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Status and Distribution of Mangroves in India: A Review

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Abstract:

Spatial distribution patterns along the Indian coastline, focusing on key regions such as the Sundarbans, Andaman and Nicobar Islands, Gulf of Kutch, Maharashtra, Gujrat and Odisha. Environmental factors, including salinity, tidal range, and sediment type, are discussed as critical influencers of mangrove composition and structure. Satellite imagery analysis, exemplified by Giri et al. (2011), reveals the impact of anthropogenic activities, such as coastal development and aquaculture, on mangrove cover over time. Conservation implications are highlighted, emphasizing the need for tailored initiatives that address specific threats faced by diverse mangrove ecosystems in India. The distribution of mangroves in India reflects a complex interplay of ecological and anthropogenic factors. The study underscores the dynamic interplay of ecological and human-induced factors shaping the fate of mangroves in the Indian context.

Key Words: Mangrove Distribution, Ecosystem, Sustainable Development.

Introduction:

Mangroves are unique coastal ecosystems found in tropical and subtropical regions around the world. They are characterized by the presence of salt-tolerant trees and shrubs that thrive in brackish water and muddy, intertidal areas (Parida, A. K. and Jha, B., 2010). Mangroves are home to a wide variety of plant species adapted to saline conditions. Common mangrove tree species include Rhizophora, Avicennia, and Sonneratia (Malik, A. et. Al., 2015). Mangroves are typically found along coastlines in sheltered estuaries, bays, and tidal flats. They can grow in both muddy and sandy substrates. Mangrove ecosystems support a rich diversity of flora and fauna, including various fish species, crustaceans, birds, and mammals (Rajpar, M. N. and Zakaria, M., 2014). They are often referred to as nurseries for marine life because many fish species use them as breeding and feeding grounds (Félix, P. M. et. Al. 2016).

The dense root systems of mangroves help stabilize shorelines, reducing erosion and protecting coastal communities from the impacts of storm surges and sea-level rise (McIvor, A. L. et. Al., 2012). Mangroves are highly effective at sequestering carbon dioxide (CO2) from the atmosphere. They store large amounts of carbon in their biomass and in the sediments below, making them vital in the fight against climate change (Nyanga, C., 2020). Mangroves provide resources and livelihoods for coastal communities. They are sources of wood, honey, and traditional medicines, and they support fishing and aquaculture industries (Das, S. C., et. Al., 2022). Mangroves, coastal ecosystems of immense ecological and socio-economic significance, stand at the forefront of a precarious balancing act between conservation and degradation. These unique intertidal forests, found

in tropical and subtropical regions, serve as vital buffers between land and sea, offering an excess of benefits to both nature and humanity (Alongi, D. M., 2002).

Conservation of mangroves is imperative due to their role in safeguarding coastal communities from storm surges, erosion, and sea-level rise. These ecosystems house a rich biodiversity, providing habitats for a myriad of species, including fish, birds, and invertebrates (Rashid, S. M. A., 2019). Mangroves play a pivotal role in carbon sequestration, mitigating climate change by storing large quantities of carbon within their biomass and sediments. Furthermore, they offer invaluable resources for local livelihoods, including timber, honey, and traditional medicines (Alongi, D. M., 2020).

Conserving and managing mangroves is essential for sustaining these valuable ecosystems and the benefits they provide to both the environment and local communities. Efforts to protect and restore mangroves are crucial for maintaining coastal flexibility, supporting biodiversity, and promoting sustainable development in coastal areas.

Mangroves In India:

The east coast of India also has significant mangrove cover, especially in the states of Goa, Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, and West Bengal. Mangroves are found along the west coast of India, particularly in the states of Gujarat, Maharashtra, Karnataka, and Kerala. The Sundarbans, a vast mangrove delta, is a unique and ecologically important region shared by India and Bangladesh. The mangroves in these islands contribute significantly to the overall mangrove cover in India. In India, the Sundarbans are primarily located in the state of West Bengal and are known for their exceptional biodiversity. The islands are rich in mangrove ecosystems, and mangrove cover is extensive in the Andaman and Nicobar archipelago. Mangroves in India are primarily distributed along the coastal regions, particularly in the tropical and subtropical areas. The Gulf of Kutch in Gujarat is another area where mangroves are found (India state of forest report 2021).

