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The 'Tri Hita Karana' Ecotourism Approach For Sustainable Marine Resource Management And Tourism in Bali

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***Abstract*— Marine ecotourism in Bali is vital for integrating environmental conservation, cultural preservation, and community empowerment. Despite its potential, sustainability efforts face significant challenges, including coral reef degradation, coastal erosion, marine pollution, and gaps in policy implementation. This study aims to evaluate the application of the Tri Hita Karana philosophy as a holistic framework to address these challenges in Bali's marine ecotourism sector. A literature review method was used, synthesizing peer-reviewed studies, government reports, and case examples from major ecotourism sites such as Nusa Penida and Perancak Mangrove Forest. The results demonstrate that the Tri Hita Karana philosophy effectively integrates ecological, social, and cultural dimensions. Successful initiatives include coral reef restoration and community-based conservation programs that enhance biodiversity and support local economies. However, challenges such as inconsistent policy enforcement, visitor overcapacity, and infrastructure pressures remain significant. This study concludes that adaptive management strategies, including capacity assessments, collaborative governance, and technology integration, are essential to ensure the long-term sustainability of marine ecotourism in Bali. The findings contribute to the global discourse on sustainable tourism, offering Tri Hita Karana as a model adaptable to other culturally rich and ecologically sensitive regions.**

Keywords—marine ecotourism, Tri Hita Karana, sustainable tourism, Bali, biodiversity conservation

I. INTRODUCTION

Ecotourism is one of the primary approaches in tourism that integrates environmental sustainability, community development, and cultural preservation. This concept has evolved into a global strategy to address significant challenges such as climate change, ecosystem degradation, and social inequality [1]. Bali, as Indonesia's leading tourism destination, holds great potential to become a global model for culturally and environmentally sustainable ecotourism. However, challenges such as increasing pollution, declining environmental quality, and pressure on natural resources have become major obstacles to achieving sustainable tourism. According to the Ministry of State Secretariat of the Republic of Indonesia, this situation emphasizes the urgent need to develop more sustainable tourism management systems.

Based on Regulation No. 9 of 2021 issued by the Ministry of Tourism and Creative Economy, sustainable tourism must consider ecological, economic, and socio-cultural aspects in the utilization of natural and cultural resources. While Bali possesses extraordinary potential for developing culturally based ecotourism, its

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management still faces numerous challenges. These include marine ecosystem degradation, conflicts over resource utilization, and pressures from uncontrolled infrastructure development. These issues not only threaten natural ecosystems but also affect the social and economic well-being of local communities. Consequently, sustainable marine ecotourism management strategies are crucial to simultaneously support environmental preservation and protect community welfare.

One of the primary challenges is the tangible impact of these pressures on the sustainability of marine ecotourism in Bali. Damage to coral reef ecosystems caused by tourism activities and infrastructure development has resulted in a significant annual decline in live coral cover. Research shows that live coral cover decreases by up to 5% per year due to plastic waste pollution and unregulated snorkeling activities [2]. This decline not only disrupts marine ecosystems but also diminishes the appeal of destinations for tourists seeking nature-based experiences. Furthermore, coastal infrastructure development, such as hotels and airports, has exacerbated beach erosion, with Bali's coastline shrinking by an average of 1.21 meters annually due to a combination of human activities and climate change [3]. This situation poses a serious threat to coastal ecosystems, which serve as the foundation of marine ecotourism in the region.

TABLE 1.
BIODIVERSITY INDICES OF CORAL REEFS AND MARINE TURTLES IN BALI

Location	Biota Category	Diversity Index (H')	Years	Sources
Pemuteran Waters	Coral Reef Fish	2.9	2011	[4]
Manggis Waters	Coral Reef Fish	2.60	2019	[5]
Menjangan Island	Coral Reef Fish	2.13	2013	[6]
Penimbangan Beach	Nudibranchs	1.79	2022	[7]
Jemeluk Bay, Amed	Coral Reef Fish	2.76	2021	[8]

The data presented in Table 1 illustrates the biodiversity indices for key marine biota in various locations in Bali. The indices reveal moderate diversity, with H' values ranging between 1.792 and 2.913. This range indicates that Bali's marine ecosystems, particularly coral reefs, face ecological pressures from human activities and climate change. The declining health of these ecosystems, as seen in areas like Pemuteran and Menjangan, underscores the urgency for sustainable management strategies that prioritize biodiversity conservation

This problem is further supported by data indicating accelerated erosion in Bali's coastal areas. Over the past five years, the coastline has shrunk from 668.64 kilometers to 662.59 kilometers due to hotel developments along the coastline and coastal reclamation projects [9]. In addition, damage to coral reefs in Nusa Penida marked by a 4.0% reduction in hard coral cover and a 2.7% reduction in live coral cover violates regulations stipulated in Ministerial Decree No. Kep.38/Men/2004 [10]. This degradation highlights inefficiencies in environmental management, particularly in addressing pressures from tourism development.

