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The role of butterfly sanctuaries in promoting biodiversity conservation and sustainable tourism management

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Abstract
Innovative conservation initiatives like butterfly sanctuaries have increasingly become promising models to reverse the ongoing existential threats posed by biodiversity loss and achieve sustainable tourism development. This literature review provides a comprehensive exploration of butterfly sanctuaries as effective environmental strategies of saving at-threatening lepidopteran species and conserving them and opportunities for economically viable ecotourism venture. The synthesis of primary data obtained from multiple sources, including global case studies, policy provisions, and empirical research in the past two decades contributed to the evidence promoted by this literature review. According to the review findings, butterfly sanctuaries offer successful strategies in conserving biodiversity through habitat restoration, community inclusion, scientific monitoring, and visitor education and generate economic benefits for the destination community.
The review looks at notable examples, such as the recently established Aralam Butterfly Sanctuary in Kerala's Kannur district, India, the Monteverde Butterfly Gardens in Costa Rica, and other Asian and African projects. According to analysis, butterfly sanctuaries create sustainable livelihood opportunities through ecotourism, promote in-situ conservation of native flora and fauna, and act as educational platforms for environmental awareness. But issues like the effects of climate change, financial limitations, and the complexity of visitor management call for flexible management techniques and strong legislative backing. The review comes to the conclusion that butterfly sanctuaries are effective models for balancing conservation objectives with aspirations for community development when they are planned and run-in accordance with best practices.
Long-term impact analyses, climate adaptation plans, and scaling techniques for reproducing effective sanctuary models in various ecological and socioeconomic contexts are some of the future research avenues. In addition to adding to the expanding corpus of research on nature-based remedies, this review offers useful advice for conservationists, legislators, and tour operators looking to carry out integrated conservation-tourism projects.

Keywords: Butterfly conservation, biodiversity protection, ecotourism, sustainable tourism, community participation, habitat restoration

Introduction

Background and Global Context

Innovative conservation strategies that combine ecological preservation with sustainable human development have been spurred by the escalating global biodiversity crisis. Butterfly sanctuaries, specialized protected areas that combine species-specific conservation, educational tourism, and community involvement, are among the most promising of these strategies. Butterfly conservation is important for reasons other than their aesthetic value. Because butterfly populations are sensitive to environmental change and can serve as early warning systems for ecosystem degradation, they are important ecosystem indicators that offer a window into the health of entire ecological communities.
But at their simplest, butterfly sanctuaries are examples of a transformation from archaic notions of conservancy to broader, interconnected notions of ecological concern, civic good, and financial viability. In reality, sanctuaries fulfil at least four critical roles in this world. They include protecting vital habitats utilized by endangered butterfly species, preserving original plant life used by lepidopteran species in their life cycles and reproductive behaviours, offering focal points about conservational issues that might be stressed on to the wider community, attracting economically viable ecotourism and related commercial interests.
Urbanization, intensified agriculture, habitat destruction, and climate change pose an unprecedented threat to butterfly diversity worldwide. With more than 180,000 known species worldwide, the Lepidoptera are one of the most diverse insect orders and are essential to food webs, pollination networks, and ecosystem function. According to recent studies, butterfly populations have decreased by 50% or more in many areas over the past few decades. Specialist species have seen especially sharp declines because of their unique habitat needs and restricted ability to disperse. (Chandra *et al*., 2023; Dhiman *et al*., n.d.) [12],(Checa *et al*., n.d.),(Singh *et al*., n.d.)

Conceptual Framework: Defining Butterfly Sanctuaris

Butterfly sanctuaries include an equally broad variety of protected and managed settings with a conservation focus primarily on lepidopteran species and the communities or habitats associated with those species. They can be legal protected areas, community-managed/owned conservation areas, butterfly gardens in city areas, or specific ecotourism sites. The important characteristics that indicate butterfly sanctuaries include: habitat management for butterfly life history dimensions, focus on native plant conservation, incorporation of research and monitoring, educational and interpretative programs, and often, tourism components for revenue generation to support conservation work.

The ecological function of butterfly sanctuaries is basically is to support viable target species populations through habitat protection, restoration and management this means protecting or recreating the specific micro habitat conditions needed for each life stage (egg-laying, larval host plants, adult nectar sources and overwintering). Good sanctuaries will maintain habitat heterogeneity, manage edge effects, control invasive species, and can frequently act as stepping stones or corridors setup with nearby protected areas.

The social and economic aspects of butterfly sanctuaries can be just as impactful as the biological ones and include community involvement, environmental education, and the production of sustainable livelihoods. Many successful butterfly sanctuaries engage local communities as stakeholders and beneficiaries, and provide training in conservation techniques, job opportunities in ecotourism, and a venue for the exchange of traditional ecological knowledge. The ecotourism element, if managed appropriately, provides economic incentives for conservation while improving awareness of biodiversity issues and the need to protect ecosystems.(Sanwal and Dhakate, n.d.),("Impacts of land use change on native plant-butterfly interaction networks from central Mexico [PeerJ]," n.d.),(Vairagade, 2024),(Majumder *et al*., 2013) [30],(Ashalatha, 2025) [6]

The Imperative for Biodiversity Conservation

The present crisis of biodiversity, usually called the "sixth mass extinction," requires bold and novel reactions to conservation. Butterflies, in particular, serve as strong indicators of the overall health of the ecosystem given their sensitivity to environmental change, their associations with specific plant communities, and their relatively short generation times, meaning any responses to environmental pressures can be demonstrated in the population relatively quickly. The population decline of butterflies often reflects larger ecological degradation impact multiple tact's and ecosystem services.

Biodiversity conservation involving butterflies is fundamentally linked to habitat conservation; most butterfly species are either reliant on specific host plants for reproduction or are reliant on very specific nectar sources, or may depend on specific conditions of the microclimate around the host plant for survival. By conserving butterfly diversity and abundance, a mosaic of diverse plants and natural structures will be maintained, providing a conservation benefit to many other species. The umbrella effect described above, where butterflies are used as flagship species to conserve all other biodiversity, is unique to butterfly conservation efforts.