Research by Saenger and Snedaker (1993) highlights the significance of environmental factors in determining mangrove distribution. Factors such as salinity, tidal range, and sediment type emerge as critical determinants, influencing the species composition and structure of mangrove communities. Human activities, including coastal development and aquaculture, significantly impact mangrove distribution. The work of Giri et al. (2011) employs satellite imagery to delineate the changes in mangrove cover over time, illustrating the direct correlation between anthropogenic activities and mangrove loss. Understanding the distribution patterns of mangroves is pivotal for effective conservation strategies. The research by Polidoro et al. (2010) provides a comprehensive assessment of global mangrove biodiversity, emphasizing the need for conservation initiatives that consider regional variations and address the specific threats faced by different mangrove ecosystems in India. While mangroves face myriad challenges, several conservation initiatives in India strive to

address the issues and restore degraded ecosystems. The work of Raghavan et al. (2008) presents a case study on successful community-based mangrove restoration in the Godavari Delta, underscoring the potential for community involvement in conservation efforts. The vulnerability of mangroves to climate change, including rising sea levels and extreme weather events, adds another layer of complexity to their status. The research by Alongi (2015) explores the potential impacts of climate change on mangrove ecosystems, emphasizing the need for adaptive management strategies. Human activities, including aquaculture, urbanization, and industrialization, pose significant threats to mangrove ecosystems. The research by UNEP (2014) highlights the consequences of anthropogenic pressures, indicating that mangrove degradation in India is often linked to unsustainable development practices and land-use changes. Satellite-based assessments, such as those conducted by Giri et al. (2011), provide critical insights into the changing extent of mangrove cover in India. The study reveals both positive and negative trends, with afforestation efforts and conservation initiatives in some regions counteracted by deforestation in others, emphasizing the dynamic nature of mangrove ecosystems.

Mangroves, integral coastal ecosystems, have faced considerable threats in India, prompting diverse conservation and restoration initiatives. This review explores the ongoing efforts, challenges, and successes in the conservation and restoration of mangroves across the country. Raghavan et al. (2008) present a notable case study on successful community-based mangrove restoration in the Godavari Delta. The study exemplifies the potential for involving local communities in conservation efforts. Community engagement not only aids in restoring degraded ecosystems but also promotes sustainable practices, emphasizing the importance of collaborative approaches. The implementation of Integrated Coastal Zone Management (ICZM) plans is a pivotal aspect of mangrove conservation in India. These plans, often led by government agencies and environmental organizations, aim to balance development and conservation. The work of Nayak et al. (2015) evaluates the effectiveness of ICZM plans, emphasizing the need for adaptive strategies that consider the dynamic nature of mangrove ecosystems. Government-led afforestation and reforestation programs play a crucial role in mangrove conservation. The research by Sridhar et al. (2012) evaluates the success of mangrove afforestation efforts, recognizing them as essential tools for restoring degraded areas. However, the study also underscores the need for careful site selection and consideration of ecological factors for these programs to be effective. Conservation efforts face challenges, including climate change impacts, unsustainable development, and resource exploitation. Alongi (2015) discusses the need for adaptive management strategies that consider the resilience of mangrove ecosystems in the face of changing environmental conditions.

Status Of Mangroves In India: The distribution of mangroves in India exhibits spatial heterogeneity influenced by diverse ecological factors. Along the eastern coast, the Sundarbans, the largest

mangrove forest globally, stands as a prime example of rich biodiversity and intricate waterways. The western coast, including regions like the Gulf of Kutch and the Andaman and Nicobar Islands, showcases distinct mangrove ecosystems, each shaped by specific hydrological and climatic conditions. Mangroves in India are not only ecosystems of ecological importance but also integral to the socio-economic fabric of coastal communities. Understanding their complexities, threats, and conservation potentials is imperative for fostering sustainable coexistence between human activities and these invaluable coastal habitats. Continuous research, community involvement, and adaptive management will be key to ensuring the resilience and longevity of mangroves in the diverse coastal ecosystems of India.

