Proceedings of ICBioMed 2025 Symposium: AI for Healthcare: Advanced Medical Data Analytics and Smart Rehabilitation
DOI: 10.54254/2753-8818/2025.AU25570

Analysis of the Relationship Between Ecological Value and Ecotourism in the Osa Peninsula

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Abstract: The Osa Peninsula has undergone a significant economic transformation, shifting from a primarily agriculture-based economy to one centered on ecotourism. As a critical representative of tropical rainforest ecosystems, the region is home to abundant and diverse flora and fauna. Historically, the peninsula experienced environmental degradation due to agricultural expansion and industrial activities. Today, it serves as a microcosm of broader ecological development trends. Recognized globally as a model for ecotourism and conservation, the Osa Peninsula has benefited from a series of national policies in Costa Rica that have contributed positively to its environmental protection. Nonetheless, despite its successes, ecotourism in the region faces several ongoing challenges that warrant critical attention and sustainable management strategies.

Keywords: Osa Peninsula, Ecotourism, Costa Rica, Tropical Rain Forest

1. Introduction

Ecotourism has emerged as a vital and sustainable industry that balances environmental conservation with economic development. Ecotourism destinations are typically located in areas that have not suffered from severe environmental degradation. Internationally, the promotion of ecotourism is increasingly regarded as a key approach to preserving natural ecosystems.

Costa Rica exemplifies this trend. Its natural landscapes have been historically reimagined—from indigenous resource base, to agricultural land, to a pristine haven for modern ecotourists. Among its most iconic regions is the Osa Peninsula, situated in southern Costa Rica (UTM zone 17P, approx. 8°49'59.988" N, 83°30'0" W). Bordered by Coronado Bay, the Pacific Ocean, and the Gulf of Dulce, the peninsula spans roughly 30 km northeast to southwest and 55 km northwest to southeast [1].

Renowned for its untouched natural beauty, the Osa Peninsula is home to secluded beaches, dense primary rainforest, and extraordinary biodiversity. Its unique combination of terrestrial and marine ecosystems makes it one of the most biologically intense places on Earth. With temperatures ranging between 25–35°C throughout the year, the region experiences a dry season from December to April and a rainy season from May to November, with the heaviest rainfall occurring from late August to early November.

This paper explores the role of the Osa Peninsula in Costa Rica's ecotourism development and environmental preservation, highlighting the interplay between ecological integrity, tourism dynamics, and sustainable regional growth.

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DOI: 10.54254/2753-8818/2025.AU25570

2. Osa Peninsula

2.1. Plant diversity and ecological significancep

The Despite occupying only about 0.00000085% of the Earth's surface (approximately 1,200 km²), the Osa Peninsula stands out as one of the most biologically rich regions on the planet. This compact landmass harbors an extraordinary 2.5% of the world's terrestrial species, making it a global hotspot for biodiversity. It is also home to the most extensive remaining stretch of Pacific lowland tropical rainforest in Mesoamerica, with forest ecosystems reaching all the way to the ocean's edge.

The peninsula supports over 700 tree species and around 4,000 species of vascular plants. These plant communities are far more than scenic greenery—they form the foundation of a complex ecological web. From providing food and shelter for insects, birds, and mammals to regulating microclimates and maintaining soil and water quality, vegetation on the Osa Peninsula plays a vital role in sustaining life. Furthermore, the region's dense forests contribute meaningfully to climate regulation by acting as carbon sinks, helping to mitigate the effects of global warming and prevent soil erosion that could otherwise disrupt aquatic systems [2].

Among the botanical highlights is the Walking Palm (Socratea exorrhiza), whose peculiar stilt roots allow it to "move" incrementally toward light, embodying the forest's adaptability. The towering Ceiba tree, often reaching heights of 70 meters, functions as a structural and ecological pillar—its canopy provides food and nesting space for monkeys, toucans, and countless other species. Similarly, the Strangler Fig exhibits a fascinating parasitic growth pattern, enveloping host trees and forming cavernous structures that become vital microhabitats for forest fauna.

