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SUSTAINING INDIA'S MANGROVES: EVALUATING LAW AND POLICIES FOR ECOLOGICAL RESTORATION

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Abstract

Mangroves are essential for the environment and serve as a barrier. They are only found in the intertidal areas of rivers and estuaries, acting as nurseries for fish and other marine life with great ecological and monetary values. It also recycles nutrients and preserves the hydrological cycle and coast protection from storm surges. Although being a plant that can withstand high levels of salt, mangroves require a steady supply of fresh water to exist. Mangroves have been rapidly disappearing from the past many years, which have had detrimental effects on the ecosystem, climate, and society by reducing benefits including carbon sinking, coastal protection, and seafood production. Mangrove forest restoration is feasible and has already been attempted in a number of locations, but these initiatives have largely failed due to their fragmented nature. The current paper describes the results of a new initiative to identify and map the locations where mangroves can be restored, as well as to estimate the potential benefits from such restoration with reference to India.

The present research is carried out with the following objectives:

- *Mangrove loss and threats, as well as actions made to restore them.*
- *Evaluation of Gujarat and Indian mangroves.*
- *Stressing the need of rules and regulations for the rehabilitation of mangroves.*
- *Repercussions for management and policy recommendations.*

Keywords*: Mangroves, threats, restoration, sustainable development, strategies and implications, law and policies*

INTRODUCTION

"Life means not only physical existence. It means the use of every limb or faculty through which life is enjoyed…the right to life includes the right to healthy environment…"- justice P N Bhagwati

India is one of the mega bio-diverse country in the world with ample biodiversity and various ecosystems. It has the fourth largest mangrove area in the world, with a coastline of around 7516.6 km, including the island territories. These mangrove habitats are divided into three distinct zones: East Indian Scenario coast habitats with a coastline of approximately 2700 km facing the Bay of Bengal, West coast habitats with a coastline of approximately 3000 km facing the Arabian Sea, and Island Territories with a coastline of approximately 1816.6 km. West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, the Andaman and Nicobar Islands, Kerala, Goa, Maharashtra, and Gujarat all have large areas of mangroves. One of the main tenets of sustainable development is to live within the bounds of our environment, and as a nation is moving towards sustainable development, the environmental issues need to be taken seriously. Mangroves are a complex and productive ecosystem that provides a variety of ecosystem services to both local and global societies.It is special as it consists of trees and plants with aerial roots that resemble fingers reaching above wet, swampy ground; and are found across the tropics and subtropics on a global scale. They occur here in the intertidal zone, which is the area between the land and the water. Moreover, global climate regulation through carbon sequestration and storage is done with the help of mangroves. Mangroves, like the bulk of natural systems, are under jeopardy. Mangrove cover is declining and deteriorating globally as a result of urbanization, agricultural conversion, and aquaculture, among other things.

Mangroves are salt-tolerant forest ecosystems found in tropical and subtropical intertidal zones that are abundant along the Indian subcontinent's coastlines. They are among the most biodiverse ecosystems in India, and they also

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shield the coastlines from the whims of bad weather. Mangrove plantings have demonstrated to make coastal lands resilient, avoiding floods, land erosion, and acting as a buffer for cyclones, as climate change increases the incidence of extreme weather events around the world. Only 15 countries are home to over three-quarters of the world's mangroves. India is another one of them. Regardless, these ecosystems are critical for local livelihoods, biodiversity, and ecological function. It provides a variety of provisioning ecosystem services to the local communities in the area, such as food and fodder as well as medicines; a variety of regulating services, such as shoreline stabilization during extreme weather events and pollination; and serves as an important carbon sink by sequestering carbon in the form of vegetation.India reportedly lost 40% of its mangrove land over the past century, according to one estimate. But according to the government's biannual India State of Forest Reports (ISFR), mangrove cover has been increasing recently. These figures were cited in the most recent Economic Survey, which was published on January 31, to demonstrate how India's mangrove cover increased from 4,639 sq km in 2009 to 4,992 sq km in 2021.[1]

