay because it discourages simplistic conclusions such as “more room means more permissible tourists.” Instead, it shows that ecological thresholds must be interpreted through management filters. Zoning, online booking, route allocation, and monitoring staff can alter effective capacity, but they do not erase biophysical vulnerability [9], [39], [40].

The Paljaya and Tugurejo studies further show how carrying-capacity values can vary dramatically even among apparently similar mangrove destinations. Paljaya’s estimated carrying capacity was 37 people/day for a 230 m mangrove track [10], whereas Tugurejo’s study estimated 668 people/day under its operational configuration [11]. Such variation underscores a basic but often neglected point: carrying capacity is site-specific, not transferable. It depends on route length, habitat sensitivity, visitor activity type, operating hours, and management assumptions. For Tomini Bay, therefore, any future carrying-capacity assessment must be locally measured and not borrowed from other destinations, even within Indonesia.

The Bangkalan literature is especially useful because it combines ecosystem-condition assessment with tourism potential. Nugraha et al. found that all investigated sites were in the

"sufficient" category for tourism development and documented major spatial variation in mangrove thickness, density, and species richness [12]. Syah et al. similarly identified good mangrove health in Sepulu, with dense NDVI-derived conditions and relatively strong canopy cover [13]. These studies reinforce a strategic lesson: tourism planning should begin with an ecological baseline that can later be used to monitor change. Without a pre-tourism baseline, managers cannot easily determine whether increased visitation is degrading mangrove structure or associated biota over time.

Studies from Balang Baru and West Lombok also confirm that "appropriateness" does not imply uniform development intensity. Both cases show that suitable ecosystems still require selective use and route-specific control [14], [15]. In other words, a site can be generally appropriate for ecotourism while particular sections remain unsuitable for heavy visitation because of restoration needs, wildlife sensitivity, substrate instability, or limited evacuation access. This suggests that Tomini Bay should avoid the common planning mistake of labeling large coastal stretches as "ecotourism zones" without finer internal zoning.

A notable contribution of the newer literature is its increasing attention to ecosystem services and resilience. Rather than treating mangroves only as scenic vegetation, recent studies position them as blue-carbon assets, nursery habitats, shoreline stabilizers, and climate-resilience infrastructures [6], [12], [13], [22]. This matters because carrying capacity should not be calculated only against tourism functions but also against non-tourism ecosystem functions. A mangrove area that appears spacious enough for more visitors may already be near its ecological threshold in terms of regeneration, sediment dynamics, or disturbance to fauna. The review therefore suggests that ecological carrying capacity in Tomini Bay should incorporate restoration objectives, carbon and biodiversity values, and the distribution of high-sensitivity habitat patches, not merely visual attractiveness or route length.

5. From Visitor Quotas to Multi-Dimensional Capacity

The most useful insight from the uploaded literature is that carrying capacity is best understood as multi-dimensional. The visitor number itself is only one layer. In practice, managers must deal with at least four capacity dimensions: ecological, physical, social, and institutional.

Ecological capacity refers to the tolerance of the mangrove ecosystem to trampling, noise, litter, boat wakes, sediment disturbance, wildlife disruption, and infrastructure insertion. Studies from PIK, Paljaya, Tugurejo, and Pangandaran emphasize that ecological fragility can be masked by visually healthy canopy conditions if monitoring focuses only on broad structural indicators [9]–[11], [37], [38]. This means that Tomini Bay should design monitoring around both structural indicators (density, cover, species composition) and process indicators (regeneration, wildlife presence, sediment change, water quality, and disturbance signs).

Physical capacity concerns route width, access points, parking, toilets, docks, safety infrastructure, and travel time. Several studies show that the route or track itself often determines daily capacity more strongly than the total mangrove area [8]–[11], [39], [40]. The implication is practical: rather than widening access indiscriminately, managers can shape capacity through route segmentation, one-way circulation, timed entry, and the distribution of attractions. Physical design is therefore a governance tool, not just an engineering detail.