Sustainable ecotourism should integrate environmental conservation, authentic cultural experiences, and improvements in local community welfare. Bali faces significant challenges in applying this principle, especially concerning oceanographic factors such as currents, temperature, and water quality, which greatly influence the conditions of marine ecosystems [11]. These factors play a vital role in maintaining coral reefs, fish populations, and other key marine attractions. Recent reports indicate coral reef coverage and biodiversity in Penuktukan Village highlighted the significant impact of human activities, particularly tourism-related practices, on the coral reef ecosystem. Tourist activities, such as snorkeling and boating, have contributed to coral reef degradation, resulting in coverage levels ranging from 53% to 56%. These activities have exacerbated the stress on coral reefs, disrupting their natural balance and contributing to ecosystem decline [12]. This data gap presents an obstacle to developing evidence-based policies for more effective ecotourism management.

In addition to data limitations, insufficient discussion of policy gaps and practices in managing marine ecotourism in Bali is another major issue. Regulations such as Bali Governor Regulation No. 97 of 2018 on reducing single-use plastics represent a positive first step, but their implementation remains limited. Studies show that the main barriers include inadequate monitoring and the low participation of local communities in supporting conservation initiatives [13]. Furthermore, conflicts of interest between tourism infrastructure development and environmental conservation continue to be a persistent issue. For instance, the reclamation project in Benoa Bay has raised public concerns for potentially endangering mangrove ecosystems, which are vital habitats for biodiversity [14].

The 'Tri Hita Karana' approach to ecotourism holds significant potential as a solution to these challenges. This framework emphasizes harmony among humans, nature, and spirituality, offering a holistic model that integrates environmental conservation with cultural preservation. Globally, many ecotourism models focus on environmental sustainability and community empowerment, such as Community-Based Ecotourism in Southeast Asia [15]. However, Tri Hita Karana has unique

advantages in uniting spiritual, cultural, and ecological values within a single holistic framework. Implementing this concept can also enhance local community engagement in ecotourism management, ultimately supporting cultural preservation while fostering economic well-being.

However, the contribution of this study to the literature on culture- and environment-based ecotourism in Bali still needs to be emphasized. Previous studies have often focused on a single aspect, such as environmental conservation or cultural preservation, without integrating the two. Some studies highlight the importance of coral reef conservation in supporting tourism sustainability [16], while others emphasize cultural preservation in a global context without providing specific solutions for environmental challenges in coastal areas [17]. In the context of Bali, the integration of cultural preservation and environmental conservation holds significant potential for supporting ecotourism sustainability. Nevertheless, further exploration is needed to determine how the Tri Hita Karana approach can be implemented as a holistic framework.

This study also aims to address gaps in the literature related to policies for managing marine ecotourism. Some studies suggest that effective policies require multi-stakeholder collaboration involving government, communities, and the private sector [18]. However, in Bali, the implementation of such collaborations often faces various obstacles, particularly in terms of coordination among stakeholders. This study is expected to provide specific and applicable policy recommendations based on empirical analysis to support more sustainable marine ecotourism management.

Therefore, this study aims to address the primary challenges in managing marine ecotourism in Bali through the Tri Hita Karana approach. This approach is expected to deepen understanding of the relationship between environmental conservation, cultural preservation, and community welfare. Furthermore, this study contributes by offering policy recommendations that can enhance the sustainability of marine ecotourism while strengthening Bali's position as a global model for sustainable ecotourism.

II. METHOD

This study employs a literature review approach to gather data from written sources relevant to the topic of sustainable marine ecotourism. This literature review involves examining various documents to gain an in-depth understanding of theories and previous research findings related to sustainable marine resource management issues [10].

A. Data Collection Materials and Sources

Data were collected from literature that met specific criteria, namely relevance to ecotourism, sustainable tourism, and community-based environmental conservation. Additionally, researchers ensured that the data sourced from the literature were current and verified for accuracy through highly credible sources.

B. Data Analysis Procedure

The data analysis process was conducted in three main stages:

(1) Data reduction, filtering and simplifying information from the literature to produce coherent data.
(2) Data presentation, organizing the reduced data into a narrative format to systematically present findings to the readers; and
(3) Verification and Data Triangulation, comparing various sources to validate the data. This triangulation enhances the credibility of the study results through cross-validation, allowing the research conclusions to be more convincing [11,12].