State / UT	Very dense mangrove (km^2)	Moderately Dense mangrove (km^2)	Open mangrove(km^2)	Total (km^2)
Andhra Pradesh	0	126	226	352
Goa	0	20	2	22
Gujarat	0	182	876	1058
Karnataka	0	3	0	3
Kerala	0	3	3	6
Maharashtra	0	69	117	186
Orissa	82	97	43	222
Tamilnadu	0	16	23	39
West Bengal	1038	881	236	2155
Andaman & Nicobar Islands	283	261	73	617
Daman & Diu	0	0.12	1.44	1.56
Pondicherry	0	0	1	1
Total	**1403**	**1658.12**	**1601.44**	**4662.56**

Table 1: Different types of Mangroves distributed along the Indian Coast and their area (Source: Forest Survey India, 2021

Mangroves restoration: Reviving the roots

According to The Convention of Biological Diversity (CBD), individual countries are responsible for conservation and sustainable use of their biological diversity.[2]Mangroves are vital ecosystems for biodiversity, serving as home to 341 globally threatened species. The drier areas of the habitat are home to terrestrial wildlife, which includes everything from insects to tigers. Sea life, including mollusks, crustaceans, oysters, crabs, shrimp, and other species, call mangrove pools and channels home and serve as breeding grounds for these organisms.[3] An estimated 100 billion crab and bivalves, as well as nearly 600 billion young shrimp and fish species, are produced by mangroves. These habitats also help other biodiversity hotspots stay healthy, allow species to transition between different ecosystems, and sometimes serve as last resorts for stranded species.[4]

The primary tools for putting the Convention on Biological Diversity into practice both domestically and internationally are National Biodiversity Strategy and Action Plans (NBSAPs). Contracting Parties are obliged by Article 6 of the Convention to create, implement, and periodically review NBSAPs. Through them, nations can incorporate sustainable use and biodiversity conservation into sector-specific and cross-sectoral initiatives. These plansintegration of mangrove ecosystems has the potential to mobilize funding and mobilize national and international action for the preservation and restoration of mangroves.A crucial chance for countries to seize increased mangrove action and to reinforce commitments made under other international and national processes is presented by the decision CBD/COP/DEC/15/65,[5] which calls for the review and updating of NBSAPs, or at least national targets, by 2024. The Global Mangrove Watch (GMW) provides Parties to the Convention with an essential tool to assist in incorporating mangrove commitments into their national reports and NBSAP revisions, thereby collectively igniting ambition and action on mangroves.

[1] Forest Survey Report, 2021(https://fsi.nic.in)
[2]https://www.unep.org/resources/report/convention-biological-diversity-june-1992.
[3]Leal, Maricé and Spalding, Mark D (editors), 2022 The State of the World's Mangroves 2022. Global Mangrove Alliance.
[4]https://www.mangrovealliance.org/wp-content/uploads/2023/06/Global-Mangrove-Watch_Integrating-Mangrove-Ecosystems-into-NBSAPs_v13.pdf.
[5]15/6. Mechanisms for planning, monitoring, reporting and review, (Mar. 30, 2023), https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-06-en.pdf.

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Mangrove restoration is a management tactic used to make up for lost and damaged ecosystem goods and services. It has the ability to strengthen the basis of mangrove resources, give locals a job, safeguard vulnerable tropical coastlines, and boost biodiversity and fisheries output. India has unique geo-climatic circumstances, due to which it has historically been vulnerable to natural calamities like floods, droughts, cyclones, earthquakes, landslides, and other natural disasters have been common. Devastating disasters has taken place in India like 1999 Super Cyclone Odisha (formerly known as Orissa), 2001 Gujarat earthquake, and 2004 Indian Ocean tsunami, after which it has enact the Disaster Management (DM) Act in 2005, adopt the National Policy on DM in 2009, and develop the National Disaster Management Plan in 2016 with a goal policy "Sustainable Reduction in Natural Disaster Risk" in some of the most hazard prone districts in selected states of India"

India's huge coastal stretch is vulnerable to a variety of sea-borne threats.Coastal hazards are physical events that put a coastal area at risk of property damage, death, and environmental degradation.Include major cyclones with high winds, waves, and surges, as well as tsunamis caused by undersea earthquakes and landslides.Mangroves are critical to the coastal environments in which they live.They act as a physical barrier between marine and terrestrial ecosystems, protecting shorelines from destructive winds, waves, and floods.

