**A review on ecological importance of Mangroves**

**Sedyaaw P1, Koli J. M2 and Sanket K1**

**-------------------------------------------------------------------------------------------------------------**

1. **Post Graduate student, College of Fisheries, Shirgaon, Ratnagiri.**
2. **Professor, College of Fisheries, Shirgaon, Ratnagiri.**

**----------------------------------------------------------------------------------------------------------------**

**Abstract**

One of the most prolific ecosystems in the world, mangroves are currently under threat. They offer a wide range of products and services, some of which have a direct value but are frequently accompanied by several benefits that are apparent yet indirect. Mangroves, which are found in the intertidal zones of the tropics and subtropics, are one of the most endangered ecosystems in the world. They benefit coastal communities economically and environmentally. Coastal communities are protected by them from storm surges, hurricanes, cyclones, and tsunamis, protecting both people and property. The rise in anthropogenic activity, such as the conversion of mangrove wetlands for aquaculture and the logging of mangrove forests, is the main factor contributing to the degradation of the mangrove environment in India. The world has lost a significant amount of land due to the indiscriminate and exploitative manner in which its resources are extracted. Mangroves are vital bio-resources for the coastal ecosystem and are of utmost importance. Mangroves are fast disappearing as a result of over-exploitation, over-agriculture, aquaculture, tourism, and urban growth. The main goal of the current review is to identify the state and trends of the mangrove ecosystem in India, as well as the causes of its decline, recovery, and traditional preservation.

**Keywords:** Mangroves, species, Forest

**Introduction**

Mangrove is the crossroad, where oceans, freshwater, and land meet. True mangroves, which are 54–75 species wide and taxonomically separate from their terrestrial cousins, can only be found along coastlines in the intertidal zones. Mangrove forests are among the most intricate ecosystems on the world, thriving in conditions that would quickly eradicate the majority of other plant life. Mangroves can withstand excessively salty seas and soils because of their great degree of environmental adaptability and capacity to exclude or expel salt. As per the [India State of Forest report 2021](https://www.clearias.com/india-state-of-forest-report-2021/), the area under Mangrove forest has increased by 17 sq km making India’s total mangrove cover as 4,992 sq km. Figure 1 indicates the top 3 states showing mangrove cover increase: Odisha (8 sq km), Maharashtra (4 sq km), and Karnataka (3 sq km). "South East Asia accounts for 6.8% of the world's mangrove cover, or about 40% of all mangroves, and India accounts for about 3% of the total mangrove cover in South Asia, "Compared to the last assessment, India's mangrove cover has increased by 54 sq km (1.10%)."According to the most recent data, the country's mangrove cover is 4,975 sq km [(1.2 million acres)], or 0.15% of its overall geographic area. Nearly half of the land in India covered by mangroves is in the Sundarbans in West Bengal alone. India's mangrove cover is made up of 42.45% of West Bengal's land, 23.66% of Gujarat's, and 12.39% of the A&N Islands. Gujarat had the largest overall increase in mangrove forest cover, at 37 square miles. Among the states, Kerala (9 sq km) and among the UTs, Puducherry (2 sq km) have the least Mangroves cover (Fig 1, 2 and table 1)

**Figure 1 .Top 3 states showing mangrove cover increase (Source : India State of Forest Report 2021)**

West Bengal has a total of 42.45% of India’s mangrove cover, followed by Gujarat at 23.66%, and A&N Islands at 12.39%. All around the country, Gujarat showed a maximum increase in mangrove forest cover of 37 sq. Following graph gives the information about top 5 states showing mangrove cover in India. Among the given states west Bengal ranks 1st place

**Figure 2 .Top 3 states showing mangrove cover increase (Source : India State of Forest Report 2021)**

**Table 1 .Top 3 states showing mangrove cover increase (Source : India State of Forest Report 2021)**

|  |  |
| --- | --- |
| **State** | **Place** |
| **Gujrat** | Gulf of Kutchh, Gulf of Khambhat, Dumas-Ubhrat |
| **Andhra Pradesh** | Coringa East Godavari Delta, Krishna Delta |
| **Odisha** | Bhaitarkanika, Mahanadi, Subarnarekha, Devi-Kauda, Dhamra, Chilka |
| **West Bengal** | Sunderbans |
| **Andaman & Nicobar** | North Andaman, Nicobar |
| **Maharashtra** | Achra-Ratnagiri, Devgarh-Vijay Durg, Veldur, Kundalika-Revdnada, Mumbra-Diva, Vikroli. |
| **Goa** | Goa |
| **Karnataka** | Coondapur, Dakshin Kannada/ Hannavar, Karwar, Mangalore Forest Division. |
| **Kerala** | Vembanad, Kannur (North Kerala) |
| **Tamilnadu** | Pichavaram, Muthupet, Ramnad, Pulicat, Kaznuveli |

Mangrove forest provides wood and non-wood forest products and benefits to native population (Bandaranayake, 1998; Ewel et al., 1998; Gilbert and Janssen, 1998; Dahdouh-Guebas and Koedam, 2006). Mangroves protect the coastline from destruction and maintain the ecosystem diversity and also provide lot of resources for the forestry, fisheries, food and agricultural industries (Miles et. al, 1999). Extreme weather events account for 11% of contemporary global mangrove forest loss, with their proportion in the 21st century increasing relative to human drivers of deforestation (Goldberg et al., 2020). Approximately 40% of the world’s mangrove forests are distributed in areas prone to cyclone activity; while evidence on the impacts of cyclones on mangrove biomass at the global scale is mixed (Simard et al., 2019; Rovai et al., 2021), cyclones have clear impacts on mangrove forests at the landscape scale in regions where they occur. Cyclones cause a range of disturbances on mangrove forest structure, functioning, and geomorphology, including immediate defoliation and short-term biomass loss, changes in carbon and nutrient cycling, peat collapse, and eventual marine transgression (Castañeda-Moya et al., 2010; Jones et al., 2019; Krauss and Osland, 2020). This leads to observable impacts on the ecosystem services that mangrove forests provide, such as their ability to store and sequester carbon to regulate the global climate (Friess et al., 2020;Peneva-Reed et al., 2021).