Butterflies and their habitats contribute to ecosystem services that involve the pollination of wild plants, as well as crops; pest regulation via predation on herbivorous insects; and cultural services that are important for aesthetic and educational reasons. These habitats also provide the ecosystem services of climate regulation, soil formation and maintenance, and water cycle maintenance, especially if they include types of ecosystem habitats such as forest, grassland, or wetland. While it is challenging to accurately assess precise economic values for services provided by ecosystem services, the economic value is likely high and increasing as natural habitats continue to diminish globally.("(PDF) Distribution and Influences on Butterfly Diversity in Urban Park Green Spaces: A Case Study of Harbin, China," n.d.),(Singh *et al*., n.d.),("Aralam Wildlife Sanctuary – famous for butterfly wealth | Ecotourism Locations in Kerala," n.d.)

Sustainable Tourism and Nature-Based Experiences

Over the last few decades, the international tourism sector has witnessed rapid and sustained growth, with the nature-based and ecotourism segments growing particularly quickly. Tourism growth is a reflection of heightened interest in environmental matters, desire for authentic and educational experiences, and recognition that tourism can facilitate conservation. Butterfly tourism is considered a specialized sub-market within the broader ecotourism segment, attracting a wide audience, including wildlife enthusiasts, photographers, families looking for educational experiences and international travelers wanting to learn about local biodiversity.

The principles of sustainable tourism encourage minimizing adverse environmental and social effects while maximizing positive contributions to communities and conservation. In butterfly sanctuaries, these principles influence careful management of visitors on site, infrastructure development that minimizes disturbance to habitats, interpretive programs that aim to build environmental awareness, and economic models that provide most of the revenue generated from tourism to fund conservation and community development activities.

The possibility of butterfly sanctuaries playing a role in achieving sustainable development goals is high, especially in rural areas potentially lacking other livelihood options. Tourism businesses that are linked to butterfly sanctuaries can generate jobs for naïve guides, hospitality workers, artisans and technicians in conservation sectors. Supply chain opportunities for the sanctuaries can generate economic benefits while contributing to environmental conservation to include gardens and nurseries with native plants, organic food production, and sustainable craft activities.(Dhiman *et al*., n.d.),(Checa *et al*., n.d.),("(PDF) Distribution and Influences on Butterfly Diversity in Urban Park Green Spaces: A Case Study of Harbin, China," n.d.),(Fisher and Bradbury, 2023) [20], ("Events & Engagement Training Module Part 1 Transcript_FINAL.pdf," n.d.), (Molua *et al*., 2023) [32]

Biodiversity Conservation through Butterfly Sanctuies

1. Butterflies as Bioindicators

Due to their susceptibility to environmental changes and their quick response to modifications in habitat, butterflies have been used as bioindicators for an extended period. Butterflies generally have short life spans, restricted host plant range, and low rates of dispersal. This life history creates vulnerability for butterfly populations in relation to vegetation structure, microclimate conditions, and connectivity within landscapes. Sensitivity is part of the rationale for researchers and conservationists using butterfly monitoring as an early warning system to detect changes leading to eventual ecosystem degradation and stress to the environment more broadly.

Studies have found important relationships between butterfy diversity and community patterns of biodiversity in a diverse range of other taxonomic groups. Studies in diverse ecosystems have generally found that sites with high diversity of butterflies have high diversity of birds, mammals and other invertebrates (which may suggest that

protection for butterflies provides umbrella protection for communities of other organisms). Butterfly monitoring programs are more cost-effective than many other monitoring programs, and they have been shown to be manageable enough for long-term programs, making them applicable for feeding adaptive management of protected areas and restoration sites.

Though overshadowed by bees and other insects, the pollination services of butterflies can be very important for many plant species, especially in tropical ecosystems. Adult butterflies are present at flowers seeking nectar, but they are also contributing to cross-pollination for wild plant and cultivated species, aiding in the reproduction of plants and increasing genetic diversity. As such, the loss of butterfly populations can have cascading effects on plant communities and the ecosystem services they provide.(Dhiman *et al*., n.d.; Kemmerling *et al*., 2023) [27],(di *et al*., 2024)

2. Habitat Preservation and Restoration

Successful butterfly sanctuaries emphasize the protection and restoration of indigenous habitats that support full butterfly life histories. In general, native butterfly habitats require the management of diverse systems of plants that provide larval host plants and adult nectar plants, as well as suitable microhabitat considerations for mating, egg-laying, and overwintering. Habitat management strategies often include selective vegetation removal to maintain openings and edge habitats, control of invasive species, and restoration plantings with native plant materials. Butterfly habitat design should consider the spatial and temporal requirements of individual species, their migration routes in relation to seasonality, breeding territories, and patterns related to resource distributions. Successful sanctuaries create habitat heterogeneity by developing a variety of microhabitats ranging from open meadows to forest edge, in riparian zones, and at wetland margins. This heterogeneity supports a variety of species with different ecological needs and protects against environmental variances.

Restoration in butterfly sanctuaries often centers on attempting to recreate native plant communities that have been damaged or lost due to historical or previous land use activities. This process may involve soil remediation, collection and propagation of seeds, transplanting native plants, and ongoing maintenance to ensure successful establishment. The process for selecting which plant species to use for restoration is essentially based upon knowledge of the local butterfly fauna and their relationships with host plants. This process often entails the collaboration of a botanist, entomologist, and/or holders of local ecological knowledge.(Dhiman *et al*., n.d.),(Sanwal and Dhakate, n.d.),(Checa *et al*., n.d.),("Impacts of land use change on native plant-butterfly interaction networks from central Mexico [PeerJ]," n.d.), (Ashalatha, 2025) [6]

3. Conservation Education and Community Engagement

Butterfly sanctuaries can be impactful venues for educating the public and engaging the public in conservation action. Sanctuaries offer guided interpretation, tours, and activities that enable visitors to experience butterflies and their behavior, and to explore developmental stages and ecological relationships and to understand the links between habitat protection and conservation of biodiversity. The educational experiences can be a profound experience for visitors to appreciate natural world and to inspire environmental behavior.