Hazards to the Coastal Ecosystem

Mangroves are among the world's most biologically significant and diverse natural systems. Mangroves are vital to the health and productivity of coastal ecosystems because they offer a variety of products and services, such as food and other resources, shelter for local wildlife, sequestration of carbon dioxide, and defense against natural calamities like storm surges and coastal erosion. It is also clear that there are a number of threats to mangroves, which have already caused a global decline in the number of mangrove areas.[6]According to the Indian State of Forest Report, 2021, the mangrove cover in the country has been estimated at 4992 sq.km. with a net increment of 17 sq.km. in the year 2021 as compared to 2019.[7]Apart from these benefits we can see mangroves are facing serious threats in India. The biggest hazard to mangroves may be coastal development. Increase in temperatures, carbon dioxide concentration, rise in sea levels and extreme weather events like cyclones and droughts are some of the factors that could impact them .[8]Conservation strategies such as afforestation, restoration of degraded mangrove areas, and community-based conservation initiatives can help protect it.[9]Mangroves in India face several threats, including:

1. **Coastal Development**: Urbanization and infrastructure development often lead to the destruction of mangrove forests for construction and tourism projects.
2. **Pollution**: Pollution from industrial effluents, sewage, and agricultural runoff can harm mangroves and the wildlife that depends on them.
3. **Climate Change**: Rising sea levels and increased temperatures can impact mangrove habitats, making them vulnerable to climate change-induced stressors.
4. **Deforestation**: Illegal logging and overharvesting of mangrove wood for fuel or construction can deplete these ecosystems.
5. **Agriculture**: Conversion of mangrove areas for aquaculture and agriculture reduces the extent of these ecosystems.
6. **Invasive Species**: Invasive species, like the Prosopis juliflora plant, can outcompete native mangrove vegetation.

Mangroves are an essential ecosystem that improves communities, the economy, and the environment. However, they are gravely in danger. Worldwide, it is estimated that 67% of mangrove habitat has been lost or degraded, with 20% of this loss occurring since 1980.[10]In India, efforts are being made to preserve and revitalize mangrove ecosystems in order to lessen these dangers and safeguard their priceless ecological and socioeconomic advantages. According to a report by the Birbal Sahni Institute Palaeosciences (BSIP), climate change will cause 50% of India's mangroves to shift or disappear by 2070.

[6]HinaAkram, Mangrove Health: A Review of Functions, Threats, and Challenges Associated with Mangrove Management Practices, Mangrove Health: A Review of Functions, Threats, a https://www.mdpi.com/1999-4907/14/9/1698.

[7]Status of Mangrove Plantations, (Aug. 10, 2023), https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1947426.

[8]Climate change threatens Indian mangroves, (Feb. 21, 2015), https://www.indiawaterportal.org/articles/climate-change-threatens-indian-mangroves.

[9]Elizabeth C Ashton, Threats to Mangroves and Conservation Strategies, SpringerLink (May 25, 2022), https://link.springer.com/chapter/10.1007/978-981-19-0519-3_10.

[10]Gail Sucharitakul& Jamie Hardy, *A threat and a solution – tourism's role in mangrove protection*, race to resilience (July 26, 2021), https://climatechampions.unfccc.int/a-threat-and-a-solution-tourisms-role-in-mangrove-protection/.

