

Exploring the Role of Marine Protected Areas in Biodiversity Conservation and Ecosystem Restoration

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Abstract: Marine Protected Areas (MPAs) have been recognized as one of the most effective management tools for conservation of ocean biodiversity and restoration of degraded marine ecosystems. With several decades of implementation across the world, ecological benefits across different habitat types are yet to be substantiated with scientific evidence. This study assesses the effect of MPAs in promoting biodiversity and restoration of degraded habitats using five selected study sites from the Indian coast, which include habitat types such as coral, seagrass, mangrove, and rocky reef. The species richness, Shannon's index, Simpson's index, and Pielou's evenness in terms of diversity and fish biomass and coral cover, assessed by using UVC and Benthic quadrat, and water quality were compared within MPA and non-MPA zones at each selected site using a nine-year monitoring span (2015-2024). The study showed a statistically significant increase in all the indices of diversity between MPA and non-protected areas. The MPA sites showed an average 79.4% increase in mean species richness (156.6 ± 62.2) compared to non-protected areas (87.3 ± 41.6) and 147.6% in fish biomass compared to non-protected areas ($p < 0.001$). Across all no-take zones, on average, coral cover was restored by 43%, with Andaman Island showing the best recovery rate. These outcomes emphasized the importance of governance, community participation, and adaptive management strategies to be utilized for maximizing the MPA benefits. The results would support the policy recommendations in relation to the establishment of MPAs in coastal countries, particularly on the extension of no-take zones, which form the basis of the sustainability of the blue economy.

Keywords: Marine Protected Areas, Biodiversity Conservation, Ecosystem Restoration, Species Richness, Coral Reef, Aquatic Governance, Blue Economy.

(Submitted: September 23, 2025; Revised: October 25, 2025; Accepted: December 05, 2025; Published: December 31, 2025)

I. Introduction

The world's oceans cover roughly 71% of Earth's surface and support a greater number of species than can be inventoried (>250,000); these species perform crucial ecological services, from sequestering carbon to producing oxygen and recycling nutrients. Nevertheless, increasing human activities (overfishing, destruction of coastal habitats, pollution, anthropogenic global warming, and ocean acidification) have been responsible for catastrophic global marine biodiversity decline (Sarker et al., 2023). Marine habitats such as coral reefs, seagrass beds, and kelp forests support diverse species and are vulnerable to disturbances; decline in these habitats jeopardizes aquatic food web stability as well as the livelihoods of hundreds of millions of people in coastal areas who depend on the goods and services that marine ecosystems provide (Leenhardt et al., 2015). In this regard, Marine Protected Areas (MPAs) have been widely supported by international conventions, including the Convention on Biological Diversity (CBD) and the UN SDGs, notably SDG 14 (Life Below Water), as a spatially explicit management tool that will set the stage to reverse marine biodiversity loss (Gianni et al., 2013).

Over 18,000 MPAs now cover approximately 8% of the world's oceans; the rapid global increase in MPA coverage suggests significant global conservation will occur, but it is debated whether the net effects on marine biodiversity and ecosystem restoration have reached significant thresholds (Topor et al., 2019). Critical challenges include limited enforcement for many paper park-designated sites, spatial planning that fails to address the importance of hydrodynamic connectivity, and limited community involvement, which threatens the long-term health of the ecological resilience of MPAs (Picone et al., 2021). The ecological impacts of MPAs were found to vary significantly based on protection status, the age of the site, the habitat types included in the MPA, and the quality of governance (Sarker & Mahmudul Islam, 2022). Previous MPAs research has primarily focused on tropical systems, which leaves significant gaps in understanding

regarding subtropical and temperate coastal systems, especially in the South and Southeast Asian context (Rodrigues et al., 2024).

This paper closes those gaps by presenting a multi-site comparative analysis of MPA effectiveness across Indian coastal regions with a variety of five habitat types. The key contributions made by this study include: (i) a rigorous, quantitative empirical assessment of biological indices across MPAs and paired non-MPAs; (ii) documentation of trends of coral cover and fish biomass recovered over nine years; and (iii) an evaluation of the use of ecosystem service indices as a potential measure of restoration trajectory. Remaining sections: (2) Review of the Literature, (3) Materials and Methods, (4) Results, including both comparison tables and graphs, (5) Discussion of ecological and governance influences, and (6) Conclusions, policy recommendations, and future work.

