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Popular Article

Strengthening Mangrove Ecosystem Conservation: Addressing Threats and Strategies for Effective Protection

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Abstract

Mangrove ecosystems, which flourish in coastal saline or brackish environments, play a crucial role in environmental protection and climate regulation by offering shoreline stabilization, supporting diverse species, and capturing carbon. However, their stability is threatened by deforestation, pollution, and climate change. Conservation strategies, such as establishing Marine Protected Areas, fostering community engagement, and promoting reforestation, are often impeded by conflicting regulations and policy inconsistencies. Successful examples from India and Vietnam show the importance of tailoring conservation efforts to local contexts and ensuring effective policy implementation. Protecting these critical ecosystems requires strong governance and flexible management practices.

Key words: Mangroves, Ecological Importance, Threats, Conservation

Introduction

Mangroves are salt-tolerant shrubs or trees from families like Rhizophoraceae and Acanthaceae, thriving in coastal regions. Although they cover less than 1% of tropical forests globally, they play a vital role in coastal ecosystems. Approximately 77 species from 21 genera of flowering plants are highly specialized for tidal wetlands (Alappatt, 2008). Mangroves provide essential benefits like air and water purification, habitat support, sediment stabilization, and wave energy absorption. These vital coastal forests also enhance water productivity and support fisheries in saline environments (Bhadarka et al., 2023). mangroves face severe threats from human activities, resulting in their rapid decline and making them one of the most endangered ecosystems worldwide



(Bindiya et al., 2023). Efforts to conserve, manage, and restore mangroves are essential for maintaining their ecological value and safeguarding the well-being and security of coastal communities.

Threats to Mangrove Ecosystems

Deforestation and land conversion

Mangrove ecosystems are under considerable pressure from human activities like deforestation and habitat conversion. Mangrove wood is prized for its durability and resistance to rot, driving extensive harvesting for timber, firewood, and charcoal. Furthermore, urban growth and industrial development contribute to the transformation of mangrove areas into farmland, shrimp ponds, and urban zones. These actions disturb the natural habitat and alter water dynamics, worsening environmental decline (Kumari and Pathak, 2023).

Pollution and habitat degradation

Mangrove ecosystems are facing escalating threats from pollution and habitat destruction, primarily due to human activities. In the Niger Delta, activities such as oil extraction, deforestation, and urban development have caused significant biodiversity loss and heightened the vulnerability of coastal communities to environmental hazards like flooding (Aransiola et al., 2024). Additionally, aquaculture contributes to pollution by

altering viral communities in mangrove sediments, disrupting biogeochemical processes (Su et al., 2024).

Climate change impacts: sea level rise, storms, and temperature changes

Climate change threatens mangrove ecosystems through sea level rise, stronger storms, and temperature changes. Higher sea levels cause habitat loss and increased salinity, negatively affecting the health and biodiversity of mangroves (Waleed et al., 2024). Severe storms can damage mangrove structures, diminishing their role in coastal protection and carbon storage (Cuenca-oacay, 2019). Temperature increases disrupt ecological functions and alter species distributions, reducing critical functional groups essential for mangrove health (Ferreira et al., 2024).

Conservation Strategies

Protected area designation and management

Marine Protected Areas (MPAs) and reserves are essential for mangrove conservation, as they manage human activities to safeguard marine biodiversity. Marine reserves, which impose stricter regulations by prohibiting extractive activities, facilitate ecosystem recovery. Studies indicate that MPAs are instrumental in replenishing marine populations and enhancing ecological stability, thus supporting overall biodiversity (Ghosh et al., 2017).



Community-based conservation initiatives

Community-based conservation (CBC) initiatives are essential for the protection of mangroves, as they harness local knowledge and encourage sustainable practices. These programs actively involve communities in managing resources and addressing conflicts, which are vital for the long-term sustainability of mangrove ecosystems. Notable examples, such as community-led restoration in Gujarat, India, have successfully increased mangrove coverage despite challenges from coastal development, illustrating the impact of local engagement in conservation efforts (Shah and Ramesh, 2022).

Reforestation and restoration efforts

Mangrove conservation through reforestation and restoration is essential for boosting ecosystem services and addressing climate change. Abu Dhabi's project resulted in a 5,857 ha increase in mangrove coverage, while Madagascar's Tahiry Honko project saw a 355ha reduction over four years (Farzanmanesh et al., 2024). In Myanmar, restoration efforts notably enhanced soil organic carbon levels, demonstrating strong carbon sequestration potential following restoration (Pandey et al., 2024).

Sustainable management practices

Integrated coastal zone management approaches

Mangrove conservation plays a vital role in Integrated Coastal Zone Management (ICZM), which seeks to harmonize environmental protection with human development. Effective ICZM emphasizes the resolution of stakeholder conflicts, encourages community participation, and implements sustainable practices (Nurse-Bray and Smith, 2024). In India, the ICZM Project has successfully facilitated mangrove conservation through reforestation and pollution management, yielding benefits for both ecosystems and communities (Kumar and Suthar, 2022).

Sustainable harvesting and aquaculture practices

Sustainable aquaculture and harvesting practices are crucial for protecting mangroves while promoting coastal ecosystems and economic development. Integrated systems, such as maintaining an 80%-20% ratio of mangroves to shrimp ponds, help improve water quality, reduce environmental damage, and support mangrove recovery (Ilman et al., 2024). Closed aquaculture systems, which have a reduced environmental footprint, also promote more sustainable practices (Kamara, 2023). Training small-scale farmers in Improved Aquaculture Management Practices



(IAMP) has significantly increased productivity and income, underscoring the value of sustainable farming education (Haque et al., 2025). Additionally, eco-friendly approaches like integrated multi-trophic aquaculture enhance sustainability and food security within the aquaculture industry.

Policy and governance measures

India's mangrove conservation initiatives benefit from a robust policy and governance framework that emphasizes legal protection, community participation, and ecological restoration. Nonetheless, challenges in enforcement and stakeholder engagement persist. The Biological Diversity Act of 2002 provides legal safeguards for biodiversity, including mangroves, but encounters difficulties in implementation (Goswami and Kuri, 2024). In Gujarat, effective policies have successfully integrated mangrove conservation with economic development, showcasing a balanced strategy (Shah and Ramesh, 2022). In Vietnam, financial incentives for mangrove conservation have produced mixed outcomes due to conflicting national policies that encourage both conservation efforts and aquaculture expansion, highlighting the need for better alignment with local needs (Pham et al., 2022).

Conclusion

Mangrove ecosystems are crucial for coastal defense, carbon storage, and supporting biodiversity, but they are increasingly at risk from deforestation, pollution, and climate change. Conservation measures like creating Marine Protected Areas, community initiatives, and reforestation often encounter obstacles due to policy conflicts and regulatory issues. To enhance conservation efforts, it is necessary to align policies and address conflicts between environmental protection and development goals. Adopting integrated coastal zone management that includes local expertise, along with global collaboration and research, will help improve restoration methods and adaptive management strategies.

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