Several successful sanctuaries have developed an extensive range of educational programs that cater to multiple audience groups, including school children, families, university researchers, and conservation practitioners. Educational activities may include classroom presentations, field workshops, citizen science excursions, and specialized training programs and field workshops for identifying and monitoring butterflies. Moreover, involving local community members as educators and guides offers an employment opportunity, while serving to integrate educational narratives that include traditional ecological knowledge.

Citizen science projects tied to butterfly sanctuaries have been particularly effective in widening monitoring coverage and generating public interest in conservation. Projects such as butterfly counts, migration monitoring, and phenology observations both allow volunteers to contribute valuable data while developing considered connections to conservation outcomes. These kinds of participatory projects enhance constituency support for sanctuary strategies and broad conservation efforts while offering scientific information that can be used for adaptive management.(Vairagade, 2024), (Lijun and Ahmed, 2024) [29],(Lemelin *et al*., 2019) [28],("The Butterfly Sanctuary of Mindo: Biodiversity and Beauty in Ecuador's Cloud Forest | Tourism Ecuador 24 | Our passion is tourism," n.d.),(Fisher and Bradbury, 2023) [20], ("Why the UK's butterflies are booming in 2025," n.d.), (Garraway *et al*., 2017) [21]

Butterfly Sanctuaries and Tourism Management

1. Ecotourism Models and Sustainable Practices

Butterfly facilities, as have butterfly safaris in particular, exemplify successful forms of ecotourism that balance visitor access with habitat protection and conservation-related goals. Such facilities provide educational, immersive opportunities based on participant observations of wildlife while educating participants about the local culture and ecology while also keeping to high standards of minimizing environmental, social, and economic impact. The most successful butterfly tourism enterprises tend to combine the authentic natural experience with quality interpretive and visitor services that allow for memorable experiences that encourage visitors to pay premium prices to experience, and repeat visits.

Important aspects of sustainable butterfly tourism are the timing of visits to coincide with seasonal butterflies, group sizes that minimize disturbance, viewing areas and trails that reduce impacts to delicate butterfly habitat, and an educational component that enhances visitor enjoyment while instilling awareness for their role in conserving the butterflies. Some sanctuaries engage local naturalist guides who add value by providing expertise in butterfly behavior and ecology and creating jobs and opportunities for local community members.

Butterfly sanctuaries prioritize low-impact design for infrastructure development to avoid fragmentation of habitat and disturbance to the environment. This may include walkways elevated above sensitive areas, strategically located viewing blinds, and visitor centers designed to be in

harmony with the natural environment. Water and waste management systems are usually designed to avoid pollution of adjacent habitats, and energy systems may use renewable technologies to reduce environmental footprints.(Dhiman *et al*., n.d.),(Checa *et al*., n.d.),("(PDF) Distribution and Influences on Butterfly Diversity in Urban Park Green Spaces: A Case Study of Harbin, China," n.d.),(Singh *et al*., n.d.),(di *et al*., 2024), (Molua *et al*., 2023) [32]

2. Economic Impact and Community Benefits

Tourism to butterfly sanctuaries provides local communities with diverse economic returns originating from direct job opportunities, business development, and multiplier effects in associated sectors. The direct job opportunities may be guides, interpreters, maintenance staff, and operational staff, and may also serve as stable, year-round income when these communities are accustomed mostly to seasonal work. The work itself may also create a need for local services, including accommodations, food service, transportation, and handicrafts.

Research into the economic impact of butterfly tourism operations has found substantial revenue generation and income distribution associated with these businesses. For example, successful butterfly farms and exhibition centers have generated gross revenue of hundreds of thousands of dollars in Central and South America and have employed dozens of community members. The economic benefits of butterfly exhibition and farming are significant especially in rural areas which may have limited economic alternative livelihoods, or where local economic activities conflict with conservation measures.

The development of value-added products and services related to butterfly sanctuaries further increases economic benefits. These may take the form of growing and selling native plants for butterfly gardens, creating educational materials or merchandise, offering photography workshops and tours, and also developing unique experiences for different market segments. Revenue sharing mechanisms that direct tourism revenue into conservation activities help to ensure the sustainability of economic and ecological outcomes in the long term. (Dhiman *et al*., n.d.; Kemmerling *et al*., 2023) [27],(Lemelin *et al*., 2019) [28],(Fisher and Bradbury, 2023) [20], (Jhajhria, n.d.), (Warren *et al*., 2021) [46], (Garraway *et al*., 2017) [21].

3. Visitor Management and Infrastructure Development

An effective visitor management system at butterfly sanctuaries will require a delicate balance between providing an acceptable experience while protecting sensitive habitats and species. This often means using carrying capacity guidelines based on habitat quality and butterfly behavior, using seasonal closures during sensitive times (e.g., breeding, migration) and designating floors for observation, where behaviors are affected as little as possible while maximizing opportunities to observe.

Planning and upkeep of trails are important parts of managing visitors, as trails are intentionally located to give access to different types of habitats while generally avoiding the most sensitive areas. Through interpretive signs, and appropriate protocols attached to guided tours, visitors are informed about important behavioral guidelines, such as not collecting anything, taking flash photography, and not going off-trail. Many sanctuaries use timed entry or reservations to manage visitor flow, especially to avoid peak periods of crowding.