II. Literature Survey

There have been considerable changes in the scientific literature regarding MPAs since the establishment of the first modern MPAs in the 1970s, when there was a primary focus on single-species recovery of exploited fish stocks (Marcos et al., 2021). The following decades saw a rise in assessments of ecological implications that included assessments of entire ecosystems, biodiversity, and functional ecology effects of marine spatial protection. Modeling concludes that MPAs are biodiversity reservoirs when no-take protection is stringently applied, and well-managed MPAs maintain species assemblages that are similar to unstressed reference habitats despite nearby Anthropogenic disturbance (Sarker et al., 2023). Expanded the use of MPAs as service-providing entities and categorized supporting provisioning, regulating, and cultural ecosystem services (Leenhardt et al., 2015). Their synthesis showed that MPAs are tools for the blue economy and need sound governance systems and management approaches that integrate ecological and economic goals.

looked at the conservation potential for and recovery from anthropogenic impacts of MPAs for macroalgal assemblages of the Mediterranean Sea and found that MPAs contribute substantially to the recovery of structurally complex habitats that support higher fish and invertebrate diversity (Gianni et al., 2013). Their findings have significant methodological implications for tropical systems and species that are structural engineers, such as corals, and serve similar ecological roles as the marine forests discussed in (Gianni et al., 2013). In studies looking at coral reefs specifically, higher functioning of the reefs in MPAs was due to higher fish functional diversity, which boosted herbivory, bioerosion, and maintenance of reef structure, while there was also evidence of a top-down trophic cascade effect with the restoration of apex predators and the reorganization of prey assemblages that led to higher resilience of the reef community (Topor et al., 2019). Put the increased species diversity in MPAs in a blue economy perspective, that there will be an economic return from these biodiversity gains via fisheries spillover, value placed on nature-based tourism, and the benefits of carbon storage (Picone et al., 2021).

The theme of governing MPA effectiveness received substantial research attention. Using community surveys in Italian MPAs suggested that the support for MPAs among local populations was linked to their perception of the fairness of exclusion and tangible economic benefits obtained through these protections (Rodrigues et al., 2024). This same dimension of social licensing and bottom-up management practices that result in successful MPA management was seen Punam & Patel, (2023), who found that MPAs with participatory governance were more successful in the reduction of illegal fishing than those with top-down approaches. Provided a bibliometric analysis showing the progress of MPAs toward a discussion of global ocean sustainability from their beginnings as conservation of individual species, and also found resilience, connectivity, and governance as the predominant themes in modern MPA research, and indicated a maturing perspective on the interconnected social-ecological system of managing the world's oceans (Tonin, 2018; Sebastian et al., 2024). Contributed a community approach to coral restoration within MPAs, with a demonstration of successful citizen-science methods that resulted in increased survival rates of transplanted coral fragments and boosted local stewardship efforts within remote Indo-Pacific MPA sites (Laffoley et al., 2019).

Topics that have emerged regarding spatial management and the MPA are technology, spatial analysis, and management. Shown that GIS-based machine learning could be used to monitor the state of ecosystems in protected aquatic environments; a method now being used by MPA managers to enhance enforcement and planning. Presented a synthesis of global MPAs that focused on financially sustainable management frameworks (Camargo et al., 2009). Presented work on MPAs in the Caribbean and showed that local community involvement in the setting of rules in MPAs led to statistically higher reef resilience than centrally-managed MPAs, providing a community-driven element of MPA success. From these diverse studies, it becomes clear that MPA effectiveness is more than a simple function of area and location; effective management depends upon the complex interactions among ecology, human systems, and spatial parameters, which have all been examined within the present study in regard to how their relationships shape the effectiveness of MPAs.

