



Review Article

Coral Reef Communities of Astola Island: The First Marine Protected Area of Pakistan

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ABSTRACT

This study emphasizes on the environmental, ecological, geographical, economical and cultural importance, while assessing the current situation, vulnerability and management of Astola island, as the first ever notified marine protected area of Pakistan. Declaring MPAs is important for the conservation of coral reefs and other associated biodiversity, which provides ecological, socioeconomic, and cultural outcomes while strengthening resilience against climate change. Since 2017, Government of Balochistan has declared three MPAs to date i.e., Astola, Churna and Miani Hor. Coral reefs in the Arabian sea meet unique environmental stressors, yet they entertain significant diversity with remarkable endemism and resilience. Astola island is home 29 hard, 01 black, and 08 soft coral, supporting diverse marine life. The fourth global mass coral bleaching event (2023-25), which has affected 83.9% of coral reef communities worldwide, raised concerns and elevates the importance for active conservation of coastal belts. Key challenges for protection include insufficient resources, baseline data, limited stakeholder integration, coordinated monitoring systems, poor enforcement and lack of approved management plan. Overall, the coral reefs of Astola island represent ecologically and environmentally valuable yet vulnerable ecosystems. Functional and effective conservation needs adaptive management, scientific innovation, community engagement and international collaboration to ensure persistence of coral reefs under expanding anthropogenic and accelerating climate change.

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MK: Data collection, literature analysis, conceptualization and paper writing. **AR:** Data interpretation, scientific evaluation, and article critical revision. **YY:** Supervision, methodological advice, and final manuscript editing.

Key words

Arabian sea, Balochistan, Astola island, Coral reefs, Biodiversity, MPAs

INTRODUCTION

Marine protected areas (MPAs), which usually covers coral reefs, coastal zones, estuaries, open ocean water, mangroves, seagrass beds, are legally and designated marine areas which are managed to protect and preserve biodiversity, provide ecosystem services, and maneuver values of culture for present and coming generations (Horta e Costa *et al.*, 2016). The main and principal goals of marine protected areas are preservation of coral reefs, protecting oceanic biodiversity, conservation of endangered species, reducing overexploitation or degradation of ecosystems, biomass and species recovery, increasing climate change

resilience, implementation of sustainable strategies for fisheries, improve livelihood of local residents (Indriyani *et al.*, 2025; Collins *et al.*, 2021). Other key platforms offered by MPAs are include scientific evaluation, monitoring, educational approaches, and engagement of communities (Jiang *et al.*, 2024). In Pakistan, total three marine protected areas have been declared so far which are

Abbreviations

SST, Sea Surface Temperature; MPAs, Marine Protected Areas; SPSC, Small Polyp Stony Corals; LPSC, Large Polyp Stony Corals; SPSC, Small Poly Soft Corals; NPBC, Non Photosynthetic Black Corals; CBD, Convention on Biological Diversity; IUCN, International Union for Conservation of Nature; WWF, World Wide Fund for nature; CBOs, Community Based Organizations; NGOs, Non Governmental Organizations; NOAA, National Oceanic and Atmospheric Administration; CRW, Coral Reef Watch; DHW, Degree Heating Week; MCP, Marine Conservation Pakistan; CRCP, Coral Reef Conservation Program; NCORE, National Center for Coral Reef Research; GCRMN, Global Coral Reef Monitoring Network; ICRS, International Coral Reef Society; GFCR, Global Fund for Coral Reefs; CTI-CFF, Coral Triangle Initiative on Coral reefs, Fisheries and Food security; ICRAN, International Coral Reef Action Network; ICRI, International Coral Reef Initiative; BACI, Before After Control Impact.

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Table I. The longitude and latitude of Astola island.