**Ecological Importance of Mangroves**

**1. Carbon Management**

According to recent developments in estimating photosynthetic production, mangroves are typically more productive than saltmarshes, seagrasses, macroalgae, coral reef algae, microphytobenthos, and phytoplankton on an area basis (Duarte & Cebrian, 1996). According to Duarte and Cebrian (1996), the majority of mangroves fix carbon substantially over the amount needed by the environment, with the extra carbon accounting for 40% of net primary output. According to Duarte and Cebrian (1996), of the mangrove carbon produced, 9% is consumed by herbivores, 30% is exported, 10% is stored in sediments, and 40% is broken down and recycled within the system. Recent observations of mangrove photosynthesis (Clough et al., 1997) suggest that either more carbon is stored in wood, where it finally decomposes within the system, or more carbon is stored in sediments, where it is transported to the nearby coastal zone, than Duarte and Cebrian (1996) calculated. Mangroves store large amounts of carbon; therefore, their removal could have a substantial effect on the world's carbon balances. Cebrian (2002) calculated that the loss of around 35% of the world's mangroves has resulted in a net loss of 3.8×1014 gC stored as mangrove biomass in a recent examination of the destiny of fixed carbon in marine ecosystems.

**2. Fisheries**

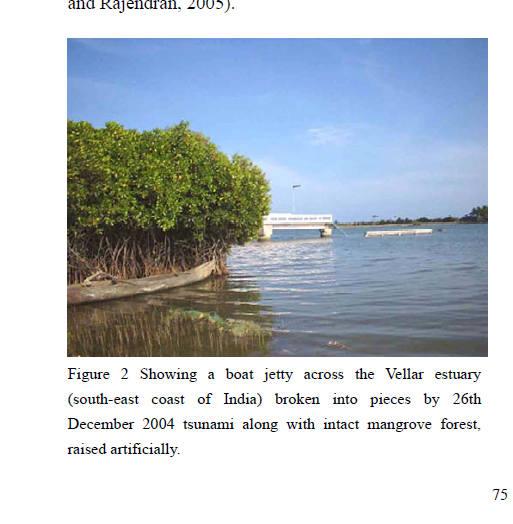
Budgets and mass balance estimations at the ecosystem level typically do not take into account the ecological significance of mangroves in terms of wood and fisheries productivity. Despite statistical evidence to the contrary, mangroves are significant breeding habitats (Baran 1999). Due to variations in catch techniques, forest structure and productivity, and the fishery species in issue, the slope of the link between fish and prawn landings and mangrove data varies throughout regions (Chong & Sasekumar 1994). In many places of south-east Asia, overfishing has resulted from and contributed to habitat damage and environmental stress due to the expansion of the trawl fishing industry (Mohsin & Ambak 1996; Hinrichsen 1998). Given the increased fishing effort, there is a great likelihood that these coastal waters will once again be overfished. Any loss in the size and condition of mangrove forests will undoubtedly make this situation worse (Mohsin & Ambak 1996). Due to the lack of long-term data, particularly from commercial operators who, for a number of reasons, either do not keep proper records or do not accurately submit their totals to government organisations, it is frequently difficult to even recognise such problems in mangrove-dominated areas.

Mugade et al 2017 carried out research on Ethnoecological Study of Mangroves along the Estuaries of Rajapur and Devgad Tehsils, Coastal Maharashtra. He said that most of the local population depends on fishing for their daily bread and butter. Everyone has permission for fishing. Their daily food is fish. In monsoon season fishing in deep sea is totally banned due to heavy rainfall and cyclonic conditions, this is a period of fish breeding. Most of the fishing is carried out in estuaries during rainy season. They fish different type of fish-species for their subsistence use and also sell the remaining one for getting money. Crabs, shrimps, barnacles, oysters, mussels (fig 3) and other fish species are collected from fishing. During low tide, especially womens are going to collect oysters and mussels. Very few respondents are not engaged in fishing activity but they collect fish from others(Fig.3)



Figure 3: Collection of oysters (kalva) and mussels: Phanase estuary (Source: Ethnoecological Study of Mangroves along the Estuaries of Rajapur and Devgad Tehsils, Coastal Maharashtra (Mugade et al 2017

1. **Protecting coastal areas**



**Figure 4**: Showing a boat jetty across the Vellar estuary (south-east coast of India) broken into pieces by 26th December 2004 tsunami along with intact mangrove forest, raised artificially **Source:** Importance of Mangrove Ecosystem (K. Kathiresan 2012)