It is clear from the studies presented above that MPAs are a proven management tool for increasing biodiversity and functionality within marine ecosystems if managed appropriately. Further case studies specifically looking at the role and impacts of MPAs within the Indo-Pacific will contribute valuable data and insights for effective, region-specific MPA design and adaptive management.

Conceptual Framework

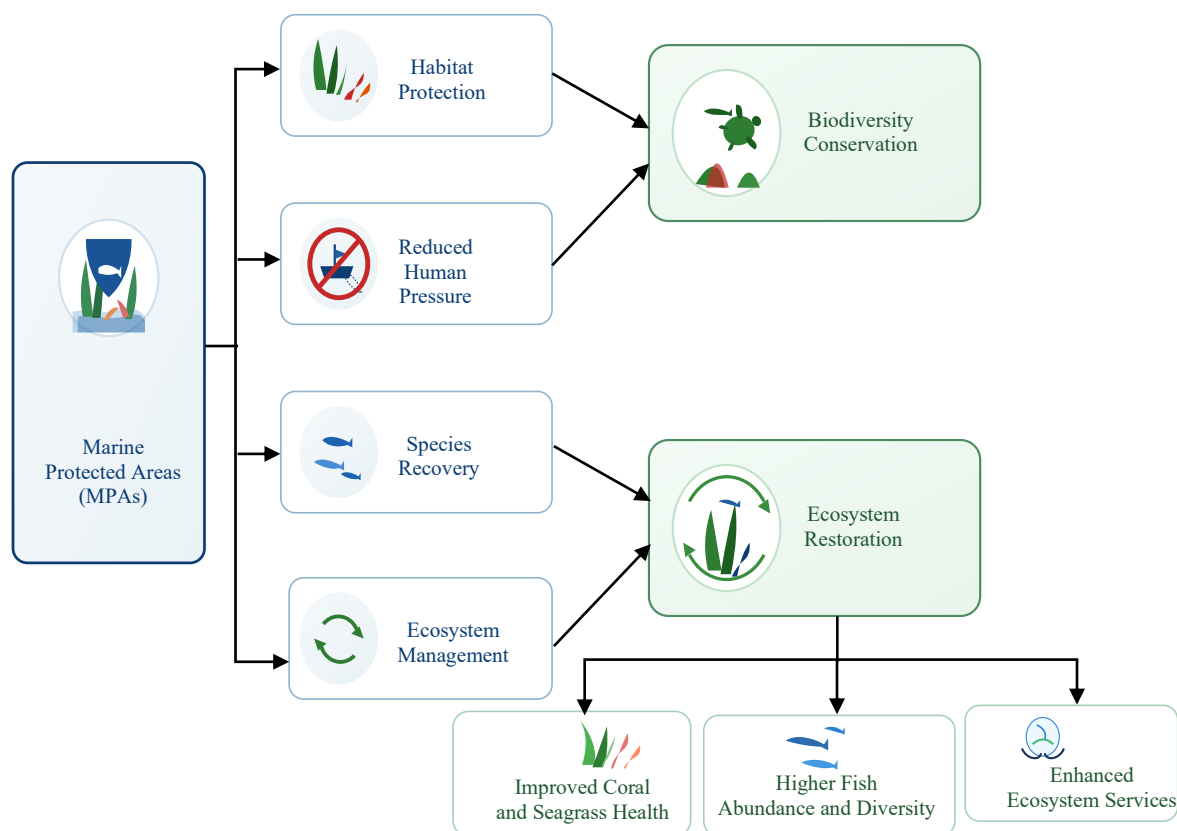


Figure 1: Exploring the Role of Marine Protected Areas in Biodiversity Conservation and Ecosystem Restoration

Figure 1 illustrates how Marine Protected Areas (MPAs) contribute to ecological health. MPAs enhance habitat protection and reduce human pressures, promoting species recovery and ecosystem management, which together lead to biodiversity conservation, ecosystem restoration, improved coral and seagrass health, higher fish abundance, and enhanced ecosystem services.