III. RESULTS AND DISCUSSION

Overview of Marine Ecotourism in Bali

Marine ecotourism in Bali serves as a compelling model for integrating environmental conservation, community empowerment, and cultural preservation [19,20,21]. As a prominent global tourist destination, Bali has embraced the concept of sustainable tourism through the principles of Tri Hita Karana, which emphasize harmony among humans, nature, and spirituality. This unique philosophical framework underpins the island's marine ecotourism initiatives and has positioned Bali as an exemplary case for sustainable tourism practices that balance economic growth with ecological and cultural preservation.

According to the International Ecotourism Society (TIES), ecotourism is defined as "responsible travel to natural areas that conserves the environment, sustains the well-being of local people, and involves interpretation and education." In Bali, marine ecotourism has evolved from three main perspectives: as a product, a market, and a development approach.

1) As a product, it focuses on nature-based attractions such as coral reefs, mangroves, and marine biodiversity, with a strong emphasis on conservation.
2) As a market, it targets environmentally conscious tourists who seek authentic cultural experiences while supporting conservation efforts.
3) As a development approach, it employs sustainable management practices rooted in Tri Hita Karana to ensure long-term ecological and cultural viability [22,23].

These principles are operationalized in Bali's marine ecotourism destinations such as Nusa Penida, Menjangan Island, and Perancak Mangrove Forest. Each site integrates natural conservation efforts with cultural preservation while providing economic benefits to local communities.

Marine ecotourism in Bali has been instrumental in conserving marine biodiversity. Table 2 illustrates some of the most popular marine ecotourism sites in Bali,

TABLE 2.
KEY MARINE ECOTOURISM SITES IN BALI WITH HIGH VISITOR INTEREST IN 2023

Ecotourism Location	Visitors in 2023 (people)	Primary Resources	Management System
Nusa Penida	653,579	Coral reefs, endemic species (manta rays)	Marine conservation zones, visitor limits, routine sea patrols, coral rehabilitation programs
Perancak Mangrove	23.000	Mangrove forest, bird habitats	Restricted access zones, community-led education programs, eco-tourism pathways
Tenganan Village	47.450	Traditional Balinese culture	Community-managed regulations preserving local traditions, controlled visitor access during cultural ceremonies
Menjangan Island	15.000	Coral reefs, tropical marine ecosystem	Part of West Bali National Park; strict regulations on boating, diving, and coral reef monitoring programs

Source: Bali Province Bureau of Statistics, 2023

highlighting their primary resources, visitor management systems, and conservation efforts.

Based on table 2, Nusa Penida exemplifies the success of marine conservation zones. Visitor limits, routine patrols, and coral restoration projects have led to the recovery of ecosystems. The coral coverage in Nusa Penida has increased by 6% since the establishment of marine conservation zones in 2018, demonstrating the efficacy of these interventions [11]. Moreover, the presence of iconic species such as manta rays enhances its appeal as a sustainable tourism destination. Then, Perancak Mangrove highlights the role of local communities in managing ecotourism resources. The site integrates conservation education with tourism, providing guided tours along eco-friendly pathways. Studies found that mangroves in Perancak mitigate coastal erosion while serving as habitats for diverse bird species, underlining their ecological and economic significance [23]. The last, part of the West Bali National Park, Menjangan Island showcases a holistic approach to marine ecosystem preservation. By implementing strict regulations on diving and boating, the park has preserved coral reefs and maintained a high biodiversity index (H') of 2.76 [24]. Coral monitoring programs conducted annually have also reduced damage caused by unregulated tourism.

Marine ecotourism in Bali is closely linked to the empowerment of local communities [25,26]. The Community-Based Tourism (CBT) model has been effectively implemented to engage residents in managing tourism resources [24,26]. Community members often take on roles as tour guides, educators, and conservation stewards, ensuring that ecotourism activities adhere to sustainability principles.

Marine ecotourism generates direct economic benefits by creating jobs and generating income for local communities. In Nusa Penida, coral rehabilitation projects employ residents as divers and reef monitors, fostering sustainable livelihoods. Similarly, community-led conservation efforts in Perancak Mangrove provide income through eco-tourism activities and environmental education programs [27, 28].

Education initiatives are vital for enhancing community capacity to manage ecotourism resources [29]. Training programs focused on waste management, marine conservation, and guiding techniques have equipped locals with the knowledge and skills necessary to promote sustainable tourism. Such programs have increased local participation in conservation initiatives by 34% over the past five years [30]. The development of marine ecotourism in Bali aligns with the Tri Hita Karana philosophy, which emphasizes a harmonious relationship between humans, the environment, and the divine. This local wisdom has been integrated into regional regulations to ensure the preservation of the natural environment and Balinese culture [31].