Buffer zone		Area	Core zone		Area	Total area
Longitude (E)	Latitude (N)		Longitude (E)	Latitude (N)		
63°44' 53.0343"	25°12' 44.9818"	225.83 km ²	63°46' 22.2757"	25°11'23.7367"	175.64 km ²	401.47 km ²
63°56' 46.9657"	25°12' 44.9818"		63°55' 17.7240"	25°11'23.7367"		
63°56' 46.9657"	25°01' 55.0142"		63°55' 17.7240"	25°03' 16.2611"		
63°44' 53.0343"	25°01' 55.0142"		63°46' 22.2757"	25°03' 16.2611"		

The main and central focus of declaring MPAs is coral reefs protection, which are the most.

found in jurisdiction of Balochistan, these include Astola island, Chruna Island and Miani Hor.

Astola Island (Fig. 1) having an area of 401.47 km² (Table I), was declared as first marine protected area of Pakistan, by Government of Balochistan under section 34, 40, 46, 47, and 48 of the Balochistan Wildlife (Protection, Preservation Conservation and Management) Act-2014, on 15th June, 2017. The fundamental principal aim of this declaration was to protect coral communities and other marine aquatic biological diversity along the coastal region of Balochistan (Astola island, First Marine Protected Area in Pakistan, 2018).



Fig. 1. Astola island geographic location.

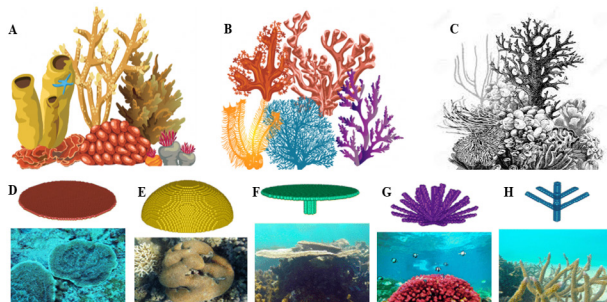


Fig. 2. Types and physical appearance of coral reefs. A, Scleractinian (Hard or Stony corals); B, Alcyonacea (Soft or Ahermatypic corals); C, Antipatharia (Black corals); D, Encrusting; E, Hemispherical; F, Tabular; G, Corymbose; H, Branching.

The main and central focus of declaring MPAs is coral reefs protection, which are the most environmentally, economically, culturally, and ecologically important, valuable but susceptible ecosystems. These MPAs are essential tools in mitigation of coral reefs degradation and secure the ecological, cultural, and economic benefits (Pakistan, 2016).

Coral reefs are formed by marine invertebrates called as coral polyps. The Corals are classified into hard or stony (subclass; hexacorallia/scleractinia), soft (subclass; octocorallia) and black (Fig. 2) within class Anthozoa and phylum Cnidaria (Peel, 2017; Rouzé *et al.*, 2021). The hard corals are found in shallow water followed by soft coral and the black corals are inhabitant of deep-sea water (Fig. 3). These Cnidarians secrete the calcium carbonate skeletons that gather and accumulate over long period from 10,000 to 30 million years to form complex reef shapes and structures. Reefs are basically classified into Barrier, Fringing, Atolls and sometimes into Patch reef (Fig. 4). The barrier reef grows close to shorelines, fringing reef grows from shoreline forming a lagoon, atoll reefs grow and encloses the lagoon and patch reef grows within a large reef system on the seafloor in a lagoon (Davin *et al.*, 2021).

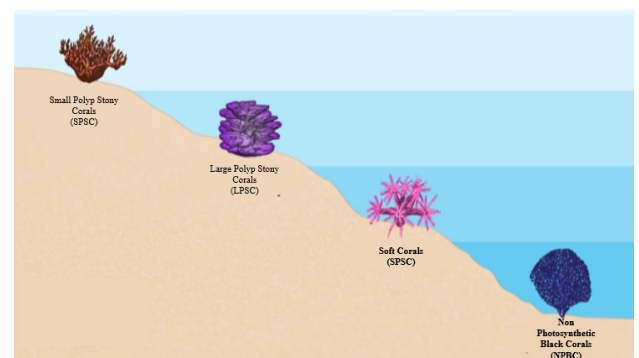


Fig. 3. Habitat of coral reefs in marine ecosystem.