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CONSERVING MANGROVE ECOSYSTEM: LAW AND POLICIES IN INDIA

A coalition of parties and non-state actors is gathering momentum to direct increased action for mangroves in support of the Mangrove Breakthrough, and mangroves and other coastal ecosystems are becoming more and more important on the international agenda. This includes the upcoming UNFCCC COP28 presidency priorities. The UN Decade on Ocean Science and the UN Decade on Ecosystem Restoration both fall between 2021 and 2030. By 2030, the worldwide Mangrove Alliance (GMA) hopes to have accomplished the most ambitious worldwide mangrove goals to date. These objectives include restoring half of the recently lost mangrove area (over 400,000 ha at a rate of approximately 50,000 ha per year until 2030), doubling the area-based protection of mangroves from 40% to 80% (an additional 6,100,000 km2 under protected areas and other effective area-based conservation measures), and stopping the loss of mangrove ecosystems by reducing net anthropogenic mangrove loss to zero.[11] Mangrove ecosystem conservation and restoration is essential to achieving the Sustainable Development Goals (SDGs), which include SDG 6 on freshwater, specifically Target 6.6 on protecting and restoring water-related ecosystems, SDG 14 on life below water, and SDG 13, which focuses on limiting and adapting to climate change.10. SDG 2 (zero hunger), SDG 8 (economic growth), and SDG 12 (responsible consumption and production) are all related to mangroves because of their significance to livelihoods. 116 voluntary commitments, including "the restoration, rehabilitation, protection and management of mangroves and associated ecosystems," were made by participants in the 2017 United Nations Conference to Support the Implementation of SDG 14.[12]

Article 21 of the Indian Constitution states that it is a violation of citizens' fundamental rights when mangroves are destroyed. In light of the requirements of the Indian Constitution's Articles 21, 47, 48A, and 51A (g), the State, as well as its agencies and instrumentalities, are required to protect and preserve mangroves. India has implemented both regulatory and promotional measures in an effort to safeguard, preserve, conserve, and increase the cover of forests in the nation. The National Coastal Mission Program's "Conservation and Management of Mangroves and Coral Reefs" Central Sector Scheme is being used to carry out the promotional activities. Every coastal state and union territory develops and implements an annual Management Action Plan (MAP) for the conservation and management of mangroves. Regulations under the Environment (Protection) Act, 1986, the Wild Life (Protection) Act, 1972, the Indian Forest Act, 1927, the Biological Diversity Act, 2002, and rules under these acts as amended from time to time are implemented through the Coastal Regulation Zone (CRZ) Notification (2019). [13]Mangroves are safeguarded in India by a number of laws and regulations designed to preserve these important ecosystems. The following are some of the main laws and guidelines pertaining to mangroves in India:

1. **Forest (Conservation) Act, 1980**: Under this law, development projects close to mangrove areas, as well as any other non-forest use of forest land, require Central Government approval.. This Act strongly restricts the use of forest land, including mangroves, for non-forest activities and mandates central government consent in advance. This involves a thorough approval procedure to evaluate the effects on the environment and look into other solutions. Reforestation and the restoration of mangrove ecosystems are two examples of conservation initiatives that the Act promotes. It also ensures legal accountability by penalizing unpermitted use of forest land. Notwithstanding its strong foundation, the Act's execution is complicated by issues including encroachment, unlawful activity, and the requirement to strike a balance between development and conservation. Coordination between local communities, government agencies, and other stakeholders is necessary for effective enforcement.
2. **Wildlife Protection Act, 1972:** This Act offers extensive safeguards for the preservation of animal ecosystems, such as mangrove forests, which are essential to many species' existence. Mangrove areas may be declared under this Act as protected areas, like animal sanctuaries or national parks, where it is absolutely forbidden to engage in activities like hunting, poaching, and logging. In order to lessen the effects of human activity, the Act also makes it easier to create buffer zones surrounding these protected areas. It also gives authorities the ability to prosecute violators, strengthening the defences of mangrove habitats. The Wildlife Protection Act of 1972 contributes to the preservation of mangrove biodiversity and ecological services, which are essential for coastal protection, carbon sequestration, and local livelihood support, by protecting these special habitats.
3. **Coastal Regulation Zone (CRZ) Notification**: In order to manage and safeguard India's coastal environments, particularly mangrove ecosystems, a crucial regulatory tool is the Coastal Regulation Zone (CRZ) Notification. The CRZ Notification, issued under the Environment (Protection) Act, 1986, divides coastal areas into several zones, each with unique development activity requirements. Recognized for their ecological significance, mangrove regions are usually classified under CRZ-I as environmentally sensitive areas (ESAs), subject to severe regulations aimed at preventing their destruction. Construction, land reclamation, and other actions that can