One particularly valuable tree in the region is Mahogany (Swietenia macrophylla). While globally known for its prized timber, in the Osa Peninsula it also plays a central ecological role. Mahogany trees are slow-growing and long-lived, contributing to forest structure and stability. Their large crowns support epiphytes and host nesting birds, while their deep roots enhance soil integrity and nutrient cycling. As keystone species, they facilitate habitat diversity and help maintain forest succession dynamics.

Other notable tree species include the Almendro (Dipteryx panamensis), whose large fruits and flowers are critical food sources for monkeys and the endangered scarlet macaw; the Guarumo (Cecropia spp.), which supports birds like toucans and plays a pioneering role in forest regeneration; and Cocobolo (Dalbergia retusa), known for its dense, richly colored wood but also valued for supporting pollinators and mycorrhizal networks.

Other flora with medicinal and cultural relevance includes Guayusa, a caffeinated holly species used to brew stimulatory teas; Sangre de Drago, whose resin serves traditional medicinal purposes; and Chanca Piedra, an herb utilized for treating urinary tract ailments. Such ethnobotanical resources highlight the deep interconnection between biodiversity and human well-being.

Altogether, the diverse vegetation of the Osa Peninsula not only supports a staggering array of life but also underscores the ecological, climatic, and cultural value of protecting tropical rainforests in the Anthropocene era.

2.2. Faunal diversity and ecological interdependence

The Osa Peninsula serves as a vital refuge for one of the most diverse arrays of terrestrial and marine wildlife in the Neotropics. Its unique geographic location—bordered by the Pacific Ocean and laced with rivers, wetlands, and dense tropical rainforests—supports complex ecological interactions across land and sea. The region plays a critical role in the life cycles of numerous

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migratory species, including the scalloped hammerhead shark (Sphyrna lewini) and the humpback whale (Megaptera novaeangliae), both of which rely on the coastal waters and estuarine habitats as seasonal breeding and calving grounds.

Marine biodiversity in the surrounding waters is particularly noteworthy. Surveys have recorded 95 taxa spanning 11 phyla, 17 classes, 35 orders, and 53 families. Among sessile benthic organisms, turf algae dominate the seafloor, covering over 33% of the substrate. Other significant groups include crustose coralline algae (CCA) (15.1%), Peyssonnelia spp. (7.1%), and Dictyota humifusa, a brown macroalga (5.4%). Scleractinian corals contribute 13% of benthic cover, with key species such as Porites lobata, Pocillopora elegans, and Porites panamensis supporting essential reef structures. Soft corals (Alcyonacea), though less abundant (2.6%), add to the structural and biological complexity of these ecosystems, especially through species like Leptogorgia alba and Carijoa riisei [3].

The freshwater habitats of Corcovado National Park provide further biodiversity value, acting as nurseries for fish species that inhabit both inland and marine environments. Here, complex food webs link mollusks, crustaceans, and juvenile fishes, highlighting the continuity between riverine and coastal systems.

On land, the Osa Peninsula hosts an astonishing variety of wildlife. Over 400 bird species have been recorded, including emblematic and endangered species such as the scarlet macaw, harpy eagle, and several species of toucans and hummingbirds. These birds depend on mature forest canopies and fruit-bearing trees, which provide both nesting sites and critical food sources.

The peninsula's role as a biological corridor between marine and terrestrial systems cannot be overstated. From coral reefs and mangroves to cloud forests and lowland rainforests, the Osa Peninsula embodies a tightly interwoven ecological mosaic. Preserving this web of life is essential not only for maintaining biodiversity, but also for ensuring the resilience and functionality of ecosystems under increasing environmental pressures.

3. Ecotourism in Costa Rica: a model for sustainable development

Costa Rica stands as a global pioneer in ecotourism, with the sector forming a cornerstone of its economy. Ecotourism, defined as environmentally conscious travel to minimally disturbed natural areas, allows visitors to engage with nature and cultural heritage while fostering conservation, minimizing environmental impact, and actively supporting local communities. Through case studies, ecotourism in Costa Rica has been shown to enhance natural, sociocultural, economic, and political capital, creating a sustainable model for tourism development [4].