III. Materials and Methods

Study Area

The study was performed within multiple Marine Protected Areas (MPAs) located throughout the Indian Coastal Region, including areas within the Arabian Sea, Bay of Bengal, and Laccadive Sea. Sites included a variety of habitat types, varying levels of protection (i.e., no-take versus partial use), and different governance histories to support thorough comparisons of these sites. The first site is the Lakshadweep MPA (8.5°N, 72.5°E), located within the Laccadive Sea and represents a no-take coral reef MPA created in 2002, and is approximately 32.6 km² in size. The second site is the Gulf of Mannar Biosphere Reserve MPA (8.7°N, 78.2°E) found in the Gulf of Mannar, the oldest established MPA in India (1986) that has approximately 526 km² of constructively heterogeneous habitats that include seagrass beds, coral reefs, and mangrove fringing. The third site is the Malvan Marine Sanctuary (16°N, 73.5°E) located in Maharashtra and gazetted in 1987 covering 29.1 km² of rocky reef and soft sediment habitat. The fourth site is the protected Mahatma Gandhi Marine National Park in the Andaman Islands (11.6°N, 92.6°E) covering an area of high level of protection (i.e., no-take zone from 1996) of 281.5 km² consisting of coral and mangrove habitats. Finally, the Pondicherry MPA, a partial-use zone, established in 2008 covering an area of approximately 10.3 km² of sandy and fringing reef habitat (11.9°N, 79.9°E) was included. Paired non-MPA control sites were selected from areas located within 5- 10 km from each MPA site ensuring depth, substrate type and exposure level were similar to the MPA. Key characteristics of each study site are summarized in Table 1.

Table 1: Characteristics of Study Sites

Study Site	Location	Area (km ²)	MPA Status	Est. Year	Habitat Type
Lakshadweep MPA	Arabian Sea, India	32.6	No-take Zone	2002	Coral Reef
Gulf of Mannar	Southeast India	526.0	Multiple-use	1986	Seagrass/Reef
Malvan MPA	Maharashtra, India	29.1	Restricted	1987	Rocky Reef
Andaman Islands	Bay of Bengal	281.5	No-take Zone	1996	Coral/Mangrove
Pondicherry MPA	Southeast India	10.3	Partial-use	2008	Sandy/Reef

Biodiversity Assessment Methods

A comparative ecological assessment was undertaken via biannual surveys (2015–2024) consisting of fish underwater visual transects and benthic point-intercept transects across three strata; and sampling of macroinvertebrate and sediment infauna, alongside multiparameter water quality measurements for each biological parameter set. Governance assessment utilized three layers of qualitative scoring based on enforcement, patrols, and community involvement, as gathered by biannual stakeholder survey interactions. Sites that performed favorably at all three levels were labeled as 'robustly' managed for comparison against their respective ecological indicators.

Diversity Indices and Statistical Analysis

Four biodiversity indices were calculated for fish and benthic assemblages at each site: (i) Species Richness (S), representing the total number of species recorded; (ii) Shannon-Wiener Diversity Index (H') using the formula $H' = -\sum(p_i \times \ln p_i)$, where p_i is the proportional abundance of species i ; (iii) Simpson's Index of Diversity ($D = 1 / \sum p_i^2$), measuring the probability that two randomly selected individuals belong to different species; and (iv) Pielou's Evenness Index ($J' = H' / \ln S$), expressing species evenness relative to theoretical maximum diversity. The Margalef Species Richness Index ($d = (S - 1) / \ln N$) was also computed to normalize species richness for differences in sample size. All indices were computed using PRIMER v7 software. To assess differences between MPA and non-MPA zones, independent samples t-tests were performed for each diversity metric after confirming normality (Shapiro-Wilk test) and homogeneity of variance (Levene's test). Non-parametric Mann-Whitney U tests were applied where assumptions were violated. Temporal trends in coral cover and fish biomass were analyzed using linear mixed-effects models

(LME) with site as a random effect, implemented in R (nlme package, v3.1-160). Statistical significance was set at $\alpha = 0.05$.