[11] About Us, The Global Mangrove Alliance. Available at: https://www.mangrovealliance.org/about-us/
[12] 1Communities of Ocean Action, The Community of Ocean Action for Mangroves –Towards the Implementation of SDG14: Interim Report to UN-DESA, p. 5
[13](Mar. 24, 2022), https://www.moef.gov.in/wp-content/uploads/2022/03/Conservation-and-protection-of-mangroves.pdf.

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endanger these essential ecosystems are prohibited. In order to guarantee that any development close to mangroves is environmentally sound and sustainable, the CRZ Notification also requires state governments to create Coastal Zone Management Plans (CZMPs).

4. **The National Forest Policy of 1988**: The National Forest Policy of 1988 holds significant importance in the environmental governance of India as it places a strong emphasis on the preservation and sustainable management of forest resources, which includes mangrove habitats. This strategy recognizes that mangroves are essential for biodiversity and coastal protection, emphasizing the need to preserve biological balance and increase forest cover. The policy supports the sustainable use and restoration of mangrove forests while fighting against encroachment and degradation. By encouraging local communities to get involved in forest management, it gives them the ability to support conservation efforts and reap the benefits of sustainable resource use. The significance of protecting mangroves for their function in halting coastal erosion, sustaining fisheries, and serving as organic storm and tsunami barriers is also emphasized in the strategy. The National Forest Policy of 1988 offers through these clauses

5. **National Biodiversity Action Plan**: In line with its larger plan to safeguard the nation's biodiversity, India's National Biodiversity Action Plan (NBAP) emphasizes the vital significance of maintaining mangrove habitats. The NBAP focuses on the restoration and preservation of mangroves because they are important habitats that sustain a wide variety of plants and animals. In order to sustain the livelihoods of coastal residents, the plan places a strong emphasis on the ecological services that mangroves provide, such as fisheries support, carbon sequestration, and coastal protection. The rehabilitation of degraded mangrove habitats through community involvement and scientific treatments is advocated, as is integrated coastal zone management. To further understand mangrove ecosystems and address issues including pollution, climate change, and unsustainable exploitation, the NBAP also emphasizes the need for research and monitoring.

6. **State-specific laws**: State-specific legislation pertaining to mangrove restoration often demonstrates a dedication to protecting these essential coastal ecosystems by means of specialized legislative and regulatory initiatives. These regulations, which acknowledge the significance of mangrove regions for local economies, biodiversity, and coastal protection, frequently require the identification, designation, and protection of these areas. Replanting mangroves in damaged regions, preventing encroachment, and controlling activities that endanger the health of mangroves are typical restoration initiatives under these rules. Local groups frequently participate in conservation initiatives to promote environmental care and sustainable practices. Furthermore, these rules can encourage studies, observation, and instruction to improve knowledge and awareness of mangrove ecosystems. Governments seek to protect and restore mangroves through these state-specific frameworks, guaranteeing that the ecological advantages and services of these ecosystems are maintained for future generations. The following are some of the state- specific laws for mangroves conservation.

- Maharashtra Mangrove Conservation Act,2015
- Gujarat Mangrove Conservation Society (GMCS)
- West Bengal Mangrove policy
- Tamilnadu Biodiversity and Greening project
- Odisha Mangrove Conservation policy

The goal of these laws and regulations is to preserve mangroves, which are essential for biodiversity, coastal protection, and sustainable living. Nonetheless, state and local implementation and enforcement of these laws frequently determine how effective they are. It's crucial to get the most recent information on mangrove protection in a particular Indian region by contacting the appropriate authorities.