Infrastructure development should take into account the wide range of needs of visitors while still upholding environmental sustainability. This means accessible facilities so visitors with mobility limitations can gain access, appropriate safety parameters for visitors from diverse age groups, and weather protection to allow operations year-round. While visitor centers and interpretive facilities often provide some level of infrastructure for host educational programming, they create a controlled space for showing live butterflies and educational content.(Dhiman *et al*., n.d.),("De huisstijl van De Vlinderstichting, Titel, ook wel kop 1," n.d.),(Singh *et al*., n.d.),(di *et al*., 2024)

Case Studies and Empirical Research

1. Aralam Butterfly Sanctuary, Kerala, India

In 2025, India bestowed international recognition to the Aralam Wildlife Sanctuary in the Kannur district of Kerala, as it became the first officially designated butterfly sanctuary with ratification from the Government of India after 25 years of studies and conservation, as referenced As a member of the Western Ghats biodiversity hotspot, the 55-square-kilometer Aralam Wildlife Sanctuary has been monitored and studied to support more than 266 species of butterflies, approximately 80% of the total butterfly diversity of Kerala, and nearly 18% of the total species of butterflies present in India. Included in this remarkable diversity are 27 species that are known to be endemic to the Western Ghats and six species classified under Schedule I of the Wildlife Protection Act of India, which underlines the relevance of the sanctuary for conservation. The sanctuary's main spectacle occurs between December and February each year, which is the seasonal migration of Common Albatross butterflies (Appius Albina). In studies of the sanctuary's butterfly migrations, researchers have observed peak activity where 300,000 to 400,000 separate individuals were recorded crossing the sanctuary in one day. This spectacle and spectacle is a rare wildlife experience for India. These butterflies migrate down approximately 1,600 m. to 60 m. above sea level and gather along the banks of Cheenkannipuzha River where they mud-puddle to attain minerals.

The conservation achievements at Aralam represent the culmination of 25 years of collaboration with the Kerala Forest Department and Malabar Natural History Society, initiated in the year 2000. The project involved collaboration with more than a thousand butterfly observers, research students, and citizen scientists in multiple years - a collaborative that has now constituted one of the largest community-based butterfly monitoring projects ever in India to date. This project has provided a systematic monitoring of the butterfly population, their migratory variation, and habitat preference resulting in local conservation and scientific knowledge. While ensuring the protection of habitats, the tourism potential of Aralam has been handled in terms of visitor access. The Annually occurring Butterfly Migration Study camps occur on the times of peak migration and continue to attract nature photographers, researchers, and wildlife enthusiasts from India and beyond. These camps generate a significant amount of revenue to the camps depending on accommodation, guiding, and other nature-based activities, which is visited by adjacent local communities but must adhere to visitor policy and protection guidelines.

The management style of the sanctuary shows a successful organizational structure that incorporates habitat protection, science, and local engagement. Conservation successes include the continued conservation of tropical and semi-evergreen forest regions, continued protection of migration corridors between breeding sites located in the high mountain areas and feeding areas located in the lowland areas, contributions to butterfly taxonomy and ecology through the documentation of species, and impacts on national conservation policy by proving the efficacy of a species-specific protected area.("Aralam Butterfly Sanctuary, Vegetation, Latest News," n.d.), ("Aralam Butterfly Sanctuary – GKToday," n.d.), ("Aralam to be Kerala's first Butterfly Reserve, boosting eco-tourism and conservation," 2025), ("Rare Species of Butterflies in Aralam - BuzzOnEarth," n.d.), ("Aralam Butterfly Sanctuary - Wikipedia," n.d.), ("The Guide," n.d.),

2. International Examples: Costa Rica and Southeast Asia

The Monteverde Butterfly Gardens in Costa Rica illustrate effective conservation, education, and tourism in a tropical cloud forest ecosystem. The gardens were founded in the 1990s and provide live butterfly exhibits combined with conservation of their native habitat, which have become a model for butterfly tourism around the world. The establishment operates breeding programs for native species in addition to an educational experience for over 100,000 visitors each year, resulting in considerable income for local conservation efforts and community development. The Monteverde approach prioritizes quality interpretation, provided by undertrained educators, when providing guests with information regarding butterfly biology, ecology, and conservation. The establishments features contain a enclosed exhibit area as well as some areas representing a habitat, both of which allows visitors to observe butterflies in separate contexts by supporting research and breeding programs. All revenue from the tourism operations goes directly towards the benefit of habitat restoration, species monitoring, and community education programs throughout the Monteverde region.

Comparably successful models have been created in Southeast Asia, such as butterfly farms and conservation centers in Malaysia, Thailand, and the Philippines, often combining butterfly breeding for export markets along with ecotourism and conservation activities, with multiple sources of income supporting long-term stability and sustainability for the operations. Increasingly, the integration of traditional ecological knowledge and science-based conservation efforts has shown to be especially relevant to success in culturally diverse regions.(Sanwal and Dhakate, n.d.), ("Butterfly Garden Volunteer Project in Costa Rica," n.d.), ("The Majestic Butterflies of Costa Rica," n.d.), ("MONTEVERDE BUTTERFLY GARDENS (2025) All You Need to Know BEFORE You Go (with Photos)," n.d.), ("Conservation and Management of Monarch Butterflies - A Strategic Framework," n.d.), (Masberg and Morales, n.d.), (Chacon *et al*., 2025) [11]

Challenges and Limitations

1. Climate Change Impacts

Climate change continues to pose serious and growing risks to butterfly refuges worldwide, such as shifts in butterfly distributions, altered phenology and migration timing, and an increase in the frequency of extreme weather events. Changes in temperature and precipitation can disrupt the carefully-managed conditions in which butterflies are used to living, break the synchronicity between butterflies and their host-plant larvae, and impact the success of other conservation measures that have been established. Butterfly species that have narrow thermal tolerance ranges are particularly at risk of increased temperature. Precipitation that is changing, and can change in the future, can harm not only larval host plants but also adult nectar sources. Phenological mismatches between the emergence of butterflies and peak flowering of nectar plants is an increasing concern for managers of sanctuaries and other conserved areas. When the timing is misaligned, reproductive success and/or survival rates can drop, and exacerbated harm can be caused to conservation efforts, despite well-managed habitats. To further complicate matters, extreme weather events (i.e., extended droughts, heavy storms, and excessive heat) can inflict direct mortality and habitat degradation that takes time to recover. Climate resilience adaptation tactics include diversifying plant communities to provide resources over an extended season, strategically designing habitats to create microclimate refugia, and initiating seed banking and ex-situ breeding programs for vulnerable species. In addition, some sanctuaries are undertaking assisted migration programs to support species in tracking suitable climate conditions as they change location. ("India's First Butterfly Sanctuary Declared in Kerala - Current Affairs Usthadian Academy," 2025) [25], (Ragab *et al*., 2025), ("Butterflies at massive risk from climate change | Butterfly Conservation," n.d.)