Social capacity refers to the level of tourism that communities are willing to accept without perceiving loss of access, cultural disruption, unfair benefit capture, or declining quality of place. The Marudu Bay willingness-to-pay study shows that support for mangrove ecotourism is closely related to expected livelihood gains and long-term confidence in conservation outcomes [17]. Studies on perception and participation in Langkat, Bengkulu, Balikpapan, and Karangsong similarly demonstrate that local support depends on trust, economic relevance, institutional inclusion, and managerial credibility [15], [16], [22]–[24]. A high visitor ceiling is therefore meaningless if social carrying capacity is already being exceeded.

Institutional capacity may be the least discussed in older literature but is among the most important in newer studies. Dynamic simulation work in Lantebung, stakeholder analyses, governance studies, and policy-integration papers show that carrying capacity ultimately depends on whether the managing institution can monitor, regulate, educate, coordinate, and adapt [20], [21], [30], [31], [33], [41]. Institutional weakness converts technical capacity into paper capacity: a value written in reports but unenforced in practice.

This broader framing is particularly relevant for Tomini Bay because emerging destinations often confront institutional fragmentation. Tourism offices, village governments, forest or coastal agencies, conservation groups, and private operators may all influence the same site. The literature repeatedly warns that without clear authority, role allocation, and accountability, ecotourism may expand faster than its governance architecture [20], [21], [27], [30], [31], [41]. Thus, in Tomini Bay, capacity assessment should be paired from the outset with institutional mapping and a realistic appraisal of enforcement capability.

6. Community Participation, Livelihoods, and Local Readiness

Community participation is one of the most frequently repeated principles in mangrove ecotourism research, but the literature shows that participation varies substantially in depth and effect. In some destinations, participation means involvement in restoration, guiding, local transport, food services, and basic monitoring. In others, it is limited to consultation or symbolic representation. The distinction matters because strong local involvement tends to improve stewardship, visitor interpretation, security, and the legitimacy of tourism restrictions [15], [18], [22]–[24], [31]–[35].

Karangsong remains a useful benchmark for understanding how community characteristics shape ecotourism viability. Garsetiasih et al. showed that positive local perceptions were linked to tangible economic benefits and that a driving group played an important role in maintaining conservation enthusiasm [15]. The later Karangsong study integrating a CBT index with biophysical assessment went further, arguing that a site's sustainability cannot be understood from ecosystem variables alone [16]. This is highly relevant to Tomini Bay because many mangrove sites are located in socially heterogeneous coastal areas where fishing, small-scale trade, transport, customary access, and informal tourism uses overlap.

The Marudu Bay case provides another valuable lesson. Musa et al. found that most respondents were willing to pay for conservation-oriented ecotourism because they believed it would improve livelihoods across generations [17]. This shows that local support is strengthened when communities perceive ecotourism not merely as visitor activity but as a long-term economic and ecological strategy. However, willingness to support tourism is not unconditional; it rests on confidence in management and in the fairness of benefit distribution.

More recent Indonesian cases sharpen this point. Srifitriani et al. documented good levels of participation in planning, utilization, and management in Bengkulu, while also identifying infrastructure and public-awareness constraints [22]. Nugroho et al. used the theory of planned behavior in Balikpapan Bay and found that attitudes, subjective norms, and especially perceived behavioral control significantly influenced community intention to participate in community-based ecotourism [23]. Daulay et al., by contrast, showed that communities may acknowledge the recreational and conservation value of mangrove ecotourism while still feeling that education and economic benefits remain limited [24]. Together, these findings suggest that participation should not be romanticized; communities may support tourism in principle yet still experience uneven gains, limited empowerment, or low managerial influence.

The Babana feasibility study adds an important caution. Patawari et al. reported that social and educational dimensions were relatively feasible, but economic, health, and environmental-security dimensions remained weak [25]. This highlights that community readiness is multidimensional. A village may support ecotourism rhetorically while still lacking the health conditions, skills, safety

infrastructure, or environmental resilience needed for successful operation. For Tomini Bay, this means that social readiness assessment should precede aggressive destination marketing.