The coral reefs are sometimes referred to as the rainforests of the sea and these are biologically most

diverse ecosystems on earth. They cover only 0.1% of the ocean floor but according to an estimation it supports more than 25% of all marine species (Hoegh-Guldberg *et al.*, 2017) including fish, sea turtles, mollusks, echinoderms, crustaceans, sea mammals, cnidarians, arthropods, and different types of land and sea birds (Eddy *et al.*, 2021; Hughes *et al.*, 2017).

Beside protection of biodiversity (Fig. 5), these structures also provide shelter to food security, coastal protection, add value to economies, arrange recreational opportunities, possess medicinal potential (Doney *et al.*, 2020).



Fig. 4. A, Barrier reef; B, Fringing reef; C, Atoll reef; and D, Patch reef.

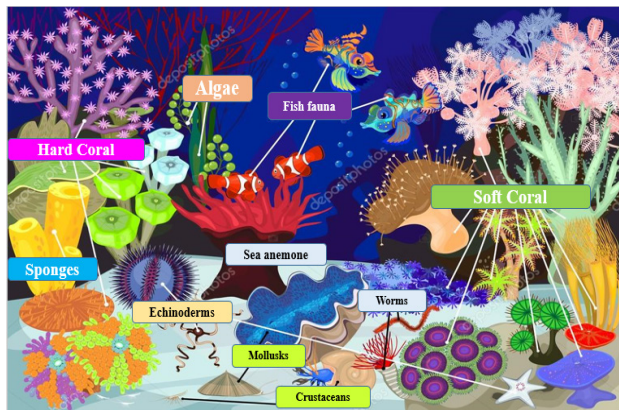


Fig. 5. Coral reef supports diverse biological diversity in marine ecosystem.

Despite of providing enormous supporting, cultural, provisioning, and regulating services, these reefs are facing environmental stressors and anthropogenic pressures such as climate change, ocean acidification, rise of ocean temperature, pollution, overfishing, nutrient runoff, habitat dismantling, coastal development etc. which make the reefs more prone and susceptible to devastation and the

situation becomes more worsen when the stressors function synergistically. More than 50% cover of corals have been lost globally from last few decades due to rise in average temperature from ~1 to 1.5 °C (Souter *et al.*, 2021).

GEOGRAPHICAL, ECOLOGICAL SIGNIFICANCE AND ASSOCIATED BIODIVERSITY IN ASTOLA

Astola is also locally known as Haftalar meaning seven hills (Fig. 6), a largest offshore island covering an area of 175.64km² (core zone) and 225.83km² (buffer zone) which expands to an area of 401.47km² (Table I), with 246 feet highest point above the sea level. The island is located about 39km off the coast near town of Pasni (Fig. 1) and the largest island in Pakistan (Tribune, 2017). North face of the island is cliff like with sharp vertical drops while the south face is more gently and naturally characterised by caves, vegetations. Island is facing freshwater scarcity and morely relying on rainfall or soil moisture (Shafqat, 2025; Spreebird, 2012).



Fig. 6. Different geographical aspects of Astola marine protected area (IUCN, 2017b, 2024; WWF, 2020).

The ecosystem of Astola island is diverse encircled with 20 to 25 species of stony several soft coral reefs (Tribune, 2017). Studies underwater show an abundance of marine life including roughly estimated 156 species of fish alongside invertebrates like lobsters, fan worms, sea urchins, other bio include algae (Zooxanthellae), fungi (endoliths, endosymbionts, and pathogens) etc. with no prominent sign of coral bleaching (Shafqat, 2025). The humpback whale (*Megaptera novaeangliae*), Indo-Pacific humpback dolphin (*Sousa chinensis*), common bottlenose dolphin (*Tursiops truncatus*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), spinner dolphin (*Stenella longirostris*), Risso's dolphin (*Grampus griseus*), blacktip shark (*Carcharhinus limbatus*), bull shark (*Carcharhinus leucas*), spot-tail shark (*Carcharhinus sorrah*) (Moazzam