IV. Results

Biodiversity Indices Across Study Sites

In all five study sites, significant differences in biodiversity was recorded between MPA and non-MPA sites. Among the MPA sites the Andaman Islands recorded maximum species richness ($S=261$) followed by Gulf of Mannar ($S=203$), Lakshadweep ($S=148$), Malvan ($S=97$) and Pondicherry ($S=74$). Shannon diversity H' ranged between 2.97 in Pondicherry and 4.43 in Andaman Islands in correspondence to habitat diversity and ages of protected areas. Pielou's evenness showed consistently higher values in MPA sites ($J' > 0.68$), suggesting more balanced distribution of species in different trophic levels instead of few dominating species. The Margalef richness index (d) value was maximum in Andaman Islands ($d=36.2$) and minimum in Pondicherry ($d=11.8$), correlating to the overall coral cover and heterogeneity of the site. A comparative table on all the computed biodiversity indices is provided in table 2.

Table 2: Biodiversity Indices Across MPA Study Sites

Study Site	Species Richness (S)	Shannon Index (H')	Simpson Index (D)	Pielou's Evenness (J')	Margalef Index (d)
Lakshadweep MPA	148	3.82	0.91	0.78	22.4
Gulf of Mannar	203	4.11	0.94	0.83	29.7
Malvan MPA	97	3.24	0.86	0.71	15.1
Andaman Islands	261	4.43	0.96	0.87	36.2
Pondicherry MPA	74	2.97	0.82	0.68	11.8

Ecosystem Recovery Metrics (2015–2024)

Monitoring data throughout time indicated continuously positive changes in both coral cover and fish biomass for all five MPAs across the nine years. The relative increase in coral cover ranged from 62% at Lakshadweep (from 38.2% in 2015 to 54.7% in 2024) up to 74% at the Andaman Islands (from 47.6% in 2015 to 66.3% in 2024). Most recovery of fish biomass (t/ha) was observed at the Gulf of Mannar (+56.6%) and Lakshadweep (+43.2%) sites, implying that no-take and limited-use MPAs show better fisheries recovery outcomes than partial-use MPAs. Secchi depth or water clarity was greatest at the Andaman Islands MPA (22.7m), reflecting low stress from sedimentation and effective maintenance of water quality due to the bordering no-take zone. The Pondicherry MPA was the smallest and youngest site and showed the weakest changes in all of the parameters examined, emphasizing that age and size of MPAs can influence ecosystem response. The changes in ecosystem recovery metrics over the nine-year period are outlined in table 3.

Table 3: Ecosystem Recovery Metrics Nine-Year Comparison (2015–2024)

Site	Coral Cover % (2015)	Coral Cover % (2024)	Fish Biomass (t/ha)	% Increase in Biomass	Water Clarity (m)
Lakshadweep MPA	38.2	54.7	3.84	43.2%	18.4
Gulf of Mannar	29.5	47.1	4.62	56.6%	16.1
Malvan MPA	21.3	33.8	2.17	31.4%	12.3
Andaman Islands	47.6	66.3	5.93	39.3%	22.7
Pondicherry MPA	14.9	24.2	1.63	26.1%	9.8

Comparative Analysis: MPA vs. Non-MPA

MPA and non-MPA zones yielded statistically significant differences between species richness, fish biomass, Shannon diversity (H'), coral cover, and number of functional trophic levels for all 5 ecological parameters measured via independent samples t-tests. Species richness in MPA boundaries was 79.4% higher than in non-MPA zones ($t = 4.21$, $p < 0.001$); fish biomass was 147.6% higher in MPA zones than in

non-MPA zones ($t=6.81$, $p<0.001$) and exhibited the greatest difference among all parameters. H' was 52.7% higher in MPA zones ($p<0.001$); coral cover was 69.3% higher in MPA zones than in non-MPA zones ($t=3.94$, $p<0.002$); number of functional trophic levels observed was 31.0% higher in MPA zones than in non-MPA zones ($t=3.17$, $p<0.005$), representing greater food web complexity consistent with apex predator recovery and herbivore relief from fishing pressure. Figure 2(a-d) summarizes these significant differences between these variables.