The literature also shows that community participation now intersects with newer agendas such as gender, social entrepreneurship, and financial literacy. Recent studies discuss women's environmental governance roles, social entrepreneurship, and the linkage between community-based tourism and sustainable outcomes [34], [36], [42]. This is especially promising for Tomini Bay because mangrove ecotourism should not be limited to boat tours and boardwalk visitation. It can be linked to local interpretation, mangrove nurseries, food and crafts, restoration labor, environmental education, blue-carbon communication, and locally branded low-impact products. Such diversification can increase the social carrying capacity of tourism by broadening its beneficiary base.

7. Governance, Institutions, and Management Strategy

If one theme cuts across the recent literature more strongly than any other, it is that ecotourism outcomes are shaped as much by governance quality as by ecosystem condition. Management strategy studies from Makassar, Bedul, Bali, Batam, and other Indonesian cases reveal that sustainable mangrove ecotourism depends on collaboration among community organizations, local government, conservation authorities, and in some cases private actors [20], [21], [27], [30]–[33], [41].

The Lantebung literature is particularly important in this respect. Daris et al. used A'WOT to prioritize management strategy in Makassar and concluded that optimizing the managing group and exploiting development opportunities could reduce ecosystem pressure and improve outcomes [20]. Massiseng et al. added a dynamic simulation perspective, showing that different policy scenarios produce different balances between conservation gains and economic returns over time [21]. These studies are valuable because they move the discussion beyond static SWOT lists and toward the dynamic trade-offs that real managers face. For Tomini Bay, where multiple villages and administrative authorities may be involved, a scenario-based planning approach would be more useful than a one-time masterplan.

Governance studies also reveal that institutional design can either strengthen or undermine carrying-capacity implementation. Budisusanto and Fathimah's RRR study from Surabaya stresses the importance of clearly defining rights, restrictions, and responsibilities in mangrove space utilization [27]. Sumarmi et al. show how collaboration between communities and park management can help maintain both ecological quality and sustainable local economic benefits [31]. The implication for Tomini Bay is clear: capacity values should be embedded in institutional rules. Without an agreed division of authority over access, restoration, supervision, and sanctions, carrying-capacity estimates remain advisory rather than binding.

The Batam governmentalities paper introduces a critical perspective often missing from managerial literature [30]. It argues that mangrove ecotourism governance can be shaped by overlapping top-down control, environmental education, market-oriented entrepreneurship, and scientific standardization, with local participation sometimes becoming tokenistic. This is a powerful reminder for Tomini Bay. Conservation-oriented tourism can still reproduce inequality if decision-making remains centralized while local people are expected mainly to perform compliance and hospitality roles. A carrying-capacity framework that is technically rigorous but socially exclusionary will likely be unstable.

Recent papers on policy integration and stakeholder perspectives reinforce this message. Nasution et al. emphasize the need to integrate environmental policy into ecotourism management [41], while Daris et al. frame sustainable mangrove ecotourism within a broader green-economy perspective [33]. These studies suggest that ecotourism should not be governed as an isolated tourism product. It must be linked to coastal protection, waste management, restoration policy, environmental education, and local development planning. This integration is particularly critical for Tomini Bay, where

tourism pressure, fisheries use, settlement dynamics, and coastal conservation are likely to intersect spatially.

8. Tourism Products, Infrastructure, Branding, and Visitor Experience

The recent literature increasingly recognizes that ecotourism sustainability depends not only on limiting visitors but also on designing the right visitor experience. Branding, route design, infrastructure quality, educational content, and local uniqueness all affect how tourists move through a site and how pressure is distributed.

Widyaputri et al. show that branding can positively shape tourist interest, though specific elements such as uniqueness or commitment may need strengthening [26]. The Pekan Arba case demonstrates that local transport heritage, in this case the "flat boat," can become an ecotourism attraction when linked to mangrove ecology and local knowledge [29]. These findings matter because Tomini Bay should not rely on generic mangrove tourism formats. Place-specific identity can reduce the pressure to maximize visitor volume by increasing the quality and distinctiveness of the visitor experience.