**A) Tsunamis**

Mangrove forests provide coastal protection from the effects of the 26th wave. This was made clear by the tsunami that hit the Indian Ocean region in December 2004. If there was another tragedy in human history after World War II, it was undoubtedly the tsunami of December 26, 2004, which claimed the lives of 3 million people in Asian and African nations, left about 2 million homeless, and caused a 6 billion US dollar loss in 13 nations (Kathiresan and Rajendran, 2005). The world's homeless and caused a loss of 6 billion US dollars in 13 nations, the tsunami-waves were caused by an undersea earthquake with a Richter scale reading of 9.3 (Kathiresan and Rajendran, 2005). Mangroves' ability to reduce tsunami risk is dependent on two tsunami-related physical processes: wave attack and towing flow. When a wave assaults, vegetation traits must be employed to respond, but mangroves' "drag force" is what allows them to respond to towing flows, preventing coastal erosion. As a result, the protective function of mangroves is influenced by two factors: (i) vegetation characteristics, such as density, height, species composition, forest density, diameter of mangrove roots and trunks, and elevation of habitats; and (ii) tsunami wave characteristics, such as wave height, wave period, and depth of water (Mazda et al., 1999a, b). It has been demonstrated scientifically that mangroves help to reduce sea waves. Harada et al. (2002) used five different models of mangroves, coastal forests, wave dissipating blocks, breakwater rocks, and houses in a hydraulic experiment to investigate the impact of permeable coastal constructions on tsunami mitigation. His study shows that mangroves are more successful in reducing tsunami damage to houses behind a forest than concrete seawalls. According to Mazda et al. (l997a), six-year-old mangrove forests of 1.5 km in width significantly lower sea waves, from 1 m high waves at the open sea to 0.05 m at the coast. If the wave height is less than 4–5 m, a 100 m wide belt of 30 trees from 10 trees may reduce the maximum tsunami flow pressure by more than 90% (Hiraishi and Harada, 2003). In my perspective, mangroves would offer tsunami protection in the event that the height of a m2) mangrove forest (with >25 trees/10) is more than the height of a tsunami wave. The preservation and restoration of mangroves, coastal forests, and sand dunes would lessen the effects of storms, sea level rise, and tsunamis.

**B) Floods**

Mangrove systems protect the coastline from floods (Fig 5), which are frequently brought on by tidal waves or by torrential rain brought on by storms. The 300 km2 mangrove area not been removed for shrimp production and rice cultivation earlier, the major flood disaster that struck Bangladesh in 191 would have been significantly lessened. Mangroves' capacity to regulate flooding is a result of their root systems, which have a wider surface area and can also encourage sedimentation. In addition to preventing flooding, mangroves shield underground water systems from seawater intrusion, providing coastal residents with a source of clean drinking water.

**Figure 5**: Differences in the effect of wave reduction (a) with and (b) without mangroves. **Source**: Mangroves as a coastal protection from waves in the Tong King Delta, Vietnam. Mangroves and Salt Marshes. (Mazda et al.,1997)

At the boundary between salt flats and mangroves, salt concentrations in groundwater have frequently undergone very abrupt shifts. This shows that mangrove systems have the ability to dramatically reduce the salinity of the groundwater (Ridd and Sam, 1996). Mangroves may move farther inland as a result of sea level rise brought on by global warming. Mangroves are unlikely to move landward in many regions of the world, however, due to human habitation near the landward limit, and the width of the mangrove forests is likely to shrink due to sea level rise. Local factors, such as the type of wetland, the geomorphic environment, and human activity inside the wetland, will affect how sea level rise will affect any mangrove habitat. The expected rate of sea level rise is between 45 and 65 cm every 100 years. Mangrove ecosystems could be gravely threatened by the expected quicker rates because they can withstand sea level rise of 8 to 9 cm per century. Historical records which show mangrove expansion under relative sea level changes nearly twice as great challenged this idea. **Source:** Importance of Mangrove Ecosystem *(*K. Kathiresan et al., 2012)

**C) Cyclones**

The coast is shielded by mangrove trees from the wrath of storms and cyclones. The super-cyclone that hit the Indian state of Odisha on October 29, 1999, with winds of 310 km/h is the best example. This cyclone caused a lot of damage, mostly in places without mangroves. In contrast, there was almost minimal damage in the areas covered in a thick mangrove forest. Nearly 10,000 individuals were murdered in this incident, along with a great deal of cattle and property loss. More than 90% of the deaths caused by the cyclone in 1999 may have been prevented if the mangrove forests had remained unharmed. Storms and tropical cyclones are more frequent in the Bay of Bengal. As a result, the south Indian coast is far more affected than the Arabian Sea coast.

The Bay of Bengal saw around 346 cyclones, including 133 severe ones, between 1891 and 1970, compared to the Arabian Sea's 98, including 55 severe cyclones. These extremely fast cyclones strike the coast and flood the shoreline with powerful tidal waves, severely harming and upsetting coastal life. But mangrove species like Rhizophora spp. appear to act as a barrier against this natural disaster (McCoy et al., 1996). On May 3, 2008, the recent cyclone known as "Nargis" struck the coast of Myanmar (Burma), causing severe effects and the deaths of over 30 000 people. Scientists believe that the loss of mangroves exposed Myanmar to the wrath of nature. The significance of mangroves as the first line of defence against storms and cyclones is thus reinforced once again by Cyclone "Nargis."

**D) Erosion**

The mangrove systems reduce the impact of waves, which stops the coast from eroding. The amount of vegetation and water depth both have an impact on wave reduction. Vietnam has served as a demonstration of this. The rate of wave reduction per 100 m in tall mangrove trees might reach 20% (Mazda et al., 1999a). In comparison to concrete seawalls and other constructions for the prevention of coastal erosion, mangroves have been shown to create "live seawalls" and to be far more cost-effective (Harada et al., 2002). For more than 50 years, a mangrove forest with a 100-meter width protected the sea dike behind the forest.