and Osmany, 2021). Whale shark (*Rhincodon typus*), common guitarfish (*Rhinobatos rhinobatos*), mobulids such as *Mobula eregoodoo*, *Mobula mobular*, *Mobula birostri*, *Mobula kuhlii*, *Mobula thurstoni*, *Mobula tarapacana* (Siddiqui *et al.*, 2025), parrotfish (*Scarine labrids*), hot-lip fish (*Plectorhinchus gibbosus*) and many more marine species have been usually sighted in the water of island. Reptiles such as endangered green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), spinny tail lizard (*Uromastix* spp.), Bengal monitor lizard (*Varanus bengalensis*), collar lizard (*Crotaphytus collaris*), long tailed desert lizard (*Mesalina watsonana*), saw-scaled viper (*Echis carinatus astolae*), carpet viper (*Echis pyramidum*), cliff racer (*Platycephalus rhodorchis*), skinks (Family Scincidae), nine types of different sea snakes are also reported in the island. Additionally, 19 terrestrial and 87 aquatic bird species are found in and around the island. Some population of birds such as sooty gulls have reduced due to predation by feral cats and rats (Agency, 2017). Astola island provides habitat to about 82 species of terrestrial plants and remains limited due to arid conditions (IUCN, 2017a; Shafqat, 2025).

The Astola island remains uninhabited due to limited sources but it serves as base during the season for fishermen from September to May and during the period they are fishing lobsters, oysters, crabs, and other marine products (Spreebird, 2012). The island is also characterized by lighthouse installed in 1982. Beside that it also carries cultural, religious, and historical significance where a small masjid named after Pir Khawaja Khizr (Fig. 7), Satadip hindu temple named after goddess Kali are features found in the island (IUCN, 2017a; Spreebird, 2012).



Fig. 7. Pir Khawaja Khizr masjid (IUCN, 2017b).

CORAL REEFS OF NORTHERN INDIAN OCEAN (ARABIAN SEA)

The coral reefs of the Arabian sea and northern Indian ocean fall within the broader biogeographic region of Indo-Pacific but constitute a unique sub region characterized by high level of salinity, variable irregular monsoon systems,

and high temperature of sea surface (Obura *et al.*, 2020; Riegl and Purkis, 2015). This region, biogeographically includes habitats of coastal corals of indian ocean countries such as Pakistan, Iran, India, Oman, Maldives, Saudi Arabia etc. The gulf of Aden and Oman is acting major transitional section between the coral reefs of Red sea and Indian ocean (Cowburn *et al.*, 2019). The strong seasonal monsoons influence the surface of sea temperature, salinity, nutrient fluxes and upwelling and dominate the regional oceanography, these dealings creat challenging and dynamic environment for the growth of corals (Purkis *et al.*, 2025). The surface of the Arabian sea exceeds up to 31°C in on regular basis in summer and this rise in temperature reaches the coral bleaching thresholds (Arora *et al.*, 2019), while Omani and Pakistani coasts are injected cold nutrient rich water which enhancing productivity which is caused by upwelling but this can also kepp stress on asemblages of corals due to reduction in aragonite saturation (Spreter *et al.*, 2022). Though there are several challenges for the survival of coral species but the region provide suitable habitat and supports a notable diversity of 200 to 250 species out of total 6000 species of corals in the nothern Indian ocean. It is important to mention that the local diversity of coral species varies significantly due to availability of nutrients, turbidity, thermal variation and other historical stress events (Chanda *et al.*, 2022; Obura *et al.*, 2020). The recent scientific studies and surveys in the Arabian sea have appeared reduction in the cover of corals in some areas such as Lakshadweep islands, gulf of kutch, and gulf of mannar in India, Makran coast including Astola island in Pakistan, coast of Maldives, Sri Lanka, and gulf of UAE, Oman, and Iran (Vinoth *et al.*, 2012). The population of corals is effected by rising of Sea surface temperatures (SSTs) and anthropogenic pressures in these areas but yet isolated refugia persist in less impacted zones especially in open areas such as such as coasts of Balochistan (Ahmad *et al.*, 2024). When the coral communities of Arabian sea are compared to the coral triangle, though the diversity is lower, but exhibit high levels of resilience and regional endemism which highlights their importance in future preservation and climate adaptation strategies (Eakin *et al.*, 2019).