Cultural Preservation through Marine Ecotourism

Cultural preservation is a central tenet of marine ecotourism in Bali. Tourists are often welcomed with traditional Balinese ceremonies and rituals, creating a unique cultural experience that complements the island's natural attractions. Sites like Tenganan Village have successfully combined cultural preservation with tourism by showcasing local crafts and rituals.

The *Tri Hita Karana* philosophy, deeply embedded in Balinese culture, serves as a foundation for harmonizing tourism activities with cultural preservation, environmental conservation, and social well-being. Its principles; *Parahyangan* (harmony with the divine), *Pawongan* (harmony among people), and *Palemahan* (harmony with nature), offer a comprehensive framework for sustainable tourism practices. These principles are not only theoretical constructs but also cultural norms practiced by the Balinese community, making them integral to the management of marine ecotourism.

1) Parahyangan (Harmony with the Divine)

   The concept of Parahyangan highlights the spiritual relationship between humans and the divine, which is manifested in daily rituals and ceremonies. In the context of marine ecotourism, Parahyangan plays a critical role in preserving Bali's spiritual heritage while integrating it into tourism practices [32].

   For example, Melasti ceremonies, traditionally held along the coast, serve both religious and ecological purposes. These ceremonies involve cleansing rituals at the sea to purify spiritual and physical impurities, symbolizing respect for marine ecosystems. Tourists are often invited to observe or participate in these ceremonies, fostering an appreciation for Balinese spirituality. According to studies, involving tourists in spiritual ceremonies creates opportunities for cross-

cultural understanding while promoting sustainable tourism behaviors [33].

Parahyangan also extends to the construction and design of tourism infrastructure. Temples located near ecotourism sites, such as Pura Goa Lawah and Pura Dalem Ped in Nusa Penida, are preserved as sacred spaces. Regulations restrict development in temple vicinities, ensuring that tourism does not disrupt their sanctity. This adherence to spiritual norms demonstrates how Parahyangan aligns with sustainable tourism practices by balancing cultural preservation and tourism development [32, 34].

2) Pawongan (Harmony among people)

Pawongan emphasizes social harmony and community engagement, making it central to the implementation of community-based ecotourism (CBET) in Bali. Through Pawongan, the Balinese community is actively involved in decision-making processes, ensuring that tourism benefits are equitably distributed [33].

Marine ecotourism projects such as the Coral Triangle Initiative in Bali prioritize local community involvement in managing coral reef conservation. Community members are employed as eco-guides, coral gardeners, and conservation educators, which not only supports economic empowerment but also strengthens social cohesion. Studies reveal that community involvement in marine conservation activities increases the effectiveness of ecotourism initiatives by 40% compared to top-down approaches [30].

Moreover, Pawongan fosters cultural resilience by integrating traditional knowledge into marine conservation strategies. For example, Balinese fishermen practicing Subak laut (traditional water management for fisheries) combine ecological wisdom with tourism, allowing visitors to experience sustainable fishing practices. This approach helps sustain livelihoods while preserving traditional values, creating a balance between tourism and cultural preservation [32,33,34].

3) Palemahan (Harmony with nature)

Palemahan, or harmony with nature, forms the cornerstone of Bali's environmental conservation efforts in marine ecotourism. This principle encourages the responsible use of natural resources and sustainable practices that minimize ecological impact [16].

Marine ecotourism initiatives in Bali often incorporate coral reef restoration and mangrove conservation under the guidance of Palemahan. For instance, the Nusa Penida Marine Park employs community-led coral rehabilitation programs, where broken coral fragments are replanted to restore degraded reefs. Research by Huang et al. (2022) indicates that these efforts have increased coral coverage in Nusa Penida by 6% over five years, demonstrating the practical impact of Palemahan-driven strategies.

Additionally, Palemahan is reflected in the strict regulations imposed in marine ecotourism zones. Activities such as snorkeling, diving, and boating are carefully monitored to prevent environmental degradation. Visitors are required to follow eco-friendly guidelines, such as avoiding physical contact with coral reefs and using reef-safe sunscreen. Such practices align with Palemahan by promoting tourism that respects the integrity of natural ecosystems.

Furthermore, Palemahan is integrated into waste management practices in ecotourism areas. Programs to reduce plastic pollution, supported by Bali Governor Regulation No. 97/2018, are implemented in collaboration with local communities and tourism operators. Coastal cleanup campaigns are organized regularly, engaging tourists and locals alike in preserving marine environments. these initiatives have reduced plastic waste in key ecotourism areas by 30%, contributing significantly to the preservation of marine biodiversity.