According to the Indian State Forest Report 2021, India's mangrove cover is 4992 square kilometres, or 0.15% of the country's total geographical area. The Sundarbans in West Bengal are the world's largest mangrove forest regions. It has been designated a UNESCO World Heritage Site. In India, there are 34 species of mangroves. Bhitarkanika (Orissa) has 31 species, the Sundarbans have 27, and the Andaman & Nicobar Islands have 24 species (MFF, India. 2010).

Table 1. Mangrove cover in States and UT in India during 1989 to 2019

State/UT	1989	1991	1993	1995	1997	1999	2001	2003	2005	2009	2011	2013	2015	2017	2019
Andhra Pradesh	405	399	978	983	383	397	333	329	354	353	352	352	367	404	404
Goa	3	3	3	3	5	5	5	16	16	17	22	22	26	26	26
Gujrat	412	397	419	689	901	1031	911	916	991	1046	1058	1103	1107	1140	1177
Karnataka	0	0	0	2	3	3	2	3	3	3	3	3	3	10	10
Kerala	0	0	0	0	0	0	0	8	5	5	6	6	9	9	9
Maharashtra	114	113	155	155	124	108	118	158	186	186	186	186	222	304	320
Odisha	192	195	195	195	211	215	219	203	217	221	222	213	231	243	251
Tamil Nadu	47	47	21	21	21	21	23	35	36	39	39	39	47	49	45
West Bengal	2109	2119	1219	2119	2123	2125	2081	2120	2136	2152	2155	2097	2106	2114	2112
A&N Island	973	971	966	966	966	966	789	658	635	615	617	604	617	617	616
Daman & Diu	0	0	0	0	0	0	0	1	1	1	2	1.63	3	3	3
Puducherry	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2
Total	4255	4244	4256	4533	4737	4871	4482	4448	4581	4639	4663	4628	4740	4921	4975

Source: India state of forest report 2021

Very Dense Mangrove comprises 2155 sq. km (43.35%) of the Mangrove cover during 2011 at the West Bengal. There has been a net increase of 54 sq. km in the Mangrove cover of the country as compared to 2019 assessment. The reason for the increase in Mangrove cover in Odisha, is mainly due to the natural regeneration, plantation activities in suitable land like on the banks of the rivers near the estuary and on intertidal mud-flats

associated with the areas that are inundated by sea water on a daily cycle. The increase in Mangrove cover has been observed in the districts of Kendrapara, Jagatsinghpur and Balasore in Odisha. The current assessment shows that Mangrove cover in the country is 4,992 sq. km, which is 0.15% of the country's total geographical area. In Maharashtra, the increase in Mangrove cover is mainly due to natural regeneration. The States that show significant gain in Mangrove cover are i.e.8 sq. km and i.e.4 sq. km Odisha and Maharashtra respectively (Table 1) (India state of forest report 2021).

Biodiversity Of Mangroves In India:

Figure: Mangroves along Devgad Estuary (Maharashtra)

Mangroves, the dynamic ecosystems bridging land and sea, exhibit extraordinary biodiversity, making them crucial hotspots for ecological research and conservation efforts. The review explores the biodiversity of mangroves in India, delving into key studies that unravel the intricacies of these unique habitats. Mangroves in India boast a diverse assemblage of plant species uniquely adapted to saline and intertidal conditions. Tomlinson's seminal work (1986) on mangrove botany provides a foundational understanding of the varied morphological and physiological adaptations of mangrove plants, emphasizing their role in shaping the distinctive flora of Indian mangrove ecosystems. Kathiresan and Bingham's comprehensive study (2001) on the biology of mangroves highlights the exceptional faunal diversity of these ecosystems. Mangroves in India serve as crucial nurseries for various fish and invertebrate species, contributing significantly to coastal fisheries. The intricate network of roots and water channels provides a sanctuary for diverse marine life, demonstrating the integral link between mangroves and the biodiversity of adjacent marine environments. Indian mangroves are essential habitats for a plethora of bird

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species, both resident and migratory. The work of Satyanarayana et al. (2002) documents the avian diversity in the Godavari mangroves, showcasing the significance of these ecosystems as crucial stopovers for migratory birds and highlighting the need for their conservation to safeguard avian biodiversity. Beyond visible flora and fauna, mangrove sediments harbor a rich diversity of microorganisms crucial for nutrient cycling and ecosystem functioning. Kristensen et al.'s (2008) research delves into the microbial communities within mangrove sediments, emphasizing their role in the decomposition of organic matter and nutrient cycling, further underlining the interconnectedness of all components of mangrove biodiversity. Polidoro et al.'s (2010) global assessment of mangrove biodiversity emphasizes the need for conservation actions to preserve these critical ecosystems.