The toral stretch of coastal belt in Pakistan is between 900 to 1050 km covering both Sindh and Balochistan. This stretch has harbors scattered but yet ecologically important coral communities which is endemic to this region (Ahmad *et al.*, 2024). At the beginning the presence of corals and the reefs in these waters was in doubt but after attention of wildlife departments and field surveys conducted by academia in early 2010s total changed the perspective about the corals. 2 landmark study was conducted in 2013 by Amjad Ali and his colleagues from university of Karachi

and documented 29 hard, 1 black and 8 soft corals, dived into 18 different sites along the coasts of Balochistan and Sindh (Ahmad *et al.*, 2024; Ali *et al.*, 2014). In 2017, more broader survey was managed and the study was expanded which reported more than 50 coral species and other associated fauna including sponges, molluscs, crustaceans, anemones, echinoderms and 54 fish species. The investigating team also exposed data about 48 fossil coral species which is dating from pleistocene to holocene at uplift sites of Jiwani and Gwadar. Before notifying any formal MPA, the coral communities faced threats from anthropogenic and environmental stressors.

In 2020 it has been studied that the health of reef has been facing declining due to different pressures such as pollution (29%), overfishing (24%), tourism (26%), climate change (16%), tourism (26%), and sedimentation (18%) (Ahmad *et al.*, 2024). For protection, preservation and conservation strategies in marine protected areas, a sustainable and regulated fishing, pollution control, community engagement, limited ecotourism, integrated management and other nature based sustainable activities were pending. In coastal belt of Balochistan to protect these creatures, Asotla island, Churna island and Miani Hor are declared as marine protected areas by Government of Balochistan, Wildlife department (Ahmad *et al.*, 2024; Khan, 2025a).

To protect the historical and delicate ecosystems of Astola island was declared as first MPA on 15th June, 2017 for aligning with international agreements and commitments under the Convention on Biological Diversity (CBD) and Aichi Biodiversity Targets (Service, 2001). The declaration mainly focus on protection, conservation, and management of fauna and flora in the region along with regulating sustainable use of resources in the island.

CORAL COMMUNITIES IN ASTOLA ISLAND

The coral communities around Astola island are important and remarkable for diversity and density mostly concentrated on the sheltered northern side where the stony coral reefs can constitute about 80% cover. The most documented and abundant coral species are *Favites complanata*, *Favites pentagona*, *Coscinaraea monile*, *Porites nodifera*, *Pocillopora damicornis*, *Porites harrisoni*, *Leptastrea pruinosa*, *Psammocora obtusangulata*, *Plesiastrea versipora*, *Psammocora superficialis*, *Acanthastrea hillae*, *Acanthastrea maxima*, *Montipora mollis*, and *Antipathes dichotoma* (Fig. 8) etc. that often occur as fringing and large monospecific patches (Ali *et al.*, 2014, 2021).

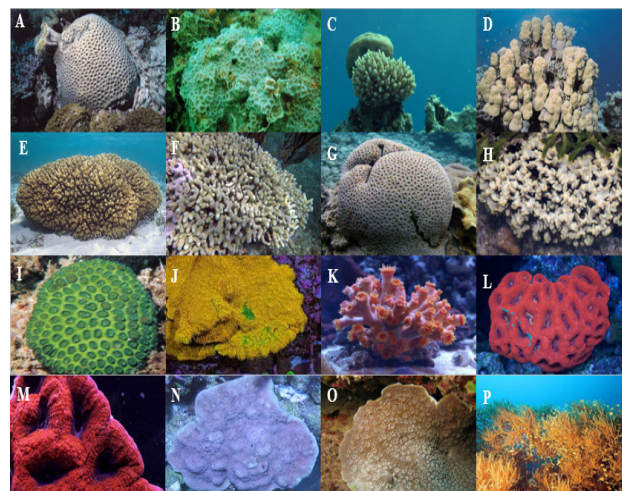


Fig. 8. Coral species: A, *Favites complanata*; B, *Favites pentagona*; C, *Coscinaraea monile*; D, *Porites nodifera*; E, *Pocillopora damicornis*; F, *Porites harrisoni*; G, *Leptastrea pruinosa*; H, *Psammocora obtusangulata*; I, *Plesiastrea versipora*; J, *Psammocora superficialis*; K, *Goniopora columna*; L, *Homophyllia bowerbanki*; M, *Acanthastrea hillae*; N, *Acanthastrea maxima*; O, *Montipora mollis*; P, *Antipathes dichotoma*.