The sea dyke was protected by the rock fencing for just about five years. This is due to the fact that mangrove forests, as seen in the Red River Delta in Vietnam, are more resilient to wave damage than rock fencing is. The mangrove planting, which cost USD 1.1 million, reduced the sea dyke's annual maintenance costs by USD 7.3 million (World Disaster Report, 2002). However, erosion issues are brought on by mangrove degradation, as has been seen in the Gulf of Kachchh and other areas.

**4) Fuel wood**

More over half of the respondents uses mangroves as fuel wood. The indigenous have extremely easy access to mangrove wood, but they must pay for other types of wood (fig. 6). Mangroves grow in salty water, which is why this wood has a higher sodium content. If this wood is used directly as fuel, the salt content will cause metal pots to crack when cooking. In order to avoid getting wet, this type of wood is stored throughout the rainy season. After that, it is allowed to dry out in the sun until it is ready to be used as fuel.

According to their perception, they pledged to not utilise mangrove wood for construction or as a fuel source. However, the current survey also discovered that people do not use kerosene, cooking gas or any other fuel to prepare their meals. Additionally, it has been seen in person that there are several piles of mangrove wood in front of their homes (fig. 6-b). It is evident that they are not selling the wood, but rather using it as fuel. Mangroves are being destroyed in similar ways in neighbouring areas as well. Following that, 13.13 percent of the respondents utilised mangroves to heat water

.



**Figure 6**: Heaps of mangroves wood at Karel Village. (**Source:** Importance of Mangrove Ecosystem.K. Kathiresan 2012)

**5) Environment services**

**Reducing the “greenhouse effects”**

Among the tropical woods with the highest carbon content are mangroves. Through photosynthesis, mangroves remove CO2 from the atmosphere. This may lessen the issues associated with "greenhouse gases" and global warming. In the tropical waters, the mangroves fix more CO2 than the phytoplankton (Kathiresan and Bingham, 2001). Calculating the total biomass per hectare and then using the proper conversion factors to arrive at carbon equivalents are necessary to estimate a forest's potential for sequestering carbon. According to Ong et al. (1995), a 20-year-old stand of Rhizophora apiculata mangrove forest absorbed 7.14 tonnes of carbon per ha per year. Mangrove mud is thought to trap carbon at a rate of about 1.5 t C/ha/year.

**Screening the solar UV-B radiation**

Mangroves have defences against solar UV-B radiation and strong sunshine. For instance, Avicennia species thrive in hot, dry climates with abundant sunlight because they are evolved to desert environments. Compared to other mangrove species, rhizophoracean species are more resistant to solar UV-B radiation. Mangrove foliage produces flavonoids, which act as UV-blocking substances. Because of this capability, mangroves protect the environment from UV-B radiation's harmful effects (Moorthy and Kathiresan, 1997a, b).

**6) Pollution**

In numerous agricultural and urban environments, mangroves serve as a sink for toxins. Mangroves have been recommended as a low cost technique to mitigate point and non-point pollution from an economic standpoint as well (ByStrom et al., 2000). By absorbing nitrate and phosphate from surface and subsurface runoff, mangroves lower the nutrient load of through-flowing water (Verhoeven et al., 2006). The maximum rate at which mangroves can remove nitrogen and phosphorus in temperate climates is between 1000 and 3000 kg N/ha/year and between 60 and 100 kg P/ha/year (Groffman and Crawford, 2003; Kadlec and Reddy, 2001).

Mangroves are harmed by agricultural runoff, untreated sewage discharge, and other urban garbage in India as well. Mangroves do, in fact, keep contaminants from surface and subsurface runoff from the catchment out of streams and rivers when things are normal. The nutrient loading in mangroves, however, far exceeds their capacity to hold pollutants and remove them through nitrification, sedimentation, adsorption, and uptake by aquatic plants as a result of rising urbanisation and land use changes. The water quality and biodiversity of the mangroves are negatively impacted by this. According to Verhoeven et al. (2006), such mangroves exhibit dramatic changes in nutrient cycling rates and species loss.

**7) Biodiversity**

The mangrove habitat is one of the places with the largest diversity of aquatic and terrestrial animals. It can be found living in a range of habitats, such as coral reefs, sea grass ecosystems, mud flats, litter-forest floors, rivers, bays, and creeks. 920 plant species (23%) and 3,091 animal species (77%) make up the largest number of species in the world, 4,011 species, which have been found in Indian mangrove habitats. The majority of species (557) were marine algae, which made up 60.1% of the flora. Other significant species were fungi (11.2%), mangrove associates (9.3%), bacteria (7.5%), and mangroves (4.2%). India is home to two mangrove species that are in danger of extinction: Heritiera fomes and Sonneratia griffth. Other invertebrates made up the majority of the fauna with 745 species, or 24.1%, followed by insects with 22.3%, fish with 17.6%, birds with 13.8%, molluscs with 9.9%, and so on (Tab No.2). One of the most endangered species of unique wildlife, the olive ridley turtle, is situated along the coast of Odisha.