MANGROVE RESTORATION INITIATIVES IN INDIA: A ROAD TOWARDS SUSTAINABILITY

The Union Budget 2023–24 highlighted green growth as a top priority and included adedicated allocation for boosting mangrove vegetation as significant carbon sinks. The budget allows for the start of the MISHTI Scheme, also known as the Mangrove Initiative for Shoreline, Habitat, and Tangible Incomes, along India's coastline and salt pan areas, in addition to other projects including the Green Credit Programme, PM-PRANAM, Gobardhan Scheme, and Amrit Darohar**.**

India recently joined the Mangrove Alliance for Climate (MAC) at the UNFCCC's COP27 to raise awareness of the importance of mangroves in combating climate change. In this sense, the MISHTI plan would be change-inducing and speed up the pace of mangrove conservation in India considering the significance of mangroves as a foundational species in coastal and marine ecosystems and a crucial link in disaster risk management. There are, however, a number of issues that prevent the plan from being a total success.

The investment in reviving mangroves is a step in the right direction because India is home to 3.3% of the world's mangrove vegetation and the Sundarbans in West Bengal, a UNESCO World Heritage Site.

Mangrove species provide a range of ecosystem services where they are found. In addition, they provide remedies for storm surges, coastal floods, and sea level rise. Mangroves have a strong capacity to store carbon, which has

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a big impact on climate. Additionally, they contribute significantly to the development of the tourism industry by offering wood for building and heating as well as a plentiful supply of fish, crabs, and shellfish. In addition to this, mangroves have been a component of the carbon credit cycle.

India has been actively involved in mangrove restoration initiatives through massive plantation initiatives. The Indian state of Gujarat has witnessed sustained mangrove plantation efforts in the last two decades. The Gulf of Kachchh coast of Gujarat in India has seen plantation to the tune of 30,000 hectares so far. In the Gulf of Kachchh, three different plantation techniques, namely, transplantation of nursery-raised saplings, raised bed method, and direct propagule dibbling, are generally followed either singly or in combination to raise mangrove plantation.[14]

The Indian government has also been supporting research by academic institutions for the development of mangrove ecosystems on a sound ecological basis. The plans broadly cover survey and demarcation, natural regeneration in selected areas, afforestation, protection measures, fencing and awareness programmes.[15]

GUJARAT'S MANGROVE RESTORATION: A LEGACY TO PROTECT AND PRESERVE

Gujarat had a large mangrove ecosystem 50 years ago, but in the 1970s, it reached its lowest point due to depletion. The area covered was less than 400 km2 in the early 1990s. Initiatives for conservation and the restoration of mangroves were implemented after the marine sanctuary and marine national park were established in 1980 and 1982, respectively. The Forest Department's remarkable mangrove restoration efforts in the 1990s reversed the trend.A mangrove development and conservation project were created in 1993 and has been in operation ever since.

- Over 50,000 hectares of mangrove species have been planted by the Forest Department in the past 20 years.
- Mangroves were planted in roughly 5,000 hectares by other organizations like the Gujarat Ecology Commission and industries.

Over the past 20 years, mangrove cover has continuously increased by two and a half times.There are mangroves in all thirteen of Gujarat's coastal districts; the state has the second-largest mangrove cover in the world, after West Bengal's Sundarbans. The districts with the greatest importance for mangroves are Kachchh and Jamnagar.[16]
In order to develop mangrove forests in an approximate 3500-acre area of Marine National Park under the Central Government's MISHTI (Mangrove Initiative for Shoreline Habitats & Tangible Incomes) scheme, Reliance Industries Ltd. (RIL) and the Government of Gujarat signed a Memorandum of Understanding (MoU).[17]This initiative's primary goals are to mobilize resources through public-private partnerships, implement best practices for plantation techniques, and explore various conservation strategies.
The restoration of mangroves is essential to the preservation and protection of endangered species. For a variety of marine and terrestrial species, mangrove ecosystems offer habitat and vital breeding grounds. Mangroves provide food, shelter, and breeding grounds for many endangered species. Mangrove habitat restoration can offer these species a suitable and safe environment in which to flourish. Unique to Gujarat's Kutch region, the endangered Kharai camel breed is a particular kind of camel that grazes on mangroves on offshore islands. They can swim up to three kilometers in the water to find mangroves, which are their primary food source. The maximum number of camels in Kutch is estimated to be 6000. Because mangrove restoration protects habitats, increases biodiversity, and reduces environmental threats, it is crucial for the survival of endangered species.