2. Funding and Sustainability Challenges

Sustainability of funding represents an ongoing struggle for many butterfly sanctuaries, particularly for those in developing countries with either minimal or seasonal tourism markets. Start-up costs to restore habitat, create infrastructure, and train staff can be large; funding for ongoing operational expenses, including maintenance, monitoring, and educational programming, requires ongoing sources of funding. Many sanctuaries rely significantly on entrance fees and revenue from tourism; however, they do so at the cost of being vulnerable to external shocks, such as economic collapses, government instability, or health emergencies that decrease visitation to the sanctuaries.

Grant funding from biodiversity agencies, governments, and philanthropic parties frequently offers important support to develop and maintain sanctuaries. However, most of this funding is project-based, and time-limited, which complicates long-term planning and continuity for the conservation of species. Repeatedly having to pursue and seek funding can detract management attention away from conservation and educational programs.

Successful sanctuaries utilize a range of funding strategies that include tourism, grants, donations, educational programming, and sales of plants or educational products. Some have developed an endowment fund or partnership agreements that provide for more stable long-term funding. Strengthening support from local communities and the government has also been important for financial sustainability and stability.("Impacts of land use change on native plant-butterfly interaction networks from central Mexico [PeerJ]," n.d.),(Majumder *et al*., 2013) [30], (Warren *et al*., 2021) [46], ("Events & Engagement Training Module Part 1 Transcript_FINAL.pdf," n.d.)

3. Visitor Management and Over-tourism Risks

Though tourism generates important revenue for butterfly sanctuaries, uncontrolled visitation can deplete those resources that attract visitors to begin with. Excessive numbers of visitors to butterfly parks can result in trampling, disturbance of sensitive species, introduction of invasive species, and/or deterioration of the natural experiences that draw ecotourists in the first place. Peak visitation occurs in concentrated time periods, which can often be when butterflies are their most vulnerable (i.e., breeding seasons, migration, etc.).

Infrastructure improvements to manage increasing visitor numbers can also divide habitats and change ecosystem dynamics if not developed in sustainable and equitable ways. The need to generate profits can provide incentives to go over sustainable carrying capacities, or develop facilities in ecologically sensitive locations. Additionally, encouragin g and advertising butterfly spectacles, often can result in unanticipated spikes of visitors that can be difficult to manage.

Examples of effective strategies to manage the impacts of tourism on sanctuaries include: establishing science-based carrying capacity limits, putting in place a reservation system to limit visitor flows, provides alternate opportunities to view animals so as not to concentrate multiple impacts at a single viewing opportunity, limiting visitor behavior by established codes of conduct and/or monitoring occupancy with staff. Some sanctuaries have engaged in tiered access systems that increase fees for premium experiences that allow them to maintain both revenue while also limiting numbers of visitors. Monitoring of ecological and social impacts continuously is critical for developing adaptive management.(Dhiman *et al*., n.d.),(Singh *et al*., n.d.), (Ashalatha, 2025),(di *et al*., 2024) [6]

Integrated Approaches and Policy Support

1. Governance Frameworks and Institutional Arrangements

To successfully develop a butterfly sanctuary, there needs to be supportive governance frameworks which integrate goals of conservation, tourism and community-based development. In most cases, there will be some need for formal coordination from more than one governmental organizational agency with representation from various stakeholders (e.g., wildlife management authorities, tourism boards, local government, research institutions, and community organizations). Protectiveness and responsibilities will vary, so you will have to have a clear legal framework for both the establishment and operationalization of your sanctuary and the provision of long-term protectiveness and security.

Many successful sanctuaries operate under co-management agreements that incorporate a combination of government management, community involvement and action, and NGO technical support. Co-management arrangements can take advantage of local and external expertise, tap into suitable resources to achieve goals, and importantly, incorporate local needs and knowledge into management decisions. Successful co-management arrangements use governance arrangements that delineate roles and responsibilities in a clear and transparent manner to reduce management conflict and ensure accountability in sanctuary management. There are numerous international treaties and agreements, such as the Convention on Biological Diversity, that provide useful policy guidelines for butterfly protection and can help to mobilize additional funding and technical capacity to establish or renew refuges. In addition, national biodiversity strategies and action plans increasingly recognize the value of butterfly refuges as tools to advance conservation objectives and sustainability initiatives.(Lijun and Ahmed, 2024) [29], ("Table of contents," n.d.), (Zeeshan *et al*., 2017) [49]

2. Policy Integration and Mainstreaming

Successful butterfly conservation will need to be integrated across policy areas of environment, tourism, agriculture, and rural development. By taking the mainstreaming approach, the aims associated with butterfly sanctuaries will be supported by broader policy frameworks, and potential issues or conflicts with other land uses would be resolved proactively. Conversely, tourism-related policies which promote sustainable and community-led initiatives can form complementary support for the establishment and operation of butterfly sanctuaries.

The significance of agricultural and land use policies for the purpose of butterfly preservation is somewhat distinct in that farming practices in habitats surrounding sanctuaries may greatly influence their effectiveness. Policies facilitating pollinator-friendly farming, reducing pesticide usage, and maintaining connectivity of habitats could create landscape scale advantages for butterfly conservation. Some regions have developed agri-environmental schemes that promote payments/bounties to farmers for adopting butterfly-friendly practices.

National biodiversity plans are increasingly acknowledging butterflies as indicator species for ecosystems and incorporate specific goal setting and actions for butterfly habitat protection. These strategic frameworks serve to foster coordination of action among multiple government agencies, and provide direction for resource prioritization and allocation.(di *et al*., 2024), (Ethiopian Biodiversity Institute, Addis Ababa, Ethiopia and Gebrenariam, 2025), (Yust, n.d.)

Research Methodology

1. Study Site and Baseline Data Collection Methods

The base data collection was conducted at Aralam Farm, a 1,530-hectare government-owned agricultural site located in the eastern part of the Western Ghats in the Kannur district of Kerala. The project focused on a 55.8-acre tourism zone within the farm that varied in elevation from 50 meters to 1,145 meters above sea level. The site was characterized by a humid tropical climate, with annual temperatures varying from 8°C to 40°C and annual rainfall between 2,500 mm and 5,000 mm, having a dry period from December to mid-May. The study site had varied habitat types including plantations (coconut, cashew, rubber, cocoa, and arecanut), open grasslands, shrub patches, wooded areas, semi-cultivated areas, natural forest patches, and perennial streams.