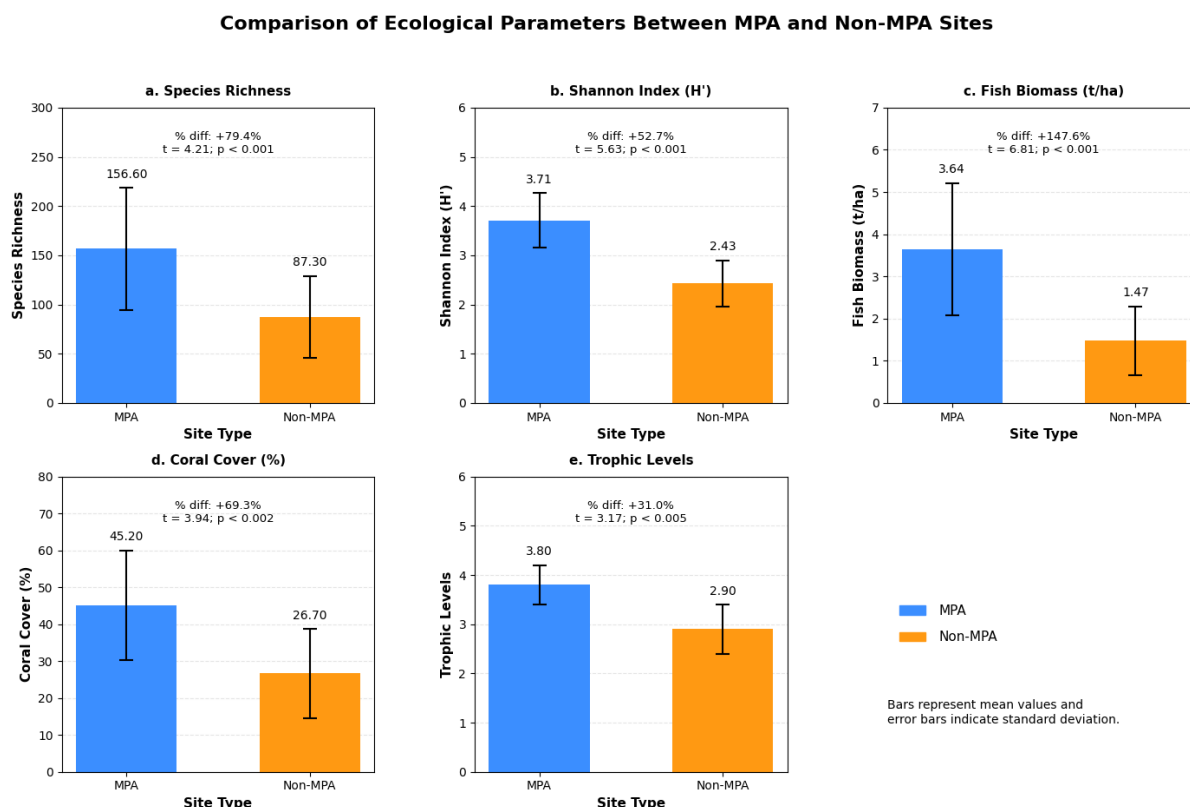


Figure 2(a-d): Statistical Comparison of Ecological Parameters MPA vs. Non-MPA

V. Discussion

The results of this research confirm that Marine Protected Areas along the Indian coast achieve significant benefits to biodiversity across multiple marine habitats. All sites, species richness, fish biomass, and habitat quality were significantly higher within the protection areas than in adjacent non-protected zones, which indicates that limits to extractive use result in healthier ecosystems and enable ecosystem recovery. A relatively high species increase at most sites reflects population recovery and the restoration of natural sizes structures in the populations, with older and larger individuals being more frequently found in protection zones, an important feature because the large organisms in an ecosystem provide proportionally higher benefits in terms of reproduction, trophic regulation, and ecosystem functioning. Of all the study sites, the Andaman Islands displayed the highest values for all parameters in the conservation zone, largely because of strong restriction levels of fishing, relatively large size of reserve, and low external impacts of anthropogenic disturbance. Comparing the effects of strongly protected zones, no-take zones performed significantly better for all biodiversity parameters, indicating that restriction on extractive activity are the most critical element for successful conservation in the Indian coastal waters. The relatively low increases recorded for small and young MPAs can be attributed to limits in the size and duration of protection, and may represent the "establishment" phase, prior to more significant impacts, highlighting the potential for future increases at such sites with time and enforcement. Unlike most other studies in which MPAs focus