**Table** :2Total number of species in mangrove ecosystems of India (**Source:** Sahu et al., (2015) Mangrove Area Assessment in India: Implications of Loss of Mangroves. J Earth Sci Clim Change 6: 280. doi:10.4172/2157-7617.1000280)

|  |  |  |  |
| --- | --- | --- | --- |
| **Category** | **Type group** | **No.of species** | **% of total species** |
| **Flora** | Mangroves | 39 | 4.2 |
| Mangroves associates | 86 | 9.3 |
| Sea grass vegetation | 11 | 1.2 |
| Marine Algae (Phytoplankton+ Sea weeds) | 557 | 60.1 |
| Bacteria | 69 | 7.5 |
| Fungi | 103 | 11.2 |
| Actinomycetes | 23 | 2.5 |
| Lichens | 32 | 3.4 |
| **Fauna** | Prawns and lobsters | 55 | 1.8 |
| Crabs | 138 | 4.4 |
| Insects | 707 | 22.3 |
| Molluscs | 305 | 9.9 |
| Other invertebrate | 745 | 24.1 |
| Fish parasites | 7 | 0.2 |
| Finfish | 543 | 17.6 |
| Amphibian | 13 | 0.4 |
| Reptiles | 84 | 2.7 |
| Birds | 426 | 13.8 |
| Mammals | 68 | 2.2 |
| **Total** |  | 4,011 | 100 |

**Preventive measures**

1. **Strategies on mangrove managements in India**

The current mangrove management approach combines community education, sustainable exploitation of forest resources through cooperative management, and legislative policy for conservation (Figure 7). The oldest documentation of forest management and conservation may be found in the British colonial administration, specifically in the National Forest Policy of 1894 and the Forest Conservation Act of 1927.The National Forest Policy, established by the Indian government in 1952, classified Indian forests into four groups: protected forests, national forests, village forests, and tree lands. Comparable to the categorization established by the National Forest Policy of 1894 is this system of classification. Source :A Review of Threats and Vulnerabilities to Mangrove Habitats: With Special Emphasis on East Coast of India

**Fig 7.** Strategies on mangrove managements in India **Source:** Chaudhuri et al.,2015.A Review of Threats and Vulnerabilities to Mangrove Habitats: With Special Emphasis on East Coast of India

**Management policies**

* Construction of artificial drainage system ,
* Scientific and ecologically beneficial plantation policy,
* Community based mangrove management.

**Natural factor**

* Sea level rise ,
* Coastal erosion and sedimentation,
* Storms and surges,
* Shoreline shifting.

**Policy and legislation**

* National forest policy of 1952,
* Wildlife protection Act of 1972,
* Forest conservation act of 1980,
* Coastal zone regulation act of 1991,
* Biodiversity act of 2002.

**Conservation through management**

* Sustainable management of forest products,
* Joint forest management program,
* Mangrove plantation.

**Conservation through awareness and education**

* Proper awareness of forest guards and local people,
* Establishment of mangrove interpretation and research center,
* Involvement of mass media to spread public awareness.

**Impacts**

* Increase in salinity,
* Loss in species diversity,
* Loss in ecological and environmental services.

**Anthropogenic factors**

* Conversion of mangrove wetland for agriculture and aquaculture,
* Illegal cutting of trees,
* Increase in pollution load,
* Decrease in flow of freshwater,
* Urbanization,
* Development of port and harbor.

**B)** **Conservation through management, education and restoration projects**

A number of non-governmental organisations working on mangrove conservation and restoration have arisen as a result of the loss in the worldwide mangrove cover and the well acknowledged ecological and ecosystem services worth of mangroves. There are international organisations like the Mangrove Action Project, Western Indian Ocean (WIO) Mangrove Network, the Mangrove Alliance, and Mangrove Watch among them, as well as domestic ones like Honko, a mangrove conservation and education group in Madagascar, and the Mangrove Forest Conservation Society of Nigeria, among others. Some nations, such Cuba and Ecuador, have made considerable financial investments and are experimenting with novel methods of mangrove protection by including local populations in the management of natural resources (Gravez et al. 2013; Lugo et al. 2014).(source Cambridge mangroves 48)

**C) Non- legislative management**

Given that India is still a developing nation, a lot of literature suggests that many coastal populations still rely on the resources that mangroves provide for their livelihoods. Since one ecosystem service is usually offered at the expense of another, it is crucial to encourage the economic development of the people that depend on mangroves. Since many livelihoods depend on the provisioning services offered by this ecosystem, maintaining mangroves does have a cost. Together with scientific organisations and the forest department, community-based management is currently playing a significant role in guaranteeing the restoration and maintenance of this ecosystem. According to Das Gupta (2013), JMM is very common in places like Gujarat, West Bengal, Orissa, and Tamil Nadu. (**Source** Current Status of Mangroves in India: Benefits, Rising Threats Policy and Suggestions for the Way Forward)

**D)Mangrove sacred groves: Traditional conservation**

India has long practised the custom of fortifying its forests with sacred groves in order to protect them. Due to their strong religious beliefs, a group of individuals guards forest areas designated as sacred groves. In certain forest regions, hunting and logging are prohibited. Some of these groves are based on smaller local religions and folk religions, while others are associated with sacred deities that may have local Buddhist, Hindu, or Islamic roots. Over 13,900 sacred groves have been identified in India, according to the C.P.R. Environmental Education Centre of the Government of India.However, there aren't many holy mangrove groves in India. The only sacred mangrove species found in inland mangrove communities around the world is Avicennia marina. **Source**:Tripathy N, Singh RS, Bakhori V, Dalal C, Parmar D, et al. (2013) The world’s only inland mangrove in sacred grove of Kachchh, India, is at risk. Current Science 105: 1053-1055.