3.1. Economic and conservation impacts

In 1999, Costa Rica's protected areas attracted 866,083 domestic and international visitors, generating approximately US$2.5 million in revenue from admission fees and services. These funds support land conservation, species protection, and site maintenance. Ecotourism fosters a national consensus among Costa Ricans that environmental stewardship is a worthwhile investment. It also promotes environmental education for both tourists and local communities, encouraging active participation in conservation efforts. When implemented effectively, ecotourism minimizes ecological harm while providing economic benefits to sustain protected areas.

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3.2. Tourism growth

Data from the Costa Rica Tourism Board (ICT), based on Immigration Services Department records, indicates a significant rise in visitor numbers. In January 2011, 31,637 tourists visited the country, marking a 28.2% increase compared to the 24,677 visitors recorded in the same period of 2010. This growth underscores the increasing global appeal of Costa Rica's ecotourism model [5].

A prime example of ecotourism's positive impact is Lapa Rios, an ecolodge in the Osa Peninsula. Designed with sustainability at its core, the lodge has undergone minimal structural changes to preserve its remote setting and reduce environmental impact. The owners are deeply engaged in local education initiatives, supporting both conservation and community development. By prioritizing environmental preservation and cultural support, Lapa Rios exemplifies how ecotourism can harmonize tourism with the needs of native ecosystems and populations.

3.3. Historical deforestation and agricultural impacts

Despite Costa Rica's global reputation as a conservation leader, the nation experienced one of Central America's highest deforestation rates during the period when protected areas were being established. Agricultural expansion, driven by economic demands, played a significant role in transforming the country's landscapes.

Coffee cultivation, for example, a cornerstone of Costa Rica's economy, distinguished it from other Central American nations. In the Central Valley, surrounded by high mountains, dense forests and limited transportation infrastructure in the 19th century posed challenges for coffee transport. The conversion of pristine forests into agricultural land was driven by economic growth and international demand, reflecting a utilitarian view of nature rooted in overcoming colonial-era poverty through agricultural development [6].

Banana cultivation, requiring warm and humid conditions, expanded into the lowlands, particularly the Caribbean region. Unlike coffee, banana fields have a short productive lifespan of about seven years, and soil infertility caused by diseases necessitated continuous forest clearing for new plantations. Scholars, such as Evans, describe banana production as more environmentally destructive than coffee due to its transient nature. Abandoned plantations led to further environmental strain, as displaced banana workers settled in forested areas, engaging in subsistence farming and accelerating deforestation. Additionally, many former banana plantations were converted into palm plantations for palm oil production, altering landscapes.

As reliance on agriculture diminished, ecotourism emerged as a dominant economic force. This shift reduced the need for extensive agricultural land while transforming previously "unprofitable" areas, such as national parks and forest reserves, into valuable tourist attractions. Ecotourism promotes the preservation of intact ecosystems, generating renewable revenue and supporting conservation efforts that benefit both the environment and local communities. Healthy ecosystems are vital for sustaining human well-being and ensuring resources for future generations, though international conservation efforts are often driven by economic incentives rather than purely altruistic motives.

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4. Ecotourism in the Osa Peninsula: opportunities and environmental challenges

4.1. Economic and social benefits of ecotourism

Ecotourism is a cornerstone of the Osa Peninsula's economy, offering stable, well-paying jobs and greater opportunities for career advancement compared to other local industries. Defined as responsible travel that prioritizes environmental conservation, ecotourism supports small-scale, nature-based enterprises that drive sustainable development [7]. Organizations like Fundacion Corcovado play a pivotal role by funding community development, promoting environmental education, encouraging recycling initiatives, and supporting sea turtle conservation. One notable program is their environmental education and art initiative, which enables local elementary students to represent their communities in San Jose, fostering pride and awareness. Ecotourism also reduces socioeconomic disparities by improving access to resources, information, and training, thereby enhancing social capital and improving livelihoods for local populations.