Baseline data collection for the development of a butterfly sanctuary at Aralam Farm included several integrated methodologies using field surveys, habitat assessments, and spatial analyses. The methods consisted of five overall components:

1. spatial mapping of the tourism area applying GPS and geospatial tools,

2. systematic surveys and documentation of host plants,
3. habitat classification and characterization,
4. biodiversity assessment, and
5. site layout for sanctuary design.

These methodologies were constructed to provide thorough baseline information required to make informed decisions regarding establishment of a butterfly sanctuary and sustainable development of tourism.

2. Spatial Mapping and Habitat Classification

An area of 55.8 acres within the Aralam Farm study site was fully mapped and delineated using GPS Waypoint app and Google Earth and with help of local guide. The mapping process established a 2-kilometer boundary around the designated tourism area that would account for butterfly movement corridors and habitat connectivity. Digital maps were developed to illustrate landscape features, examine patterns of existing vegetation, mark host plants and nectar sources, and identify areas suitable for particular sanctuary components. The spatial framework provided the critical foundation for habitat assessment and layout planning activities.

The area of study was purposely divided into different types of habitats according to vegetation structure, land use history, and ecological characteristics. The main habitat types included, and have been mapped to include, four general categories:

1. open grassland with low herbaceous vegetation for basking and foraging habitat;
2. shrub patches containing shrubby vegetation for shelter with intermediate canopy layers;
3. wooded trees providing nectar sources and microclimate diversity;
4. semi cultivated with agricultural plantation and native vegetation.

This habitat classification was useful for identifying suitable microsite conditions for sanctuary establishment, designing ecologically informed layouts, and understanding the heterogenic habitat characteristics needed to support a wise diversity of butterflies.