Infrastructure design is equally important. Tahir et al.'s work on sustainable pedestrian paths suggests that circulation design in mangrove areas is not a secondary issue but a core sustainability tool [40]. Boardwalk length, viewing nodes, resting points, interpretation panels, and emergency access shape both physical carrying capacity and visitor behavior. Poorly planned infrastructure can funnel visitors into sensitive zones or encourage off-trail movement, whereas good design can concentrate use in resilient areas and reduce ecological disturbance.

At the same time, the literature warns against overdevelopment. Studies on mobility, visitor behavior, and urban mangrove settings imply that excessive hard infrastructure can dilute ecotourism values and increase maintenance burdens [11], [27], [28]. For Tomini Bay, a low-impact and modular infrastructure strategy would therefore be preferable: limited but well-designed boardwalks, small viewing platforms, interpretive signage, timed access points, and strong restoration buffers. Capacity should be shaped through design discipline rather than through post hoc repair after overcrowding occurs.

9. Comparative Synthesis

Table 1. Selected recent studies on mangrove ecotourism carrying capacity and management

Study context	Main focus	Method/approach	Key result	Management implication	Ref.
Nusa Penida, Bali	Suitability and carrying capacity	Tourism suitability index + SWOT	CTI 74.36%; carrying capacity 360 visitors/day	Align visitor limits with infrastructure, supervision, and stakeholder coordination	[8]
Pantai Indah Kapuk, Jakarta	Multilevel carrying capacity	PCC, RCC, ECC	Visitor pressure exceeded PCC and RCC, but remained within ECC	Use zoning, online booking, and field staff to regulate flow	[9]
Paljaya, Bekasi	Suitability and carrying capacity	TSI + CCR	Suitable category; carrying capacity 37 visitors/day	Maintain restoration orientation and limit pressure on small tracks	[10]
Tugurejo, Semarang	Supporting capacity	Carrying-capacity assessment	Estimated carrying capacity 668 visitors/day	Capacity values must be interpreted with ecosystem conservation goals	[11]
Bangkalan, East Java	Tourism potential and	Species-density-thickness	All sites fell in the sufficient	Site differentiation and baseline	[12], [13]

Study context	Main focus	Method/approach	Key result	Management implication	Ref.
	ecological condition	assessment + suitability index	category for tourism	ecological monitoring are essential	
Jeneponto, South Sulawesi	Suitability analysis	Biophysical suitability assessment	Area categorized as suitable	Suitable sites still require selective zoning and monitoring	[14]
Pangandaran, West Java	Potential and carrying capacity	Potential assessment + carrying-capacity modeling	Recent studies show growing interest in visitor-threshold planning	Emerging destinations should define thresholds before aggressive promotion	[37], [38]

Table 2. Social and institutional dimensions emphasized in recent mangrove ecotourism studies

Dimension	Evidence from literature	Typical indicators	Main risk if ignored	Strategic response	Ref.
Community perception	Positive when economic and conservation benefits are visible	Local support, trust, perceived benefits	Passive resistance, weak stewardship	Early consultation and visible benefit-sharing	[15], [17], [24]
Community participation	Stronger sustainability when residents are involved in planning and management	Participation rates, role diversity, local organizations	Tokenism and low compliance	Co-management and community monitoring	[16], [18], [22], [31]
Local readiness	Intention depends on perceived behavioral control and institutional support	Skills, confidence, norms, access to resources	Project stagnation despite rhetorical support	Capacity building and staged destination development	[23], [25], [32], [34]
Institutional clarity	Rights, restrictions, and responsibilities shape operational control	Role definition, permits, sanctions, coordination	Capacity values remain unenforced	Legal-institutional embedding of capacity rules	[20], [21], [27], [41]
Governance quality	Collaboration improves durability but may also mask inequality	Stakeholder coordination, inclusiveness, transparency	Elite capture or market-centered governance	Participatory and accountable governance design	[30], [31], [33], [42]