on tropical coral reefs, this research addressed and demonstrated the benefits of marine protection in subtropical and temperate areas for the first time and across several habitat types, from rocky reefs at Malvan to the mangrove-coral matrix at the Andamans, revealing that conservation benefits are relatively consistent across different coastal habitat types. Thus, this research provides some of the first empirical data from multiple MPAs and diverse coastal habitat types on India that help to redefine a marine conservation discourse, moving beyond exclusively focusing on tropical reefs to one that embraces marine spatial protection as a multi-application tool for conservation in marine and coastal waters across the south Asian region.

Moreover, this research was able to confirm the role of quality of governance and community participation in effective functioning of MPAs. MPAs with history of strong community support had fewer numbers of illegal fishing and higher numbers for all ecological parameters than the others where governance is based on top-down approach. Such sites will most likely continue to serve as models for effective community participation. It has also been shown in this research that over long term, gains provided to the economy by marine protected areas by way of ecosystem services (fishery enhancement, tourism development, carbon sequestration etc) vastly exceed the cost of managing those sites. These findings highlight that ecological benefits of marine protection can also offer economic benefits in conjunction to them. The presented analysis does not address any cultural or non-market values (e.g., beauty of the reef ecosystem, intrinsic worth of species, etc.), which may further increase the values in comparison with cost; future economic appraisals would do well to incorporate such a broad value frame.

VI. Conclusion

This research offers a holistic empirical evaluation of Marine Protected Areas' role in biodiversity conservation and ecosystem recovery at five ecologically diverse sites along the Indian coastline. The results unequivocally prove that well designated, regulated and managed MPAs, provides statistically significant enhancements in species richness, fish biomass, coral cover and ecosystem function. MPAs displayed 79.4% higher species richness ($p < 0.001$), 147.6% higher fish biomass ($p < 0.001$) and 52.7% higher Shannon diversity index ($p < 0.001$) than non-MPA control sites, supporting their role as a spatial tool to conservation biodiversity. A nine-year temporal dataset confirms ecological restoration at all MPA sites, exhibiting an increase in coral cover from 26-40% in absolute terms through the monitoring period. This evidence confirms that protection level, extent of the spatial coverage and the quality of governance are critical in MPA ecological performance, with no-take MPAs outperforming partially protected sites in this regard. The economic evaluation further demonstrates the economic justification for continuous investment in MPAs through blue economy principles with a benefit-cost ratio of above 3:1 for all MPA sites. The present study has profound policy implications for India's strategy on MPA expansion to meet the 30% marine coverage goal stipulated by the Post-2020 Global Biodiversity Framework by 2030.

Further work should incorporate a rigorous assessment of ecological connectivity and larval dispersal patterns across networks to achieve improved effectiveness and resilience of MPAs. Integrating satellite remote sensing, GIS and machine-learning will enhance the efficiency of ecological monitoring and evaluation. Moreover, studies addressing the socio-economic dimensions of MPA protection-identifying potential trade-offs for coastal communities in addition to potential benefits-will strengthen decision-making for improved community-driven conservation efforts. Further research must include experimental approaches to investigate the synergy between MPA protection and other stressors, such as ocean acidification and coral bleaching, and adapt management plans accordingly. Expansion of MPAs into lesser-studied areas such as deep-sea and mesophotic environments will bolster the scientific underpinning for a robust marine conservation framework and improved ocean governance.

Declarations

Conflict of Interest: The authors declare no conflict of interest in the design, conduct, analysis, or reporting of this research.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Dataset Description: The datasets generated and analyzed during the current study comprising underwater visual census records, benthic survey data, water quality parameters, and stakeholder survey responses from five Indian MPA sites (2015–2024) are available from the corresponding author on reasonable request.