Scientific studies and surveys have recorded about different species of stony or hard and soft corals (Astola Island, First Marine Protected Area in Pakistan, 2018; WWF, 2020). In broader and specific terms, in regional assessments of the Astola island, (e.g., Ali *et al.* 2014) a scientific report shows 29 hard or stony corals of fourteen genera from eight different families, one black coral, and eight soft coral species of seven genera from three families (Ahmad *et al.*, 2024).

According to recent studies the habitat of coral reefs around the island is in good condition and health, no concrete evidence of coral bleaching is detected (Khan, 2025b; WWF, 2020). The proto-reef structures are generally evident, though no true authentic reef formations have been recorded yet so far (Ahmad *et al.*, 2024). However, due to ongoing stressors and pressures from anthropogenic activities such as coral removal for ornament purposes, damages from fishing nets, lobster pots impact, careless skin and scuba diving etc. increasing negative impacts on corals and lead to degradation of communities. The most susceptible species of corals such as *Pocillopora damicornis* and *Porites nodifera* are facing threat and they are reducing their prevalence in the region around island (Ali *et al.*, 2021), but the physiochemical conditions i.e. nutrient level, temperature, remain suitable for coral and associated fish communities for proper function of ecosystem in area (Ali *et al.*, 2021; IUCN,

2017a; WWF, 2020). Total assemblage type observed in expedition of the sheltered areas include up to 80% dense stony coral cover, proto reef structures formed from mono specific stands and patches, and soft coral dominating on more exposed sites (Ahmad *et al.*, 2024). The habitat and health indicators observed during the study were favoring the communities of coral reefs and no bleachings were noted. The presence of proto coral reeds were implying active flourishing however due to human activities such as coral harvesting, fishing gear, diving, and sedimentation contributed to structural damage and disease prevalence which reduced the abundance of certain species and the mortality was documented locally. Overall, the habitat remained favorable for the health of communities though proper conservation and management measures are needed to reduce anthropogenic pressures (Ali *et al.*, 2021).

THREATS TO CORAL REEFS AROUND AS-TOLA ISLAND

Scientific study has predicted that 70% to 90% coral reefs in next 20 years due to main cause of warming of oceans, acidity and pollution (Nace, 2020). Due to human activities such as illegal coral mining, devastating fishing methods, careless scuba, pollution, and skin diving have been reported as major and outreach threats which is mean of physical injury and habitat degradation. Fishing gear and mechanical disturbance from lobster pots also add contribution to this cause (Ali *et al.*, 2021; Khan, 2025). Beside that marine pollution such as oils leakage from engines, discarded nets, plastic debris, human wastes and other trashes scattered due to anthropogenic activities are expending the situation and making it poor for the communities of corals (IUCN, 2017b).

Other than anthropogenic risk, natural calamities in form of storms, temperature fluctuation, sedimentation also exaggerate dismantling of coral systems. The unusual natural storms with high intensity can break the structure of corals and sediment runoff the colonies from distant land. These smother corals and block their access to light (Donner and Potere, 2007).

Coral bleachings are noted in some regions of coastal belt in Balochistan which are triggered by rise in temperature and increasing vulnerability and relative health of ecosystem associated with coral reefs (Ahmad *et al.*, 2024; Khan, 2025).