4.2. Environmental challenges of ecotourism

Ecotourism, while offering substantial socioeconomic benefits, presents environmental risks that jeopardize the Osa Peninsula's biodiversity and ecological integrity [8]. Ideally, ecotourism should make clear and positive contributions to conservation efforts. However, achieving this in practice is complex, as the relationship between ecotourism and environmental protection can manifest in diverse and often indirect ways, such as through shifts in local livelihoods. For instance, a study near Corcovado and Piedras Blancas National Parks revealed conflicting outcomes regarding ecotourism's environmental impact. Large-scale ecotourism was found to generate economic benefits that could deter the conversion of forests into agricultural or pastoral lands. Yet, there was little evidence that participation in ecotourism-related activities influenced conservation attitudes or practices at the household level, primarily because the income generated was insufficient to discourage "consumptive" land uses, such as clearing forests for crops or grazing. Excessive tourist influx often leads to unsustainable resource exploitation and environmental degradation, a pattern observed in several protected areas across Central America. Enhancing community-based environmental education and engagement could significantly improve conservation outcomes around ecotourism projects, fostering greater local awareness of the non-consumptive value of natural resources.

Forest-based ecotourism projects directly affect the survival of wildlife, plants, and microorganisms within and beyond project areas. If these species are harmed, biodiversity loss can trigger irreversible damage to local ecosystems, reducing ecological stability and increasing vulnerability to collapse. For example, tourists may inadvertently introduce invasive species through actions such as releasing animals, discarding fruit pits or seeds, or carrying microorganisms. These invasive species can hybridize with native ones, leading to genetic exchange that compromises the genetic purity of local species and causes genetic pollution. Over time, this may result in the extinction of rare or endangered species. In some cases, invasive species proliferate unchecked due to the absence of natural predators, causing profound and lasting ecological imbalances.

Deforestation continues to pose a severe threat to the Osa Peninsula, historically driven by agriculture, cattle ranching, and mining, and now intensified by tourism-related infrastructure development, including roads, hotels, and other facilities. Between 1950 and 1990, Costa Rica suffered extensive forest loss, with forest cover reaching critically low levels in certain periods. For example, in 1987, deforestation rates in the towns of Puerto Jimenez and La Palma reached

DOI: 10.54254/2753-8818/2025.AU25570

approximately 70%. By 2000, Puerto Jimenez experienced an 11% increase in forest cover, while La Palma saw a comparable decline, largely due to divergent land use practices, with La Palma residents prioritizing agriculture and livestock farming. Tourism infrastructure development further exacerbates habitat destruction, endangering species such as the Central American squirrel monkey, whose Pacific lowland habitat has been diminished by urban expansion and agricultural activities, including banana, sugarcane, and rice cultivation.

4.3. Balancing ecotourism and conservation

Ecotourism has spurred community-led environmental education and participation, fostering appreciation for sustainable resource use and bolstering conservation efforts. However, mitigating its negative impacts requires careful planning. Strategies include stricter regulations on tourism infrastructure to minimize habitat disruption, enhanced anti-poaching measures, sustainable fishing practices, and climate-resilient conservation initiatives. By addressing these challenges, the Osa Peninsula can continue to thrive as a model for ecotourism while preserving its rich biodiversity for future generations.

When considering tropical rainforests, whether on islands or continents, ecological tourism presents a fascinating paradox, exerting both protective and detrimental influences:

Positive contributions to rainforest protection, economic Incentive for Conservation [9]. Well-managed ecological tourism provides a direct economic alternative to destructive practices like logging, agriculture, or mining. Local communities and governments can generate revenue from tourism, giving them a tangible reason to protect their rainforest assets. This financial benefit can fund park management, anti-poaching efforts, and community development projects that are aligned with conservation. Increased Awareness and Advocacy: By allowing visitors to experience the rainforest firsthand, ecological tourism fosters a deeper appreciation and understanding of these complex ecosystems. This direct engagement can transform tourists into advocates for rainforest conservation, influencing policy-makers and encouraging broader support for environmental protection efforts globally. It also creates employment opportunities for local guides, researchers, and conservationists, empowering them to become stewards of their natural heritage.

Potential negative impacts on rainforests, habitat Degradation and Disturbance: Even seemingly low-impact tourism can cause localized habitat degradation. Foot traffic can compact soil, damage delicate undergrowth, and disrupt sensitive animal behaviors. Construction of eco-lodges, trails, and observation decks, even if designed to be "eco-friendly," still involves some level of deforestation and habitat alteration, which can fragment continuous forest areas. Pressure on Biodiversity and Ecosystem Services: High visitor numbers can lead to increased demand for local resources (water, food, energy), potentially overstraining fragile rainforest ecosystems. Furthermore, repeated exposure to humans can stress wildlife, altering their natural behaviors, reducing breeding success, and increasing their vulnerability to disease. The introduction of waste, even biodegradable, can overwhelm natural decomposition processes, impacting the intricate balance of rainforest nutrient cycles.