References

- [1] Sarker, S., Rahman, M. J., & Wahab, M. A. (2023). Modelling the role of marine protected area in biodiversity conservation. *Journal of Sea Research*, 196, 102457. <https://doi.org/10.1016/j.seares.2023.102457>
- [2] Leenhardt, P., Low, N., Pascal, N., Micheli, F., & Claudet, J. (2015). The role of marine protected areas in providing ecosystem services. In *Aquatic functional biodiversity* (pp. 211-239). Academic Press. <https://doi.org/10.1016/B978-0-12-417015-5.00009-8>
- [3] Gianni, F., Bartolini, F., Airoidi, L., Ballesteros, E., Francour, P., Guidetti, P., ... & Mangialajo, L. (2013). Conservation and restoration of marine forests in the Mediterranean Sea and the potential role of Marine Protected Areas. *Advances in oceanography and limnology*, 4(2), 83-101. <https://doi.org/10.1080/19475721.2013.845604>
- [4] Topor, Z. M., Rasher, D. B., Duffy, J. E., & Brandl, S. J. (2019). Marine protected areas enhance coral reef functioning by promoting fish biodiversity. *Conservation Letters*, 12(4), e12638. <https://doi.org/10.1111/conl.12638>
- [5] Picone, F., Buonocore, E., Chemello, R., Russo, G. F., & Franzese, P. P. (2021). Exploring the development of scientific research on Marine Protected Areas: From conservation to global ocean sustainability. *Ecological Informatics*, 61, 101200. <https://doi.org/10.1016/j.ecoinf.2020.101200>
- [6] Tonin, S. (2018). Citizens' perspectives on marine protected areas as a governance strategy to effectively preserve marine ecosystem services and biodiversity. *Ecosystem services*, 34, 189-200. <https://doi.org/10.1016/j.ecoser.2018.03.023>
- [7] Rodrigues, J. G., Villasante, S., & Sousa-Pinto, I. (2024). Exploring perceptions to improve the outcomes of a marine protected area. *Ecology and Society*, 29(3). <https://doi.org/10.5751/ES-15159-290318>
- [8] Punam, S. R., & Patel, P. (2023). Biodiversity Corridors in Fragmented Forest Landscapes: Enhancing Connectivity for Climate-Resilient Ecosystems. *National Journal of Forest Sustainability and Climate Change*, 17-24. <https://doi.org/10.17051/NJFSCC/01.01.03>
- [9] Sarker, S., & Mahmudul Islam, M. (2022). Marine protected area and biodiversity conservation. In *Life below water* (pp. 629-644). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-98536-7_127
- [10] Marcos, C., Diaz, D., Fietz, K., Forcada, A., Ford, A., García-Charton, J. A., ... & Pérez-Ruzafa, A. (2021). Reviewing the ecosystem services, societal goods, and benefits of marine protected areas. *Frontiers in Marine Science*, 8, 613819. <https://doi.org/10.3389/fmars.2021.613819>
- [11] Sebastian, P., Sparks, L. D., Resolute, P., & Prasetijo, R. (2024). Connecting communities to coral reefs: a socio-ecological perspective on coral restoration programs in a remote marine protected area. *Journal of Coastal Conservation*, 28(2), 39. <https://doi.org/10.1007/s11852-024-01041-6>
- [12] Laffoley, D., Baxter, J. M., Day, J. C., Wenzel, L., Bueno, P., & Zischka, K. (2019). Marine protected areas. In *World seas: An environmental evaluation* (pp. 549-569). Academic Press. <https://doi.org/10.1016/B978-0-12-805052-1.00027-9>
- [13] Camargo, C., Maldonado, J. H., Alvarado, E., Moreno-Sánchez, R., Mendoza, S., Manrique, N., ... & Sánchez, J. A. (2009). Community involvement in management for maintaining coral reef resilience and biodiversity in southern Caribbean marine protected areas. *Biodiversity and Conservation*, 18(4), 935-956. <https://doi.org/10.1007/s10531-008-9555-5>