**E) International level Protective measures for Mangroves**

The conservation of mangroves is not covered by any specific Convention or other instrument at the international level.The Ramsar Convention is the official name of the international treaty known as the Convention on Wetlands of International Importance notably Waterfowl Habitat, which was signed in Iran in 1971.While not directly related, the Stockholm Declaration, which states that all natural resources, including air, water, land, flora, and wildlife, should be safeguarded by meticulous planning, is another international treaty that discusses mangroves and their conservation.One of the outcomes of the Rio declaration is Agenda 21**.(Source :**Mani et al., 2010)

**Threats and Vulnerabilities to Mangrove Ecosystems**

In addition to serving as a preventative measure against diseases including malaria, diarrhoea, ulcers, skin infections, diabetes, and snakebites, mangroves are vital to human survival in many other ways. However, because of human activity and climate change, many ecosystems are vulnerable. Sometimes mangrove environments are destroyed to make room for farming, resorts, and aquaculture. Climate change also affects the loss of mangroves through changes in sea level, cyclone pattern and strength, rainfall intensity, and coastline erosion. Mangrove ecosystems are less at risk from natural phenomena than from anthropogenic activity. Due to changes in land use, species diversity has reduced in many locations. **Source:** Chaudhuri et al.,2015. A Review of Threats and Vulnerabilities to Mangrove Habitats: With Special Emphasis on East Coast of India.

1. **Agriculture and Aquaculture**

States like West Bengal and Tamil Nadu are the ones most affected by these activities For the expansion of agriculture, significant areas of the land are cleared. Rainwater is used to make the lands fruitful and lower the salinity of the soil. Then, excessive amounts of fertilisers and pesticides are sprayed, having a cascading effect on the ecosystems nearby. Samyuktha et al 2018

1. **Exploitation of Mangroves for Provisioning Services**

One of the best woods, with high strength, is mangrove. They are appropriate for industrial use. Overexploitation poses a threat to states like Gujarat, Karnataka, and Tamil Nadu. Samyuktha et al 2018

1. **Natural Calamities**

Natural disasters can sometimes have an adverse effect on mangroves, despite the fact that they serve as a barrier against them. As an illustration, consider the 1999 cyclone that hit Odisha. It destroyed a huge tract of mangroves, uprooting the trees. Table 1 demonstrates that the Andaman and Nicobar Islands have consistently experienced area loss as a result of disasters. Mangroves along the south coast suffered severe damage as a result of the tsunami in 2004. Samyuktha et al 2018

1. **Pollution**

Large amounts of solid waste and effluents that enter its ecosystem pose serious dangers to mangroves that are found in cities like Mumbai and Kolkata. This hampers growth and makes it harder for the mangroves to thrive. Samyuktha et al 2018

1. **Threats from Unsustainable Tourism**

A and N islands are significantly at risk from thisUnsustainable Tourism.It is a significant contributor to area loss over time. Tourism increases the demand for services, which increases extraction, much as resource discovery increases exploitation. Conventional tourism, in turn, intensifies the aforementioned dangers and frequently forces nearby people who depend on mangroves to compete for limited resources. Samyuktha et al 2018

1. **Climate Change**

**Figure 8**: Mangrove degradation due to natural and anthropogenic factors have immensely reduced their ecosystem services and capability to recover naturally **(**Status of Indian Mangroves and a Way Forward for their Conservation)

It is one of the most significant problems that affect everyone equally and cannot be linked to any particular state. The effects of global climate change, such as rising sea levels, higher temperatures, and more frequent natural disasters, will each have their own effects on mangroves. Suparbhanga and Lohacharra, two islands in the Indian Sundarbans, have flooded as a result of sea level rise, and a dozen additional islands are also experiencing the same issue, according to a recent observation (fig No. 8).( Mangrove Area Assessment in India: Implications of Loss of Mangroves) Samyuktha et al 2018

1. **Cutting of mangroves for timber, fuel and charcoal**

People are cutting down mangroves for firewood, charcoal, and timber collection due to the high calorific value and strength of the wood [36]. Mangrove wood is ideal for the paper and chipboard industries. Therefore, because of their industrial usefulness, forests were regularly removed for these uses.( Mangrove Area Assessment in India: Implications of Loss of Mangroves) Sahu et al 2015

1. **Reduction of fresh water and tidal water flows**

In places where there is a significant volume of fresh water inflow, mangroves are well established. Construction of dams and barriers along upper reaches of rivers limits the amount of freshwater that reaches mangrove swamps. Construction of embankments and siltation at the river mouth prevent tidal water from entering mangrove wetlands. Reduced tidal and freshwater influx makes these places more salinous, which hinders mangrove germination, growth, and regeneration. For instance, in Pichavaram, South India, mangroves are primarily dying because to hyper salinity and other related issues like rising temperatures, insufficient precipitation, and ineffective tidal water flushing. Populations of species like Heritiera fomes and Nypa fruticans are declining in the Sundarbans as a result of the decline in fresh water imports. (Mangrove Area Assessment in India: Implications of Loss of Mangroves) Sahu et al., 2015

1. **Invasive species**

Invasive species plague the majority of India's mangrove zones, upsetting the ecosystem's dynamics and ecological balance. For instance, the swift invasion of Prosopis species in Tamil Nadu and Andhra Pradesh can be categorised as an invasive species. The indigenous flora of mangrove ecosystems in Sundarbans is being adversely affected by the twiner Derris trifoliate, as well as other aquatic weeds Eichhornia crassipes and Salvinia, colonising mangrove water. (Mangrove Area Assessment in India: Implications of Loss of Mangroves) Sahu et al., 2015

**Scope and future prospects of mangroves**

Given the paucity of long-term information, predicting the future of mangrove forests is difficult. However, a few fundamental predictions can be made based on plausible extrapolations from the important mangrove patterns and traits discussed here, conceivable advancements in genetics and restoration ecology, and the expansion of the present sustainable management practises. According to the severity of previous and ongoing impacts, there are a number of risks to the future of mangrove ecosystems (Table 5), which are officially categorised as high-, medium-, and low-level threats. The biggest threat to the continued existence of mangroves is still deforestation .As a result of the burning of fossil fuels, deforestation, and other types of land clearing, atmospheric CO2 concentrations and temperatures are inevitably rising, which will raise sea levels as polar ice melts (IPCC [Intergovernmental Panel on Climate Change] 2001). There are various threats to the future of mangrove ecosystems (Table 5), nominally divided into high-, medium and low-level threats, based on the level of past and current impacts.