One of the management efforts of Bali's marine ecosystem involves the application of standard operating procedures (SOPs) that safeguard marine biodiversity, including restrictions on tourist activities in sensitive areas and monitoring of coral reefs to ensure marine life preservation. Conservation efforts are also supported by sea turtle breeding programs, like those at the Turtle Conservation and Education Center (TCEC) in Serangan, where nests are monitored, and eggs are relocated to semi-natural hatcheries to protect them from predators. Additionally, hatchlings are released at optimal times to improve their survival rates in the wild [35]. Community involvement is central to marine ecotourism management in Bali, using a Community-Based Tourism (CBT) model, which actively engages locals as tour guides, conservation area stewards, and participants in environmental preservation activities [26]. Sustainable conservation initiatives also include monitoring the characteristics, density, and distribution of plastic waste in conservation areas such as Bali Barat National Park and the Nusa Penida Marine Protected Area (NPMPA) to identify human-related pollution factors in tourist sites [11]. Training programs for local communities enhance their knowledge and skills in ecotourism management, allowing visitors to authentically experience Balinese customs and traditions [36]. These programs include foreign language development, tourism attraction management, and guiding techniques [37, 38].

Ecological Challenges in Marine Ecotourism

Marine ecotourism in Bali, while celebrated for its integration of environmental conservation and community empowerment, faces significant ecological challenges that threaten its sustainability [39,40]. These challenges include coral reef degradation, coastal erosion, marine pollution, habitat loss, and the looming impacts of climate change [41,42]. The urgency of tourism infrastructure development further complicates this issue. While infrastructure improvements enhance destination appeal and accessibility, uncontrolled development can degrade sensitive ecosystems such as coral reefs and seagrass beds, leading to biodiversity loss. Additionally, rising tourist arrivals contribute to air and marine pollution, increased waste generation, and exacerbated coastal

TABLE 3.
ISSUES AND IMPACTS OF INFRASTRUCTURE DEVELOPMENT ON RESOURCE DEGRADATION

Phenomenon	Year	Description	Main Cause	Case Study Source
Coastal Erosion	2023	Erosion has significantly increased by 10-20 meters per year in southern Bali, including Badung, Denpasar, and Gianyar. The loss of sand and receding shoreline threaten ecosystems.	Infrastructure development (e.g., hotels, airports), land reclamation, sea level rise, and high tourist influx. Seawall construction may worsen downstream erosion.	[3]
Crown of Thorns Starfish Outbreak	2022	Outbreaks of Crown of Thorns Starfish (CoTS) are exacerbated by increased nutrients from local pollution, impacting coral health and diversity with coral cover loss up to 50% in affected areas.	Pollution and nutrient runoff support invasive species that harm coral reef ecosystems.	[33]
Inadequate Drainage	2021	Drainage systems are unable to handle waste and rainwater, leading to flooding during heavy rains and clogged channels with trash from other villages.	Growth of restaurants, cafes, and accommodations that discharge waste into drainage systems.	[46]
Coral Bleaching	2016,2020	Loss of 44.4% live coral cover in Northwest Bali (2016) and NOAA Bleaching Alert Level 1-2 (2020). Diver activities and boat anchors damage reefs.	Land use changes causing temperature rise and climate change, as well as inadequate waste management	[33]
Mangrove Ecosystem Deforestation	2020	Loss of 0.18% mangrove forest per year in Southeast Asia; Overcrowded mangrove tourism paths with up to 360 visitors daily.	Shrimp farming development and land conversion for tourism.	[47]
Freshwater Scarcity	1988 - 2013	Bali's tourism industry relies heavily on groundwater, particularly from coastal wells, exacerbating freshwater scarcity for locals, with a 66% increase in usage over this period.	Imbalance between water infrastructure availability and increasing demand.	[48]

erosion, threatening the sustainability of marine ecotourism in Bali [43,44,45].

The findings in Table 2 demonstrate a series of environmental resource damages resulting from development practices that neglect sustainability principles. Increased human activities, such as property development and reclamation, have amplified the risk to natural habitats [49]. Coral reefs are central to Bali's marine ecotourism, providing both ecological services and aesthetic appeal. However, they are increasingly threatened by direct and indirect impacts of human activity. Physical damage from activities such as snorkeling, diving, and boat anchoring is a primary concern [50,51]. When tourists inadvertently step on corals or anchors scrape against reef structures, the delicate coral polyps are destroyed, hindering their ability to regenerate. Sedimentation caused by coastal construction further reduces sunlight penetration, essential for coral photosynthesis, leading to bleaching and eventual death [52].

Additionally, coral reefs are affected by nutrient enrichment from untreated wastewater and agricultural runoff. Excessive nutrients in seawater can lead to algal blooms, which outcompete corals for space and resources. The balance of reef ecosystems is further disrupted when algal growth suffocates corals, accelerating their decline. Addressing these issues requires improved wastewater treatment systems and stricter regulations on agricultural practices in upstream areas that feed into coastal waters [52,53].