Year wise Mangrove cover of Gujarat (sq. km.)			
Sr.No.	Year	Area	% to G.A. (196244)
1	2021	1175	0.60
2	2019	1177	0.60
3	2017	1140	0.58
4	2015	1107	0.56
5	2013	1103	0.56
6	2011	1058	0.54
7	2009	1046	0.53
8	2005	991	0.50

[14]Springer India, Mangrove Restoration: An Overview of Coastal Afforestation in India, SpringerLink (Apr. 22, 2017), https://link.springer.com/chapter/10.1007/978-81-322-3715-0_26.
[15]R Kumar, *Unasylva*, No. 203 https://www.fao.org/3/x8080e/x8080e07.htm.
[16]Gujarat biodiversity board, Mangrove conservation, https://forests.gujarat.gov.in/writereaddata/images/pdf/17_brochure_Mangrove.pdf.
[17]Himanshu Kaushik, RIL signs MOU for Mangrove Forest in Marine National Park, The Times of India, (July 6, 2023).

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9	2003	916	0.47
10	2001	911	0.46
11	1999	1031	0.53
12	1997	901	0.46
13	1995	689	0.35
14	1993	419	0.21
15	1991	397	0.20
16	1989	412	0.21
17	1987	427	0.22

Table-2: Year wise Mangrove cover of Gujarat (Source: Forest Survey India,2021)

The data on Gujarat's mangrove cover from 1987 to 2021 is displayed in Table 2. Mangrove cover was 427 square kilometers in 1987, but it progressively increased to 1031 square kilometers in 1999. The mangrove cover increased to 1175 sq. km in 2021 as a result of numerous initiatives and restoration programs.

In order to monitor mangrove habitat plantations, Gujarat Ecology Commission, which was founded by the Indian government, and CREDUCE, a premier provider of Carbon Credits Origination and Offset solutions, have signed a Memorandum of Understanding (MoU). The goal of the strategic alliance is to protect mangroves and restore 10,000 hectares of Gujarat's coastal regions.This project aims to protect and increase the mangrove cover because by 2070, it is predicted that 50% of India's mangroves will change or disappear as a result of climate change.It will benefit the environment and give the nearby communities carbon credits.[18]

KEY STRATEGIES FOR SUCCESSFUL MANGROVE RESTORATION IN INDIA

Success in mangrove restoration is measured through ecological, social, and economic indicators. Overall, success in mangrove restoration is a multi-faceted concept, combining ecological, social and economic factors. It often requires a holistic approach that balances the needs of the environment and the local communities for sustainable development. Evalution and monitoring of these indicators over time are essential to assess and ensure the success of mangrove restoration projects.

The following are the strategies which can be undertaken for the successful restoration projects:

1. Site selection

Success of ecosystem restoration depends on the site selection by considering various factors like hydrological conditions, sediment type, biodiversity and connectivity, protection from storms, community engagement, adaptive management etc. By carefully considering these factors, you can select suitable sites for restoration of mangroves that are more likely to thrive and provide ecological and socio-economic benefits.

2. **Involvement of community**

Community involvement is essential for the successful restoration of ecosystems. Incorporating the perspectives and participation of local communities not only enhances the success of ecosystem restoration but also fosters a sense of responsibility, leading to more sustainable overcomes.

3. **Selection of species**

Local species which are well suited to the local environment should be selected for enhancing ecological stability. Selecting right species for mangrove ecosystem depends on various factors such as native species, condition of site, biodiversity, controlling erosion, local expertise, etc. Ultimately, the selection of mangrove species should align with the restoration goals, considering ecological, economic and social factors which are specific to the site.