Global warming driven due to climate change exacerbates to coral communities of Astola island through rise in SST and acidification of ocean. Rise temperatures can trigger coral bleaching which make corals to expel symbiotic algae such as *Zooxanthellae* and this leads to loss of coloration and increase mortality rate of coral

colonies (Donner and Potere, 2007; Kraft, 2014; Kurihara, 2020). On the other hand increase in atmospheric CO₂ levels, the ocean pH is decreased which reduce availability of carbonates that are required for calcification of corals (Donner and Potere, 2007). These stressors combine to reduce the resilience and threaten the long term survival of coral communities (Table II).

WWF-Pakistan funded scuba survey for study of coral communities in 2020 shows that the ecosystem around the Astola island is comparatively stable and functioning properly. During the study no signs of bleaching noted and documented abundant marine life such as different fish species, turtles, invertebrates, and rich coral habitats (WWF, 2020). The field experts caution that these ecosystems can deteriorate promptly without effective protection, conservation and management (ICSF, 2020; Khan, 2025).

Table II. Pressure hazards on coral communities in coastal belt of Balochistan.

Hazard	Particular
Anthropogenic pressure	Coral mining, destructive fishing, pollution, diving, scuba
Natural stressors	Sedimentation, storms, temperature fluctuation
Climate change	Thermal stress, ocean acidification
Current status	Coral reefs are relatively healthy, but vulnerable without management

MANAGEMENT IMPLICATION AND CONSERVATION

The conservation of coral reefs in Sindh and especially in Balochistan has moved forward but yet faces some intimation gaps. Astola Island has been declared as MPA in 2017 but still management plan even after lapse of eight years still pending for approval which is highlighting the slow operationalization (Azam, 2025). In 24th September, 2024, Churna island was declared as second MPA after approval from the Balochistan cabinet. In 2025, Miani Hor received approval from the Balochistan government to be designated as the third MPA of Pakistan, but its official notification is still pending. The expanding protection beyond small areas with low on water enforcement, buoy zoning, and visitor compliance systems (APP, 2025; Dawn, 2024; Tribune, 2017, 2024; WWF, 2025). The government wildlife departments and organizations working on nature seeks fishing communities for contributions to advocacy and surveillance for MPAs to get long term befinits and conservation of protected areas, yet combined management

frameworks and mechanisms for benefit sharing remain poor (WWF, 2025). Standardized underwater surveys, fish assemblage studies, baseline information for coral cover, disease, water quality and monitoring capacity are incomplete (Fig. 9).

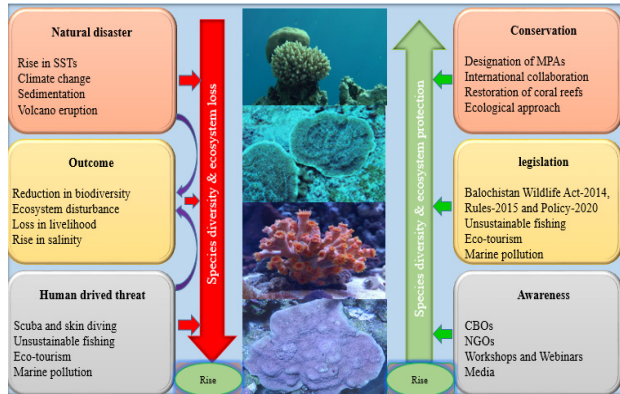


Fig. 9. The habitat of coral reefs is degraded with rise of natural and anthropogenic activities while it can be conserved and improved with the nature based strategies.

Peer reviewed site-specific studies are required further to extend adaptive conservation and management (Ahmad *et al.*, 2024). These weaknesses can deteriorate the habitat for coral reefs. The National Oceanic and Atmospheric Administration (NOAA) reported the fourth mass global bleaching event in April 2024, and by mid-2025 documented bleaching-level heat stress across most coastal regions. The rapid rise in SSTs has prompted the implementation of bleaching response protocols and post-disturbance monitoring in MPAs in Pakistan (NOAA, 2025).