Bali's coastal regions are dynamic systems where natural processes like wave action and sediment transport interact with human activities. However, rapid development along the coastline, driven by the demand for tourism infrastructure, has exacerbated erosion rates. The construction of seawalls, hotels, and reclaimed land alters natural sediment flows, preventing the replenishment of beaches and accelerating their degradation [54].

Mangroves, often removed to clear land for development, play a crucial role in protecting coastlines by stabilizing sediments and acting as natural barriers against wave action. Their removal leaves coastal areas vulnerable to erosion, leading to habitat loss for marine and terrestrial species that depend on these ecosystems. Moreover, the loss of beaches diminishes the aesthetic value of marine tourism sites, deterring visitors and negatively impacting the local economy [55,56].

A sustainable approach to mitigate coastal erosion involves restoring natural defenses, such as mangroves and seagrasses, while employing soft engineering techniques like beach nourishment [57]. Additionally, the adoption of integrated coastal zone management (ICZM) policies can help balance the needs of tourism development with ecological preservation [58,59].

Marine pollution is one of the most pressing environmental challenges facing Bali's marine ecosystems. The island generates substantial volumes of waste from both its resident population and the millions of tourists who visit annually. Unfortunately, waste management infrastructure has not kept pace with this demand, resulting in significant amounts of plastic waste entering the ocean [11,60].

Single-use plastics, such as bottles, bags, and food packaging, are the primary culprits [61,62]. Once in the marine environment, these plastics break down into microplastics, which are ingested by marine organisms, including fish and coral polyps. This not only threatens marine biodiversity but also raises concerns about food safety, as microplastics are passed up the food chain to humans. The situation is compounded by marine debris from abandoned fishing gear, which continues to entangle and kill marine life [63].

To address this issue, Bali needs a multi-faceted approach that includes reducing plastic use, improving waste collection and recycling infrastructure, and engaging communities in cleanup initiatives. Awareness campaigns targeting both residents and tourists can also play a critical role in reducing littering and encouraging sustainable behaviors [64,65].

The destruction and fragmentation of habitats, particularly coral reefs, mangroves, and seagrasses, represent a significant challenge for marine biodiversity. Habitat loss often results from coastal development, dredging, and the construction of ports and marinas. These activities permanently alter the physical structure of marine environments, displacing species and reducing their ability to adapt to changing conditions [66].

Fragmented habitats also disrupt ecological connectivity, which is vital for the reproduction and survival of many marine species. For instance, fish species that rely on coral reefs for breeding may find themselves without suitable habitats, leading to population declines. Similarly, migratory species, such as turtles and seabirds, are affected when nesting or feeding grounds are destroyed [67].

The establishment of marine corridors and the restoration of degraded habitats are crucial to addressing this issue. These measures ensure that ecosystems remain interconnected, allowing species to migrate and thrive. Additionally, land-use planning should prioritize the protection of key habitats by designating them as conservation areas [66,68].

Bali's marine ecosystems are not only impacted by tourism but also by overfishing, which disrupts ecological balance and threatens biodiversity. High demand for seafood from both locals and tourists puts immense pressure on fish stocks, often leading to overharvesting. Traditional fishing practices, once sustainable, are now being replaced by more intensive and destructive methods, such as cyanide and blast fishing, which cause significant damage to coral reefs and other habitats [69].

Overfishing also impacts ecotourism by reducing the availability of iconic marine species, such as reef fish, turtles, and sharks, which are major attractions for snorkelers and divers. Sustainable fisheries management, including the enforcement of quotas and the establishment of no-take zones, is essential to ensuring that marine resources are conserved for future generations [66, 69,70].

The impacts of climate change on Bali's marine ecosystems are profound and far-reaching. Rising sea temperatures have led to more frequent and severe coral bleaching events, reducing the resilience of reef ecosystems. Corals that experience prolonged bleaching are more susceptible to diseases and mortality, which in turn affects the entire marine food web. Sea-level rise, another consequence of climate change, poses a dual threat. It not only accelerates coastal erosion but also inundates low-lying coastal areas, impacting communities and infrastructure. Ocean acidification, caused by the absorption of excess atmospheric CO_2 by seawater, further compounds the problem by hindering coral calcification and growth [71].

To mitigate these impacts, Bali must adopt climate-resilient strategies, such as planting heat-tolerant coral species, enhancing the adaptive capacity of coastal communities, and reducing greenhouse gas emissions through renewable energy initiatives. The introduction of invasive species poses a hidden but significant threat to Bali's marine ecosystems. Invasive species, such as the crown-of-thorns starfish (COTS), prey on coral reefs, causing widespread destruction. Nutrient enrichment from agricultural runoff and sewage creates conditions that support the rapid reproduction of COTS, leading to outbreaks that devastate reef ecosystems.