Table 3. Strategic framework for Tomini Bay mangrove ecotourism

Planning domain	Recommended action for Tomini Bay	Rationale	Operational indicator	Expected outcome	Ref.
Ecological baseline	Conduct site-by-site suitability and habitat-sensitivity mapping	Capacity cannot be transferred from other destinations	Species richness, density, canopy, wildlife, restoration zones	Conservation-first tourism zoning	[8]–[14]
Visitor regulation	Apply phased capacity with timed entry, seasonal adjustment,	Visitor pressure varies by route, tide, and	Daily visitor counts, route occupancy,	Reduced crowding and habitat disturbance	[9]–[11], [37]–[40]

Planning domain	Recommended action for Tomini Bay	Rationale	Operational indicator	Expected outcome	Ref.
	and route segmentation	management strength	off-trail incidence		
Community governance	Establish village-centered co-management forums	Participation improves legitimacy and stewardship	Number of local roles, meeting frequency, benefit-sharing mechanisms	Higher social carrying capacity	[15]–[18], [22]–[25], [31]
Infrastructure	Use low-impact modular boardwalks and interpretation nodes	Infrastructure determines physical capacity and visitor behavior	Track length, safety features, waste points, interpretation quality	Better flow control and education	[8], [9], [27], [40]
Livelihood integration	Link ecotourism with restoration, local transport, food, handicrafts, and blue-carbon education	Broader benefits reduce conflict and improve support	Share of local enterprises, women/youth participation	More equitable local value capture	[17], [22], [29], [34], [36], [42]
Policy integration	Embed ecotourism in coastal management, restoration, and local development plans	Tourism alone cannot manage mangrove landscapes	Formal regulations, zoning documents, monitoring protocols	Stronger long-term institutional capacity	[20], [21], [30], [33], [41]

10. A Strategic Agenda for Tomini Bay

Based on the uploaded literature, Tomini Bay should not begin with the question "How can tourism be expanded?" but with the question "Under what ecological and institutional conditions is conservation-compatible tourism justified?" This is not a rhetorical distinction. It changes the planning sequence. Expansion-first planning tends to prioritize access, promotion, and visitor facilities; capacity-first planning prioritizes ecological mapping, route control, governance design, and community legitimacy [8]–[11], [20], [21], [31].

The first strategic priority for Tomini Bay is site differentiation. The literature strongly suggests that mangrove destinations vary enormously in ecological sensitivity and management feasibility, even within the same province or coastal type [10]–[16]. Tomini Bay should therefore classify mangrove sites into at least four categories: (1) conservation core zones with no tourism access; (2) limited-access ecotourism zones with guided or timed entry only; (3) education and interpretation zones appropriate for higher-frequency visits; and (4) community-use buffer zones integrating fisheries, transport, and livelihood functions. Such zoning would allow capacity to be spatially distributed rather than treated as a bay-wide average.

The second priority is phased carrying capacity. The literature shows that static annual visitor targets are less useful than adaptive daily or route-based controls [8]–[11], [39]. Tomini Bay should begin with a conservative entry threshold for each site, then adjust based on monitored ecological and social indicators. This phased model is superior to high initial allowances because it reduces the risk of irreversible habitat damage or community backlash.

The third priority is community-centered governance. Emerging destinations often underestimate how quickly ecotourism can become contested if local roles are unclear or benefits are narrowly captured. Evidence from Karangsong, Marudu Bay, Bengkulu, Balikpapan, Langkat, and Bedul

suggests that local support improves when residents are involved in planning, interpretation, monitoring, transport, and enterprise creation [15]–[18], [22]–[25], [31]. For Tomini Bay, this means that ecotourism institutions should be built around co-management committees at site level, backed by clear rules on decision rights, revenue allocation, restoration obligations, and visitor monitoring.

The fourth priority is blue-economy livelihood linkage. Tomini Bay should avoid a narrow tourism-only model. The literature increasingly supports integrated approaches that connect ecotourism with environmental entrepreneurship, restoration, local food, cultural interpretation, and community-based tourism outcomes [33]–[36], [42]. In practical terms, mangrove nurseries, boardwalk maintenance, local boating, interpretation services, blue-carbon education packages, and eco-products can widen benefit distribution and reduce dependence on entrance fees alone.