RECOMMENDATIONS AND FUTURE RESEARCH

The coastal belt of Pakistan still lacks contemporary consistent baseline data for health of corals, benthic cover, water quality, marine pollution, invasive species, local marine ecosystems. Developing unified scientific protocols such as phtogrammetry, annual temperature loggers (SSTs), study of eDNA for biodiversity, disease and bleaching scoring is need of hour for data documentation at national (MCP, WWF, IUCN) and international platforms (CRCP, NCORE, NOAA, GCRMN, ICRS, GFCR, CTI-CFF, ICRAN, CRW, ICRI). These measures should be taken on most urgent basis because the recent fourth global mass bleaching event between January 2023 and May 2025 has caused bleaching-level heat stress in about 83.9% areas of the coral reefs in the 83 countries which is confirmed on April 15, 2024, which is 15.7% higher than

third global mass bleaching event between 2014 to 2017. The global mass bleaching event has putting pressure on already vulnerable coral reefs in coastal belt of Pakistan and keeping corals at higher risk. The routine integration of satellite heat stress indices such as HotSpot and DHW with validation in water at MPAs should anchor as early warning system (Ahmad *et al.*, 2024; NOAA, 2025).

Scientifically active rehabilitation and restoration should be trialed in controlled environment for coral gardening with heat tolerant genotypes, selective endemic species for assisting gene flow to raise temperature tolerant colonies, and assisted recruitment in designated sites. Contemporary researches and studies show selective breeding and heritable heat tolerance have enhanced the thermal performance of offspring and hand on trait variation shows heat tolerant phenotypes can be found in most reefs. In such cases the discovery is feasible by implying the local broodstock. Side by side resilience diagnostics which is omics-based health assays, disease screening symbiont typing etc. can discover colonies and sites likely to survive under environemntal stressors. The pilots should include designs based on robust BACI and 2 to 3 years survival tracking to quantify cost effectiveness before assessing (Chille *et al.*, 2025; Denis *et al.*, 2024; Quigley and van Oppen, 2022).

The Government and Wildlife Department of Balochistan must align MPA network with global bleaching response frameworks on enhance the capacity and funding. Regionally the documentation should be taken from the field in accordance to prescribed procedures of ICRI and Green fin global coral bleaching response toolkits. The data should be incorporated to alearting system of NOAA and CRW for refining local risk forecasts. Fourth global bleaching event has mobilized and catalyzed international organizations i.e. ICRI, COP, GFCR, etc. and participation in such international fora can help to unlock technical, finanical, technological, environmental, logistical, legal, political protection, monitoring and restoration. Coordination and cooperation across Balochistan and Sindh wildlife departments, academia and NGOs should formalize coral monitoring consortium at intragovernmental, national, cross border regional and intergovernmental level which monitor the health of wild communities in MPAs at terrestrial and aquatic zones. The consortium also should publish annual research articles, reports, short communication, white paper etc. for close observation of coral reef ecosystems (ICSF, 2025; IUCN, 2024; Khan, 2025c; NOAA, 2024).

CONCLUSION

The diverse coral reefs of coastal belt of Pakistan

especially in MPAs such as Astola island represent economically, ecologically, culturally, and environmentally unique valuable ecosystems that support habitat of endemic species, food security, coastal protection, biodiversity, fisheries. Yet these areas are highly susceptible and vulnerable to anthropogenic pressures and climate change impacts more specifically to rise in SSTs, acidification, loss of calcification, etc. that has already triggered fourth global mass bleaching event (2023-25). Despite the declaration of Astola island as MPA (including Churna and Miani Hor), yet lack of resources, inadequate management frameworks, lack of baseline authentic data, protection measures, weak community integration, minimize effective conservation efforts. However, in some coastal belts, the endemism, resilience and comparatively stable conditions highlight opportunities to the government and nature-based organizations for adaptive protection and management of sustainable fisheries, community-based stewardship, preservation of ecosystems, conservation of coral communities. Adoption of green fin global coral bleaching response toolkits and CRW protocols will help for monitoring, restoration and bleaching response and enhance the survival of coral reefs. Strengthening the national and international cooperation, aligning with standard conservation processes, and investing in scientific research driven restoration protocols are required to save the important coral reef ecosystems for future.

DECLARATIONS

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Statement of conflict of interest

The authors have declared no conflict of interest.

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