The management of invasive species requires regular monitoring and intervention. For example, manual removal of COTS during outbreaks has been effective in reducing their impact. Additionally, improving water quality through better waste management can help prevent the conditions that favor invasive species [72].

Socio-Cultural, Economic, and Policy Dimensions of Marine Ecotourism in Bali: Contributions, Challenges, and Future Directions

Marine ecotourism in Bali is more than a platform for promoting environmental conservation, it is an integrated approach that simultaneously supports the socio-cultural, economic, and policy frameworks necessary for sustainable development. This holistic approach ensures that local communities benefit economically, culturally, and socially from ecotourism while safeguarding the island's rich natural and cultural heritage. However, achieving this balance requires addressing gaps in policy, deepening the implementation of frameworks such as Tri Hita Karana, and ensuring the long-term relevance of ecotourism initiatives in a global context. This section explores the socio-cultural and economic contributions of marine ecotourism, the implementation of holistic philosophies, policy challenges, and future directions for sustainable ecotourism in Bali [73,74].

Community-based ecotourism (CBET) in Bali plays a significant role in improving the welfare of local communities by creating opportunities for sustainable livelihoods. CBET integrates local traditions, ecological preservation, and tourism to create a model where communities actively participate in and benefit from tourism activities. For example, Penglipuran Village, a model CBET initiative, demonstrates how ecotourism can enhance economic resilience while preserving cultural identity. The village's structured participation in tourism, rooted in Balinese customs and traditions, has elevated its status as a must-visit destination. Visitors are drawn to Penglipuran not only for its well-preserved architecture but also for its vibrant community-led activities, which include cultural performances and eco-friendly practices [74,75,76].

The direct involvement of community members in tourism-related roles such as guides, craftsmen, and performers has significantly boosted household incomes. Additionally, the income generated is reinvested in community programs, such as education and infrastructure development, ensuring long-term benefits for residents. Penglipuran's success serves as a model for replicating CBET in other marine ecotourism sites, where traditional knowledge and practices can be integrated into sustainable tourism frameworks.

Ecotourism in Bali also fosters the preservation of socio-cultural values, which are integral to the island's identity. Cultural performances, rituals, and local crafts showcased as part of ecotourism activities not only attract tourists but also reinforce community pride in their heritage [77]. Traditional fishing villages in areas like Pemuteran and Serangan have embraced ecotourism by combining sustainable fishing practices with cultural education programs. These initiatives allow tourists to engage with the local way of life, creating meaningful cultural exchanges while ensuring that traditional practices are not lost in the face of modernization [73,78].

The involvement of local communities in ecotourism also mitigates the risks of cultural commodification, as they retain control over how their traditions are represented [79]. This alignment of cultural preservation with economic opportunities ensures that marine ecotourism becomes a tool for safeguarding Bali's heritage while providing tangible benefits to its people [1].

The Tri Hita Karana philosophy, which emphasizes harmony among humans, nature, and the divine, is a cornerstone of Bali's sustainable tourism efforts [80]. In the context of marine ecotourism, this philosophy provides a comprehensive framework that aligns environmental conservation with socio-cultural values. The implementation of Tri Hita Karana has been particularly impactful in Nusa Penida, a marine protected area renowned for its coral reefs and rich biodiversity [81].

Programs such as coral rehabilitation in Nusa Penida exemplify how Tri Hita Karana integrates ecological, spiritual, and community dimensions. Coral restoration projects involve not only scientific interventions but also rituals and blessings, ensuring that conservation efforts are culturally resonant. Furthermore, community members participate in these initiatives as reef monitors and eco-tour guides, creating a direct connection between conservation efforts and economic benefits. The Tri Hita Karana approach extends beyond ecological restoration to include the regulation of tourism activities. For example, limits on visitor numbers and eco-certification requirements for operators ensure that tourism activities align with the principles of sustainability. This model demonstrates the potential of holistic frameworks like Tri Hita Karana to address the multifaceted challenges of marine ecotourism [80, 81].

Despite its successes, the management of marine ecotourism in Bali is hindered by significant policy gaps. One of the critical issues is the lack of effective enforcement of existing regulations, such as those limiting coastal development and managing waste. [82,83]. For instance, while policies like Bali Governor Regulation No. 97/2018 aim to reduce single-use plastics, their implementation remains inconsistent, particularly in areas with high tourist activity [84].