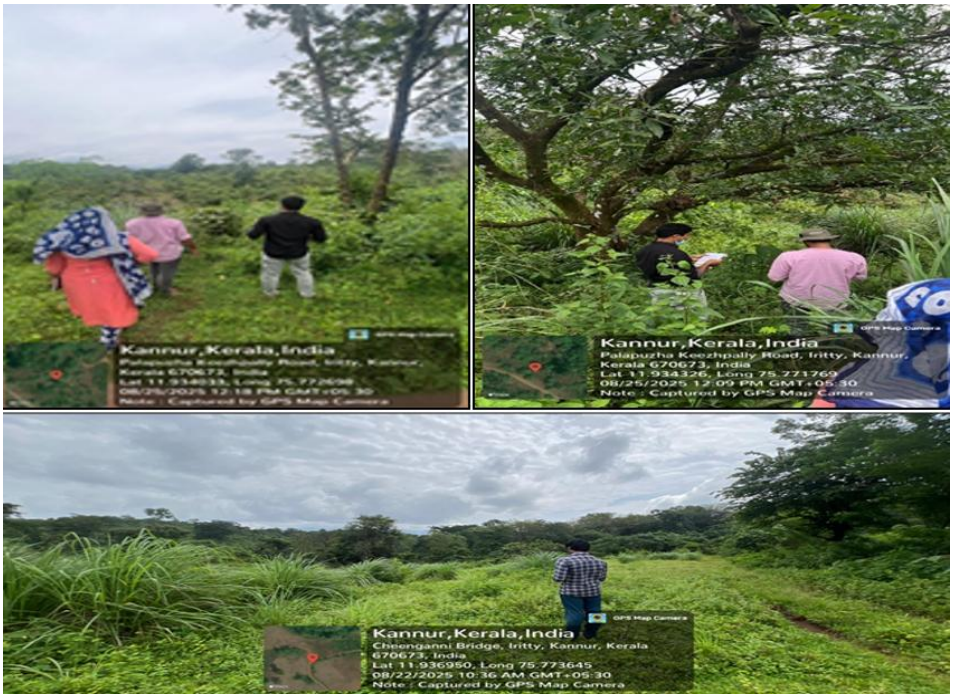


Fig 1: Area of mapping for Tourism Location

Fig 2: Spatial Mapping of Tourism Location

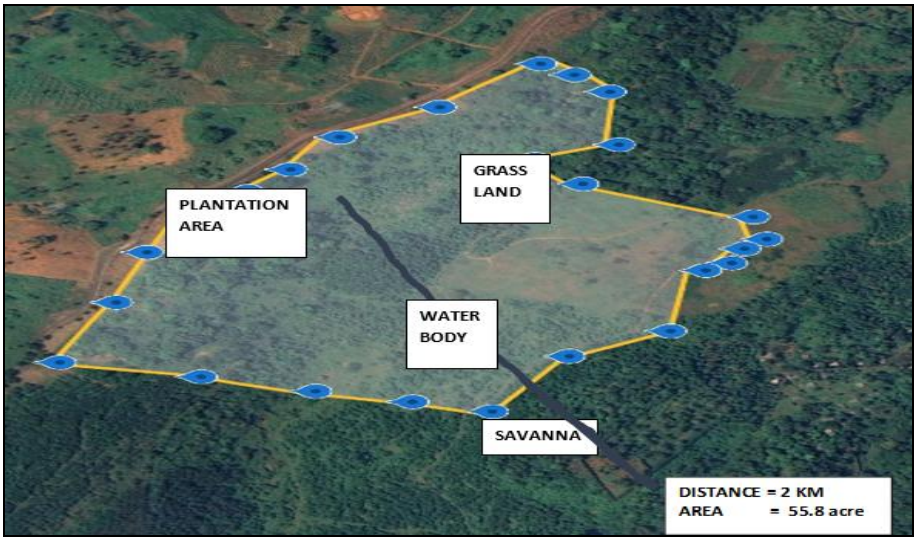


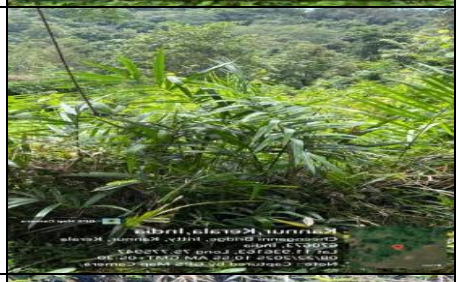
Fig 3: Habitat type Mapping

3. Host Plant Survey and Documentation

A detailed field survey was implemented to identify, inventory and geo-map host plant species within the 55.8-acre study area. Host plants are species in which butterflies lay their eggs and the larva feed on the foliage thus completing their reproductive cycle and supporting population sustainability. Fourteen host plant species were identified and recorded with scientific and common names, photographs, and geo-coordinates during the survey. Host plant species included: Mangifera indica (mango), Glycosmis pentaphylla (paanal), Calotropis gigantea (erukka), Acacia caesia (injja), Cinnamomum verum (karuva), Terminalia paniculata (maruthe), Gliricidia sepium (sheema konna), Calamus rotang (chooral), Bambusa vulgaris (mula), Artocarpus hirsutus (anjili), Cinnamomum malabatrum (vatti), Psychotria flavida (kaattu kaapi), Indigofera tinctoria (neelam), and Urena lobata (chotti). Each of the identified host plants was mapped spatially and marked on a digital map for planning habitat enhancement activities and identifying any gaps in host plant species found in the study area.

Table 1: Existing Butterfly Host plants

Si no	Plant name (scientific name)	Malayalam name	Butterfly species	Plant image tagged
1	Mangiferaindica	മാവ്	·Common Baron (*Euthaliaaconthea*) ·Common Ciliate Blue (*Antheneemolus*) ·Common Imperial (*Cheritrafreja*)	
2	Glycosmispentaphylla	പാണൽ	·Common Lime (*Papiliodemoleus*) ·Common Mormon (*Papiliopolytes*) ·Common Ciliate Blue (*Antheneemolus*)	
3	*Calotropisgigantea*	എരിക്ക്	·Plain Tiger (*Danauschrysippus*) ·Striped Tiger (*Danausgenutia*) ·Blue Tiger (*Tirumalalimniace*)	

4	Acacia caesia	ഈഞ്ച	·Common Acacia Blue(*Surendraquercetorum*)	
5	Cinnamomumverum	കറുവ	·Common Mime (*Chilasaclytia*) ·Common Bluebottle (*Graphiumsarpedon*) ·Common Imperial (*Cheritrafreja*)	
6	Terminaliapaniculata	മരുത്	·Cupithapurreea (Wax Dart) ·Antheneemolus (Common Ciliate Blue) ·Arhopalaalea (Sahyadri Rosy Oakblue)	
7	Gliricidiasepium	ശീമക്കൊന്ന	·Common Grass Yellow (*Euremahecabe*	
8	*Calamusrotang*	ചൂരൽ	Giant Redeye (*Gangarathyrsis*)	
9	Bambusa vulgaris	മുള	·Common Branded Redeye (*Matapa aria*) ·Indian Dart (*Potanthusconfucius*) ·Common Swift (*Borbocinnara*)	
10	*Artocarpushirsutus*	അഞ്ഞിലി	·Common Baron (*Euthaliaaconthea*)	

11	*Cinnamomummalabatrum*	വറ്റി	Common Bluebottle (Graphiumsarpedon) Malabar Banded Peacock (Papiliobuddha) Southern Birdwing (Troidesminos)	
12	*Psychotriaflavida*	കാട്ടുകാപ്പി	Common Palmfly (Elymniashypermnestra) Jezebels (Delias spp.)	
13	*Indigoferatinctoria*	നീലം	Pea Blue (Lampidesboeticus) Gram Blue (Euchrysopscnejus) Plains Cupid (Chiladespandava)	
14	*Urenalobata*	ചൊട്ടി	Malabar Raven (Papiliodravidarum) Common Rose (Pachlioptaaristolochiae)	

Fig 4: Host Plant Spatial Mapping

4. Sanctuary Design and Recommended Nectar Plants, Host plants

Using the baseline data provided, a more elaborate design for a butterfly sanctuary on one acre of land within the mapped extent of the tourism area was developed. The sanctuary design included multiple functional design components:

1. host plant areas for reproduction;

2. flowering plants with nectar to provide nutrition for adult butterflies;
3. basking areas that had open sunny space for thermoregulation;
4. shaded resting areas that provided cover.
5. mud-puddling areas that had moisture-retaining substrates for obtainment of minerals.
6. visitor paths and trails with low impact on habitat.
7. sites to observe and interpret.
8. visitor amenities which included trails, benches, demonstration sites, and information boards that were made of organic material for interpretation of the site. The sanctuary was designed to also incorporate year-round flowering and nectar availability through the selection of plants.

Considering both the habitat requirements of butterflies and the climate of Aralam, several nectar-producing plant species were suggested for the creation of a sanctuary and enhancement of habitat. Suggested nectar plants included: Christmas Jasmine (manimulla), West Indian Lantana (aripoo), Blue Snakeweed (sheemakongini), multi-variety roses, Zinnia dwarf, Oleander (arali), false heather, and cat's claw creeper. These species were evaluated on their flowering phenology, nectar production, appeal to general butterfly diversity, and compatibility with the climate of the Western Ghats. The inclusion of host plants for butterflies, nectar plants, and structural habitat components provided a more robust butterfly habitat meeting complete needs for life cycle and providing visitors with a meaningful experience.

The intention of the butterfly sanctuary, designed for Aralam, is to create ecological and visitor value to an area of one acre. The layout and features have been planned thoughtfully to provide a primary path and many points of interest, with seating and varied planting designs that will enable continual flowers and nectar for the butterflies throughout the year. Visitors will have shaded rest areas under circular viewpoints adorned with catsclaw umbrellas and benches, with triangular lawns in the corners, for aesthetic beauty. Also, basking areas, wood perches and a hut for unobstructed 360-degree viewing will provide visual attraction.