The fifth priority is adaptive monitoring. The review indicates that many studies stop at baseline suitability or one-time carrying-capacity estimation. For Tomini Bay, monitoring must continue after tourism begins. At minimum, managers should track mangrove density and regeneration, wildlife observation frequency, visitor counts, route congestion, waste generation, off-trail movement, community benefit distribution, and visitor satisfaction. Without a monitoring loop, carrying capacity cannot function adaptively and becomes a one-off consulting exercise [8]–[11], [20], [21], [37]–[41].

The sixth priority is narrative discipline in promotion. Branding can increase demand, but the literature warns that tourism promotion should not outpace governance and infrastructure [26], [29], [33]. Tomini Bay should therefore build its destination narrative around conservation quality, limited access, learning, and local stewardship rather than mass visitation. This would align promotion with the ecological logic of mangrove ecotourism and reduce the temptation to equate success with volume alone.

11. Operational Design Principles for Tomini Bay

To make the strategic agenda more actionable, the uploaded literature can be translated into a set of operational design principles. These principles are especially useful for Tomini Bay because they convert the review findings into implementable management logic rather than remaining at the level of broad recommendation.

First, begin with habitat logic, not tourism logic. The literature repeatedly indicates that destinations become more sustainable when route design, visitor nodes, and interpretation spaces follow the ecological structure of the mangrove rather than imposing an externally imagined tourism layout [8]–[14], [37], [38]. In Tomini Bay, this means that boardwalks should avoid newly restored areas, critical nursery grounds, and sensitive edge zones. Scenic value should be balanced against habitat fragility; the most visually attractive areas are not always the most resilient ones. A habitat-led design principle also implies that some portions of the mangrove should remain inaccessible and visible only from controlled viewpoints.

Second, separate access for learning from access for recreation. A frequent weakness in mangrove ecotourism practice is the tendency to collapse all visitors into one management category. Yet the literature suggests that educational visits, local family recreation, photography-based tourism, and guided conservation tours create different forms of ecological pressure and require different supervision intensities [6], [8], [11], [26], [29], [40]. Tomini Bay would therefore benefit from a differentiated visitor system. School groups, for example, could be directed toward shorter educational loops with strong interpretation and high supervision, while specialized ecotourists could access longer or more technical routes in smaller groups.

Third, treat community enterprises as part of carrying-capacity management. Most studies discuss local enterprises in relation to welfare, but they also matter for visitor control. When local guides, boat operators, nursery groups, food vendors, and women's cooperatives are institutionally linked to site management, they become part of the surveillance and compliance ecosystem [15]–[18], [22]–[25], [31], [34], [36], [42]. In Tomini Bay, local enterprises should not be placed outside governance;

they should be integrated into booking systems, visitor orientation, restoration activities, and waste reduction protocols. This will strengthen both economic inclusion and enforcement capacity.

Fourth, match promotion intensity to management maturity. The literature on branding and destination growth shows that visibility can increase tourist interest quickly, but management systems usually expand more slowly [26], [29], [33]. For Tomini Bay, promotional escalation should therefore occur in phases. A destination that still lacks daily monitoring, route segmentation, trained local interpreters, and emergency procedures should not be promoted as an open-access mass destination. Controlled demand growth is preferable to rapid growth followed by ecological and reputational decline.

Fifth, institutionalize restoration as part of the tourist experience. One of the strongest opportunities in mangrove ecotourism is the ability to connect visitation with active conservation. The review suggests that ecotourism is most defensible when it visibly reinforces restoration, stewardship, and environmental learning rather than merely using mangroves as a background landscape [6], [15], [21], [22], [31], [35]. Tomini Bay can operationalize this by requiring each site to maintain restoration plots, interpretation about mangrove functions, and community-led monitoring displays. Such measures increase the educational density of visitation without requiring higher tourist volumes.