5. Conclusion

Through analysis, ecotourism on Osa Peninsula has made significant contributions to environmental protection. From 1987 to 2000, the reforestation rate on Osa Island increased markedly, reflecting the initial success of ecological conservation measures. The rapid development of ecotourism in national parks has promoted economic growth while also exerting certain impacts on the local

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environment. However, the Osa Peninsula ecotourism project still has shortcomings in biodiversity conservation, as the large influx of tourists into pristine forests has had a considerable impact on forest ecosystems and wildlife populations [10].

To further optimize the sustainable development of ecotourism, future ecological risk assessments should comprehensively consider natural, economic, and social factors. Natural factors include land use rate for construction, per capita water resources, forest fire prevention and control, forest pest and disease management, prevention of meteorological and geological disasters, air quality, surface water quality, regional environmental noise, soil quality, forest coverage rate, species diversity, and urban green coverage rate. Social factors encompass the ratio of tourist reception to environmental capacity, local population growth rate, the completeness of laws and regulations, and the proportion of tourists with a college education or above. Economic factors include the rate of excellent air quality, wastewater treatment rate, harmless disposal rate of domestic waste, the proportion of local residents with high school education or above, and per capita GDP.

In summary, the Osa Island ecotourism project must strengthen biodiversity conservation and improve the ecological risk assessment system while promoting economic growth, to achieve a balance between ecological protection and tourism development, thereby providing a solid foundation for sustainable development goals.

References

[1] Benstead, J. P. . (1996). Macroinvertebrates and the processing of leaf litter in a tropical stream. Biotropica, 28(3), 367-375.

[2] Gibson, J. W. , & Gibson, J. W. . (1999). Balancing the books on conservation and development: transient corporate investment in golfito, costa rica. hku theses online, 21(230), 17-20.

[3] Hunt, C. A., Durham, W. H., Driscoll, L., & Honey, M. (2015). Can ecotourism deliver real economic, social, and environmental benefits? A study of the Osa Peninsula, Costa Rica. Journal of sustainable tourism, 23(3), 339-357.

[4] Lopez Gutierrez, B., Almeyda Zambrano, A. M., Mulder, G., Ols, C., Dirzo, R., Almeyda Zambrano, S. L., ... & Broadbent, E. N. (2020). Ecotourism: the 'human shield'for wildlife conservation in the Osa Peninsula, Costa Rica. Journal of Ecotourism, 19(3), 197-216.

[5] Driscoll, L., Hunt, C., Honey, M., & Durham, W. (2011). The importance of ecotourism as a development and conservation tool in the Osa Peninsula, Costa Rica. Center for Responsible Travel (CREST).

[6] Korsant, C. (2018). Environmentalisms in Practice: From National Policy to Grassroots Activism in Cost Rica's Osa Peninsula (Doctoral dissertation, Goldsmiths, University of London).

[7] Gutierrez, B. L., Almeyda Zambrano, A. M., Almeyda Zambrano, S. L., Quispe Gil, C. A., Bohlman, S., Avellan Arias, E., ... & Broadbent, E. N. (2019). An island of wildlife in a human-dominated landscape: The last fragment of primary forest on the Osa Peninsula's Golfo Dulce coastline, Costa Rica. Plos one, 14(3), e0214390.

[8] Ankersen, T. T., Regan, K. E., & Mack, S. A. (2006). Towards a bioregional approach to tropical forest conservation: Costa Rica's Greater Osa Bioregion. Futures, 38(4), 406-431.

[9] Lanier, P. (2014). The positive impacts of ecotourism in protected areas. WIT Transactions on Ecology and the Environment, 187, 199-209.

[10] Fletcher, R. (2013). Between the cattle and the deep blue sea: The Janus face of the ecotourism-extraction nexus in Costa Rica. In The Ecotourism-Extraction Nexus (pp. 69-87). Routledge..