**Conclusion**

The paper reviews both the mangroves' current state in India and some of the immediate and indirect benefits they offer. The dangers to India's mangrove ecosystems also underscore the significance of coastal and marine habitats. The importance of environmental security, active community involvement, and lowering the danger of natural disasters must all be considered in the context of conservation. In light of anticipatory adaption measures, which hold the key to successful and effective management, such measures need to be used more comprehensively. Mangrove ecosystems are among the most vulnerable in the world, according to the study. Due to the ongoing rise in anthropogenic stressors in coastal areas and climatic unpredictability, they are on the point of extinction. To maintain, protect, and restore the priceless mangrove wetland ecosystems, effective governance, adaptation and mitigation strategies for climate change, better planning for the rehabilitation of degraded mangroves, and raising community awareness are all urgently needed. Mangrove forests require immediate research, management, public awareness, and rehabilitation; nonetheless, it is crucial that scientists give a balanced assessment of mangrove loss that takes these global issues into account when determining the true state of the world's mangroves.

**References**

1. Alongi, D. Present state and future of the world's mangrove forests. *Environmental Conservation,* *29*(3), 2002, pp. 331-349.
2. Bandaranayake, W.M., Traditional and medicinal uses of mangroves". Mangroves Salt Marshes 2, 1998 pp. 133– 148.
3. Baran, E. A review of quantified relationships between mangroves and coastal resources. *Phuket Marine Biological Center* *Research Bulletin* 1999*.* **62:** 57–64.
4. Bystrom, O., Andersson, H., Gren, I. Economic criteria for using wetlands as nitrogen sinks under uncertainty. Ecol. Econ. 2000, 35 (1), pp. 35–45.
5. Castañeda-Moya, E., Twilley, R. R., Rivera-Monroy, V. H., Zhang, K., Davis, S. E., and Ross, M. (2010). Sediment and Nutrient Deposition Associated with Hurricane Wilma in Mangroves of the Florida Coastal Everglades. Estuaries Coasts. 2010, 33, pp.45–58.
6. Chaudhuri P, Ghosh S, Bakshi M, Bhattacharyya S, and Nath B. A Review of Threats and Vulnerabilities to Mangrove Habitats: With Special Emphasis on East Coast of India. J Earth Sci Clim Change 2015, 6: 270.
7. Chong, V.C. and Sasekumar, A. Status of mangrove fisheries in the ASEAN region. In: *Living Coastal Resources of* *Southeast Asia: Status and Management,* ed. C.R. Wilkinson, Townsville, Australia: Australian Institute of Marine Science.1994, pp. 56–61.
8. Daniel M. Alongi (2002). Present state and future of the world's mangrove forests. Environmental Conservation. 2002 ,29, pp 331-349
9. Das Gupta, R. and R. Shaw. Changing Perspectives of Mangrove Management in India–An Analytical Overview, Ocean and coastal management,2013, 80, pp.107-118.
10. Ewel, K.C., Twilley, R.R., and Ong, J. E. Different kinds of mangrove forests provide. 1998
11. Friess, D. A., Krauss, K., Taillardat, P., Adame, M. F., Yando, E. S., and Cameron, C. (2020). Mangrove blue carbon in the face of deforestation, climate change, and restoration. Annu. Plant Rev.2020, 3: pp 427-456.
12. Gilbert, A. J. and Janssen, R. Use of environmental functions to communicate the values of a mangrove ecosystem under different management regimes”. Ecol. Econ. 1998, 25, pp.323–346.
13. Goldberg, L., Lagomasino, D., Thomas, N., and Fatoyinbo, T. Global declines in human-driven mangrove loss. Glob. Chang. Biol.2020, 26, pp. 5844–5855.
14. Gravez,V., Bensted-Smith R, Heylings, P., and Gregoire-Wright, T. Governance systems for marine protected areas in Ecuador. In. Moksness, E., Dahl, E., Stottrup,.J., Eds. *Global challenges in integrated coastal zone management.* John.Wiley & Sons, Ltd., Oxford, UK, 2013, pp. 145-158.
15. Groffman, P.M. and Crawford, M.K. Denitrification potential in urban riparian zones. J. Environ. Qual.2003, 32 (3), pp. 1144–1149.
16. Harada K., Imamura F., and Hiraishi T. Experimental study on the effect in reducing Tsunami by the coastal permeable structures, Final Proc. Int. Offshore Polar Eng. Conf., USA,2002, pp. 652-658
17. Hinrichsen, D. *Coastal Waters of the World: Trends, Threats,vand Strategies.* Washington, DC,USA: Island Press:1998, 275 pp.
18. Hiraishi T., and Harada K. Green belt Tsunami Prevention in South-Pacific Region, 2003,Available at: http://eqtap.edm.bosai.go.jp /useful\_outputs/report/hiraishi /data / papers/greenbelt. pdf