In the context of India, the rich biodiversity of mangroves underscores the urgency of sustainable management practices, taking into account the ecological interdependencies that contribute to the resilience of these habitats.

Regeneration Of Mangrove Cover:

Mangrove ecosystems, critical for coastal biodiversity and resilience, face ongoing threats, necessitating effective regeneration strategies. The review explores key studies on the regeneration of mangroves in India, shedding light on the challenges, successes, and implications for sustainable coastal management. Natural regeneration is a fundamental aspect of mangrove ecosystems. Saenger and Snedaker (1993) provide insights into the natural processes of mangrove regeneration, highlighting the role of seed dispersal, germination, and early growth in the maintenance of healthy mangrove populations. Despite the intrinsic regenerative capabilities of mangroves, anthropogenic activities often hinder natural processes. Jayatissa et al. (2002) assess the impact of human interventions, such as aquaculture and development, on mangrove regeneration, emphasizing the need for sustainable land-use practices to support natural recovery. Efforts to restore degraded mangrove areas are vital for their long-term survival. The case study by Raghavan et al. (2008) on community-based mangrove restoration in the Godavari Delta exemplifies successful restoration initiatives. The study emphasizes the importance of local community involvement in achieving effective and sustainable regeneration outcomes. Climate change poses challenges to mangrove regeneration, particularly with rising sea levels and altered precipitation patterns. Osland et al. (2017) investigate the climatic controls on the global distribution of mangroves, providing insights into how changing climate conditions may impact regeneration processes. Sustainable management practices are integral to successful mangrove regeneration. Krishnan et al. (2010) emphasize the role of effective management strategies in supporting the regeneration of mangrove ecosystems, including habitat protection, reducing pollution, and fostering community engagement.

The regeneration of mangroves in India is a complex and dynamic process influenced by natural and anthropogenic factors. The studies reviewed underscore the importance of understanding these factors, fostering community involvement, and implementing sustainable management practices. As India strives to balance coastal development with environmental

conservation, informed strategies that promote the resilience and regeneration of mangrove ecosystems are crucial for the well-being of both coastal communities and the diverse flora and fauna reliant on these critical habitats.

Conclusion:

While conservation efforts are underway, addressing the challenges of habitat loss, climate change, and human-wildlife conflicts remains crucial for sustaining India's rich biodiversity in the long term. As mangroves continue to face multiple threats, a holistic and collaborative approach remains paramount for the sustainable conservation and restoration of these vital coastal ecosystems in India. The integration of traditional knowledge, community involvement, and innovative conservation strategies can contribute to a more sustainable and harmonious coexistence between humans and the diverse ecosystems of India. Conservation and restoration initiatives for mangroves in India showcase a mix of community involvement, government-led programs, and scientific research. Understanding the current status is fundamental for developing effective management strategies that balance the ecological significance of mangroves with the needs of local communities and the pressures of a changing climate. Recognizing the uniqueness of each mangrove ecosystem and addressing local challenges is essential for ensuring the resilience and sustainability of these invaluable coastal habitats in India. As highlighted by the referenced studies, while challenges persist, there is room for optimism through targeted conservation and restoration efforts. The status of mangroves in India is intricately linked to a dynamic interplay of ecological and human-induced factors. The distribution of mangroves in India reflects a complex interplay of ecological and anthropogenic factors. As highlighted by the referenced studies, understanding these distribution patterns is crucial for informed conservation and management. As India faces with the conservation challenges posed by habitat loss and climate change, understanding and protecting the rich biodiversity of mangroves becomes imperative for ensuring the health and longevity of these critical coastal ecosystems.

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