Another challenge is the absence of comprehensive carrying capacity assessments for marine ecotourism sites. Without such studies, it is difficult to establish limits on visitor numbers, leading to overcrowding and ecological degradation in popular destinations like Nusa Penida. Additionally, conflicts between conservation goals and development pressures, such as reclamation projects in Benoa Bay, highlight the need for more integrated and participatory policy frameworks [80,81].

Strengthening policy enforcement and fostering collaboration among stakeholders government agencies, local communities, and private operators are essential for addressing these gaps. Policies must also include mechanisms for monitoring and adapting to emerging challenges, such as climate change and invasive species, to ensure their long-term relevance [85].

To address these gaps, Bali's marine ecotourism policies must prioritize adaptive and inclusive management strategies. One recommendation is the development of a pentahelix approach, which incorporates collaboration among five key sectors: government, academia, business, community, and media. This model ensures that all stakeholders are actively involved in decision-making, fostering transparency and accountability [86,87].

Another critical step is the implementation of visitor management systems, including quotas for sensitive areas and eco-certification for tourism operators. These measures can help balance tourism growth with ecological preservation. Additionally, investments in infrastructure for waste management, renewable energy, and sustainable transport are essential for reducing the environmental footprint of marine ecotourism.

Finally, policies should incentivize community-led initiatives, such as coral reef restoration and marine conservation education. Empowering local communities not only enhances the effectiveness of conservation efforts but also ensures that the benefits of ecotourism are equitably distributed.

The holistic integration of community empowerment, cultural preservation, and environmental conservation in Bali's marine ecotourism serves as a novel model with global relevance. While many ecotourism initiatives worldwide focus solely on environmental sustainability, Bali's approach rooted in Tri Hita Karana offers a framework that encompasses social, cultural, and spiritual dimensions. This integration sets Bali apart as a leader in sustainable tourism practices.

Bali's model is particularly relevant for other regions seeking to develop ecotourism in culturally rich and ecologically sensitive areas [88]. For instance, the principles of Tri Hita Karana could inform sustainable tourism frameworks in the Pacific Islands, where communities face similar challenges related to coastal development and biodiversity loss. The replication of Bali's approach requires not only an understanding of its cultural underpinnings but also the adaptation of its principles to local contexts.

The economic benefits of marine ecotourism extend beyond individual communities to contribute significantly to Bali's overall economy. Revenue generated from entry fees to marine protected areas, eco-tours, and conservation programs supports local livelihoods while funding broader conservation efforts. For example, entrance fees collected at Nusa Penida are reinvested into reef monitoring and waste management programs, creating a self-sustaining model that aligns economic and environmental goals [89,90].

Moreover, the involvement of local businesses in ecotourism supply chains such as restaurants, transportation services, and souvenir production further amplifies its economic impact. By prioritizing local procurement and fair trade practices, marine ecotourism creates a multiplier effect that benefits the wider economy [86,91].

To sustain and expand the benefits of marine ecotourism, future strategies must emphasize innovation and resilience. Integrating technology into conservation efforts, such as using drones for reef monitoring and AI for waste tracking, can enhance the efficiency and effectiveness of management practices. Additionally, promoting education and awareness among tourists and operators is crucial for fostering responsible tourism behaviors. Climate adaptation should also be a central focus, with investments in projects such as mangrove restoration and coral nurseries to mitigate the impacts of rising sea levels and warming oceans. Bali's marine ecotourism must also align with global frameworks like the Sustainable Development Goals (SDGs), particularly SDG 14 (Life Below Water) and SDG 12 (Responsible Consumption and Production), to ensure its continued relevance on the global stage [86, 92,93].

IV. Conclusion

This study evaluates the implementation of the Tri Hita Karana philosophy as a holistic framework for addressing ecological, socio-cultural, and policy-related challenges in Bali's marine ecotourism sector. The findings demonstrate that Tri Hita Karana effectively aligns environmental conservation, cultural preservation, and community empowerment. Key initiatives, such as coral reef restoration in Nusa Penida and community-based conservation programs in Perancak, exemplify the integration of ecological and socio-economic benefits. These efforts not only enhance biodiversity but also create sustainable livelihoods for local communities.

Despite these successes, significant challenges persist, including inconsistent policy enforcement, visitor overcapacity, and infrastructure pressures. These gaps highlight the need for adaptive strategies, such as inclusive governance, carrying capacity assessments, and technology-driven monitoring systems, to sustain the ecological and cultural integrity of marine ecotourism.

The research contributes to the global discourse on sustainable tourism by positioning Tri Hita Karana as a replicable model for managing ecotourism in culturally rich and ecologically sensitive regions. Future studies should focus on operationalizing this philosophy in diverse contexts while addressing emerging challenges, such as climate change and increasing tourism pressures, to enhance its scalability and resilience.

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