19. Jones, M. C., Wingard, G. L., Stackhouse, B., Keller, K.,Willard, D and Marot, M. Rapid inundation of southern Florida coastline despite low relative sea level rise rates during the late-Holocene. Nat. Commun. 2019, 10:3231.
20. Kadlec, R.H. and Reddy, K.R. Temperature effects in treatment wetlands. Water Environ. Res. 2001, 73 (5), pp. 543–557.
21. Kairo, J. G., Dahdouh-Guebas, F., Bosire, J. and Koedam, N. Restoration and management of mangrove systems - a lesson for and from the East African region”, South African Journal of Botany.2001, 67, pp.383–389.
22. Kathiresan K., and Bingham B.L., 2001, Biology of mangroves and mangrove ecosystems, Advances in Marine Biology, 2001, 40: pp. 81-251
23. Kathiresan K., and Rajendran N. Coastal mangrove forests mitigated tsunami, Estuarine coastal and Shelf Science,2005, 65, pp 601-606
24. Kathiresan. Importance of Mangrove Ecosystem, Inter. Journal of Marine Science, 2012, 2,(10).pp 70-89
25. Lugo**,** A. E., Medina, E. and McGinley, K. Issues and Challenges of Mangrove Conservation in the Anthropocene. Madera y Bosques 2014,20 (3) pp.11-38.
26. Mani, Sakthivel. Protection of Mangroves: A Study with Special Reference to India.2010.
27. Mazda Y, Magi M, Kogo M and Hong P.N. Mangroves as a coastal protection from waves in the Tong King Delta, Vietnam. Mangroves and Salt Marshes1.1997, pp.127-135.
28. Mazda Y., Magi M., Kogo M., and Hong P.N. Mangrove on coastal protection from waves in the Tong King Delta, Vietnam, Mangroves and Salt Marshes, l997a 1, pp.127-135.
29. Mazda Y., Wolanski E., King B., Sase A., and Ohtsuka D. Drag force due to vegetation in mangrove swamps, Mangroves and Salt Marshes, l997b, 1(3) pp. 193-199.
30. McCoy E.D., Mushinsky H.R., Johnson D., and Meshaka W.E. Jr. Mangrove damage caused by Hurricane Andrew on the southwestern coast of Florida, Bulletin of Marine Science, 1996, 59(1): 1-8
31. Miles, D. H., Kokpol, U., Chittawong, V., Tip-Pyang, S., Tunsuwan, K., and Nguyen, C., 1999, “Mangrove Forest The Importance of Conservation as a Bioresource for Ecosystem Diversity and Utilization as a Source of Chemical Constituents with Potential Medicinal and Agricultural Value”, IUPAC, proceeding.
32. Mohsin, A.K.M. and Ambak, M.A. *Marine Fishes and Fisheries of Malaysia and Neighbouring Countries.* Serdang, Malaysia:Universiti Pertanian Malaysia Press: 1996, 744 pp.
33. Moorthy P., and Kathiresan K., , Photosynthetic pigments in tropical mangroves: Impacts of seasonal flux on UV-B radiation and other environmental attributes, Botanica Marina, 1997a 40 pp. 341-349
34. Moorthy P., and Kathiresan K., 1997b, Influence of UV-B radiation on photosynthetic and biochemical characteristics of a mangrove *Rhizophora apiculata* Blume, Photosynthetica, 1997b 34(3) pp. 465-471.
35. Mugade, Nisha and Sapkale, Jagdish. Ethnoecological Study of Mangroves along the Estuaries of Rajapur and Devgad Tehsils, Coastal Maharashtra. Interna. Journal of Oceans and Oceanography. 2017, 11. 31-44.
36. Peneva-Reed, E. I., Krauss, K. W., Bullock, E. L., Zhu, Z., Woltz, V. L. and Drexler, J. Z. Carbon stock losses and recovery observed for a mangrove ecosystem following a major hurricane in Southwest Florida. Estuar. Coast. Shelf Sci.2021, 8, pp. 106-150.
37. Ridd P.V., and Sam R., Profiling groundwater salt concentrations in mangrove swamps and tropical salt flats, Estuarine, Coastal and Shelf Science,1996, 43(5, pp. 627-635
38. Rovai, A. S., Twilley, R. R., Castañeda-Moya, E., Midway, S., Friess, D. A. and Trettin, C. (2021). Testing Macroecological Patterns and Drivers of Mangrove Carbon Stocks Across Biogeographic Regions and Coastal Morphologies.
39. Sahu SC, Suresh HS, Murthy IK and Ravindranath N. H. Mangrove Area Assessment in India: Implications of Loss of Mangroves. J Earth Sci Clim Change, 2015, 6, pp. 280.
40. Samyuktha Ashokkumar & Zareena Begum Irfan, "undated". "[Current Status of Mangroves in India: Benefits, Rising Threats Policy and Suggestions for the Way Forward](https://ideas.repec.org/p/mad/wpaper/2018-174.html)," [Working Papers](https://ideas.repec.org/s/mad/wpaper.html) 2018-174, Madras School of Economics,Chennai,India.
41. Simard, M., Fatoyinbo, L., Smetanka, C., Rivera-Monroy, V. H., Castañeda-Moya, E. and Thomas, N. Mangrove canopy height globally related to precipitation, temperature and cyclone frequency. Nat. Geosci.2019, 12, pp.40–45
42. Tripathy N, Singh RS, Bakhori V, Dalal C, Parmar D, et al. (2013) The world’s only inland mangrove in sacred grove of Kachchh, India, is at risk. Current Science. 2013, 105, pp. 1053-1055.