Host plant as: Ficusbenghalensis (peral), Sacred fig (arrayal), Hydnocarpuskurzii (marotti), Citrus sinensis(narakam), Guava tree (pera), cashew, Champak (chembakam), and Golden shower tree (kanikkana) - not only adds biodiversity, but it also creates a protective green boundary for the sanctuary. The entrance landscaping with palm tree adds cultural flavor, creating a melding of culture with conservation

Overall, this sanctuary design attempts to balance ecological sustainability with tourism potential. This will provide a natural habitat for butterflies, foster environmental stewardship, and be a refreshing recreation area for people. This project can serve as a model for eco-friendly tourism in Aralam that brings together conservation education and community in an integrated setting.

Fig 5: Area clearing for boundry fencing

Table 2: Recommended Nectar Plants, Host plant

SI NO	Host plant	Nector plant
1	Sacred fig (Arayal)	Christmas Jasmine (manimulla)
2	Ficusbenghalensis (Peral)	West Indian Lantana (aripoo)
3	Cluster fig tree (Athimaram)	Blue Snakeweed (sheemakongini)
4	Hydnocarpuskurzii (Marotti)	Multi variety rose
5	Golden shower tree (Kanikonna)	Zinnia dwarf
6	Citrus sinensis (Narakamverigates)	Oleander (arali)
7	Guava tree (Peraverigated)	False heather
8	Cashew plant (violet leaf)	cat's claw creeper
9	Date palm	
10	Foxtail palms	
11	Bamboo (Verigated)	
12	cat's claw creeper	
13	Champak (Chembakam)	

Conclusion

Summary of Key Findings

This review provides evidence that butterfly sanctuaries offer strong models for combining biodiversity conservation through effective sustainable tourism. The research clearly demonstrates that butterflies and their habitat can be effectively conserved through well-designed and well-managed butterfly sanctuaries, while providing substantial economic and educational benefits to local communities. Which as demonstrated in flagship examples across the globe, such as Aralam Butterfly Sanctuary in India and Monteverde Butterfly Gardens in Costa Rica, we have confidence that there are opportunities for scaling these approaches across various ecological and socio-economic contexts.

Sanctuary success is driven by important factors that include

a strong scientific basis for habitat management, meaningful community involvement in planning and operations, diverse funding mechanisms that enable less reliance on single funding stream, adaptive management to respond to dynamic conditions, and a policy framework that aligns conservation and tourism goals. The intersection of research, education and conservation creates synergies and amplifies the benefits across all three sectors.

While the issues facing butterfly sanctuaries are not trivial, they can be dealt with through sound planning, adaptive management and continual modification of conservation and tourism activities. Adaptation to climate change may lead to a greater focus on habitat connectivity, mobility of species and ecosystem resilience. Financial stability can be improved through diverse income strategies as well as enhanced institutional cooperation. (New *et al*., n.d.), (Bello, 2021) [8], (Baral and Dhungana, 2014), ("habitat-conservation-planning-handbook-chapter-10.pdf," n.d.)

Implications for Conservation and Tourism

Butterfly sanctuaries are successful as butterfly sanctuaries, but have implications beyond butterflies, with potential valuable outcomes for conservation and the tourism industry. These models demonstrate that charismatic species can be helpful flagships for conservation at the ecological level, and they can provide a clear benefit to people. It is the educational and inspiring experience of encountering butterflies (more so than other species), that can generate the greatest public advocacy for conservation actions and policy-supporting environmental issues.

In the tourism industry, butterfly sanctuaries demonstrate the commercial potential of high quality, educational nature-based experiences. The success of these operations shows that tourists are willing to pay a premium for a high-quality experience in a natural setting, engaged with wildlife, when it is combined with good quality interpretation and service. This model may work with other niche types of wildlife tourism, which focus on insects, birds, or other taxonomic groups.

The community development outcomes that stem from successful sanctuary operations back up the benefits of well-planned ecotourism in reducing poverty and improving livelihoods. The integration of local capacity building, traditional knowledge and equitable benefit sharing can provide indicators for sustainable tourism development in general. (Dhiman *et al*., n.d.),("De huisstijl van De Vlinderstichting, Titel, ook wel kop 1," n.d.),(Ashalatha, 2025) [6],(Hângan *et al*., 2024) [23]

Future Research Directions

This review identifies a few important research priorities. There is a need for studies that monitor over the long-term, to measure the efficacy of various sanctuary management plans and their impacts on butterfly populations and overall ecosystem health. There is also a need for economic impact studies that utilize standardized approaches to help quantify the economic benefits of butterfly sanctuaries and support business cases for their development.

Research on climate change adaptation should focus on determining the most effective means of preserving sanctuary effectiveness to changing Environmental conditions. Research might include studies of species range shifts, phenological shifts, habitat resilience, and evaluation of assisted migration and ex-situ conservation approaches to enhanced species persistence. Alternatively, research on visitors' behaviors and the minimization of impacts can provide a foundation for improving tourism management while reducing ecological consequences when tourism development occurs.

The goal of comparative studies across regions and sanctuary types would identify the most generally useful management principles and approaches. The studies would also include the assessment of different governance models, funding models, and different community engagement strategies. The establishment of standardize monitoring practices and impact assessment will allow for greater opportunity for comparison and learning across different sanctuary management organizations. (Dhiman *et al*., n.d.; Kemmerling *et al*., 2023) [27],(Singh *et al*., n.d.),(di *et al*., 2024)

Final Recommendations

The evidence discussed here suggests a number of practical recommendations for conservation practitioners, policy makers, and tourism providers interested in developing butterfly sanctuaries. First, sanctuary planning must be based on a solid scientific foundation of the local butterfly fauna, their habitat requirements and the relevant ecosystem dynamics. In addition, it is important to involve the local community from an early stage in the planning process and continue such involvement up until the development and operation phases of the sanctuary.

For long-term sustainability, myriad funding strategies that draw from several revenue sources are needed. This should include, where possible, the development of endowment funds, corporate partnerships, and funding from government support mechanisms. When funding partnerships are established, an adaptive management framework that includes regular monitoring and evaluation is essential to responding to changing conditions and better succeeding over time.

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