Sixth, define trigger points for management change. Carrying-capacity implementation often fails because destinations do not specify when management should respond. The literature provides many estimates of capacity, but fewer examples of clear adaptive trigger points [9]–[11], [37]–[39]. Tomini Bay should correct this by defining thresholds such as: a decline in regeneration rates, repeated crowding on key routes, increased off-track movement, visitor complaints related to congestion, or evidence of wildlife displacement. Crossing such thresholds should automatically trigger management responses—reduced quotas, temporary closure, intensified supervision, or route redesign.

These operational principles reinforce the core conclusion of this review: carrying capacity becomes useful only when it is embedded in everyday governance, local enterprise structure, restoration logic, and adaptive monitoring. For Tomini Bay, the challenge is not simply to know the number of visitors allowed, but to create a management system capable of acting on that knowledge.

12. Research Gaps and Future Directions

Although the recent literature is rich, several gaps remain. First, many studies still rely on short-term field assessments and do not evaluate how carrying capacity changes over time after tourism intensifies. Longitudinal studies are needed to test whether the thresholds calculated at project initiation remain valid after infrastructure expansion, habitat change, or shifts in visitor composition [8]–[14], [37]–[39].

Second, the literature remains methodologically fragmented. Suitability analysis, capacity calculation, community-perception studies, governance analysis, and branding studies are often conducted separately. Integrated designs that combine ecological monitoring, social acceptance, institutional analysis, and visitor behavior would produce more operationally useful knowledge [16], [21], [23], [30], [41]. Tomini Bay would be a strong candidate for such integrative research because it is better to embed monitoring before tourism scales than to retrofit it later.

Third, there is still limited direct attention to climate resilience in capacity planning. Yet recent studies increasingly frame mangrove ecotourism within climate adaptation, ecosystem services, and resilience discourse [6], [22]. Future research for Tomini Bay should therefore ask not only how many tourists can be accepted, but how tourism interacts with restoration goals, shoreline protection, blue-carbon narratives, and disaster preparedness.

Fourth, the governance literature needs deeper treatment of power asymmetry, gender, and justice. The Batam governmentalities paper and recent work on women's environmental governance suggest that formal participation may coexist with unequal influence [30], [42]. For Tomini Bay, future

research should examine who defines carrying-capacity thresholds, who enforces them, who benefits from them, and whose mobility or customary use may be restricted by them.

Fifth, digital tools are entering ecotourism practice, but their role in carrying-capacity enforcement is underdeveloped in the uploaded literature. Online reservations, timed ticketing, QR-based monitoring, visitor heat mapping, and digital interpretation could help Tomini Bay control visitor flow while improving education and data collection. This is a significant research and management opportunity. This emerging direction also resonates with recent INOTERA work from Gorontalo that proposes smart mangrove monitoring for resilience and blue-carbon governance through remote sensing, IoT sensing, and MRV-oriented decision support [45].

Taken together, these local and regional INOTERA contributions strengthen the practical relevance of the Tomini Bay agenda advanced in this review by linking ecological baseline assessment, coastal tourism planning, and technology-enabled mangrove governance within one regional frame [43]–[45].

13. Conclusion

The updated literature shows that the contemporary debate on mangrove ecotourism has moved beyond whether ecotourism is desirable and toward how it should be governed. Carrying capacity has emerged as a central organizing concept because it links ecological thresholds with visitor use, community legitimacy, infrastructure performance, and institutional capability. Across Indonesian and comparative cases, the evidence consistently indicates that carrying capacity should not be reduced to a fixed daily quota. It is a multi-dimensional governance framework that must be recalibrated through ecological monitoring, community participation, visitor management, and policy integration [6], [8]–[11], [20], [21], [30], [31], [41].

For Tomini Bay, the main lesson is clear: sustainable mangrove ecotourism must be built on a conservation-first and community-based foundation. Ecological suitability mapping, phased capacity limits, low-impact infrastructure, co-management institutions, and diversified local livelihoods should precede aggressive promotion. The most promising future for Tomini Bay is therefore not mass tourism in mangrove settings, but carefully regulated, knowledge-rich, and locally rooted ecotourism that treats carrying capacity as an adaptive instrument of coastal stewardship rather than as a one-time technical calculation.

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