4. **Development of nursery**

One of the most important steps in mangrove restoration is nursery development, which guarantees the availability of healthy seedlings and saplings.Mangrove restoration is a long-term project that requires careful planning and the nursery is essential to having healthy mangrove plants available. It's critical to modify your nursery procedures in accordance with the unique requirements of the mangrove species and the regional climate.

5. **Protection from livestock**

It is essential to keep livestock out of mangrove restoration areas in order to preserve the survival and development of young mangrove plants. These fragile ecosystemsmay be threatened by livestock, such as goats and cattle. Mangrove restoration areas must be successfully protected from livestock using a combination of physical barriers, community involvement, education, and local cooperation. In order to successfully restore and

[18]Narasimha Raju, *CREDUCE signs MoU with the Government of Gujarat to provide carbon credit development, monitoring, and trading services for the mangrove preservation and restoration project*, CXOToday.com (July 18, 2023), https://www.cxotoday.com/press-release/creduce-signs-mou-with-the-government-of-gujarat-to-provide-carbon-credit-development-monitoring-and-trading-services-for-the-mangrove-preservation-and-restoration-project/.

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preserve these important ecosystems over the long term, conservation efforts must be balanced with the needs and customs of the surrounding communities.

6. **Monitoring and Maintenance**

Long term success of restoration depends upon the sustainability of the efforts taken for it. Monitoring and maintenance are essential for the sustained health and resilience of ecosystem. They enable adaptive management, issues can be detected on early basis, and ongoing care to ensure that restoration efforts are successful in long run.

7. Sediment Management

Sediment management is a critical component of restoration, especially in areas like wetlands and coastal ecosystems. Nutrition cycling, land formation, erosion control, water quality, and the overall success of restoration efforts are influenced by the sediment management.

8. **Government Support**

Government support is essential for the success of mangrove ecosystem for the success of restoration process by providing the legal framework, funding, resources and coordination needed to protect and rehabilitate the valuable coastal habitats.

9. Long-term Commitment

Recognize that mangrove restoration is a long-term process, and ensure sustained commitment and funding. It is helpful in many ways like ecosystem recovery, preservation of biodiversity, carbon sequestration, controlling erosion, economic benefits etc. Long -term commitment is crucial for the resilience and effectiveness of mangrove restoration, ensuring the sustained health of mangroves and the benefits they provide.

10. Research and Education

Promote research to improve restoration techniques and educate the public about the importance of mangroves. Research enhances our understanding of mangroves and threats they face, enabling effective restoration techniques. Education raises awareness and community support, leading to policy advocacy and sustainable efforts for restoration. In combination, research and education are key drivers of successful mangrove restoration, ensuring vital ecosystems can continue to thrive and provide numerous ecological and socio-economic benefits.

A study in Gujarat, India, has identified a model for a successful combination of mangrove conservation and development. The study conducted in Surat and Mundra district of Gujarat state suggests that collaboration between government agencies, local communities, and the private sector could lead to such models in the country. The Gujarat model's success is attributed to multi-stakeholder participation, public-private partnerships (PPP), and good governance. The study also highlights the importance of mangroves as a common resource pool for the community. The Gujarat Ecological Society has created biodiversity management committees to train local fishing communities in mangrove conservation. The study also highlights the state government's integration of several sectors for mangrove protection and restoration.[19]

CONCLUSION

In summary, the restoration of mangroves is an important project with significant advantages for society, the economy, and the environment. The researcher has highlighted the role that mangroves play in supporting livelihoods, preserving biodiversity, protecting coastlines, and sequestering carbon through research. The long-term viability of these ecosystems depends on the implementation of effective restoration strategies that are based on scientific research and community involvement. Investing in mangrove restoration is still an effective way to protect coastal areas and advance sustainability, especially as global issues like climate change become more pressing.

[19] https://india.mongabay.com/2022/07/successful-model-of-development-in-tasndem-with-mangrove-restoration/