

# A REVIEW ON ECOLOGICAL IMPORTANCE OF MANGROVES

## Abstract

One of the most prolific ecosystems in the world, mangroves are currently under threat. They provide a wide range of goods and services, some of which are directly valuable but typically come with several benefits that are obvious yet indirect benefits. Mangroves, which are found in the intertidal zones of the tropics and subtropics, are one of the most endangered ecosystems in the world. These are beneficiary for coastal communities economically and environmentally. They safeguarded people and property from storm surges, hurricanes, cyclones, and tsunamis by conserving coastal flora and animals. Anthropogenic activity was the main reason responsible for the degradation of the mangrove environment in India which was developed due to the anthropogenic activity like utilisation of mangrove wetland for the purpose of aquaculture. 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 more-exploitation, over-agriculture, aquaculture, tourism, and urban growth. The current review's major goal is to determine the condition and trends of the mangrove ecosystem in India as well as the reasons behind its recovery and customary preservation of mangroves in coastal areas.

**Keywords:** Mangroves, species, Forest.

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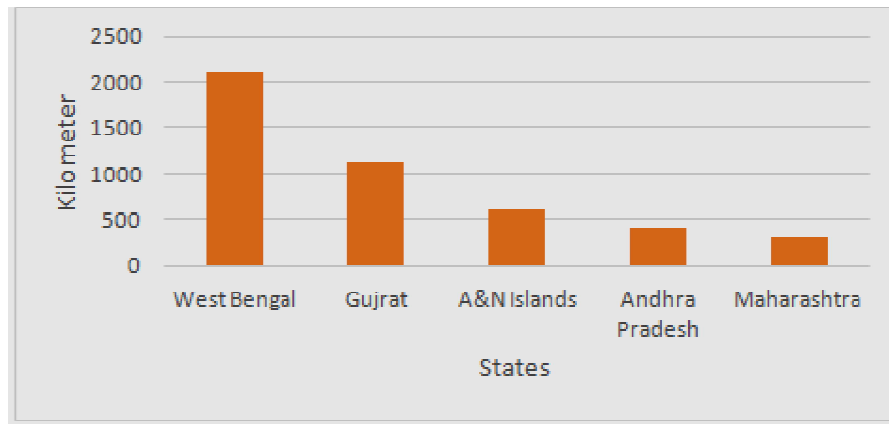
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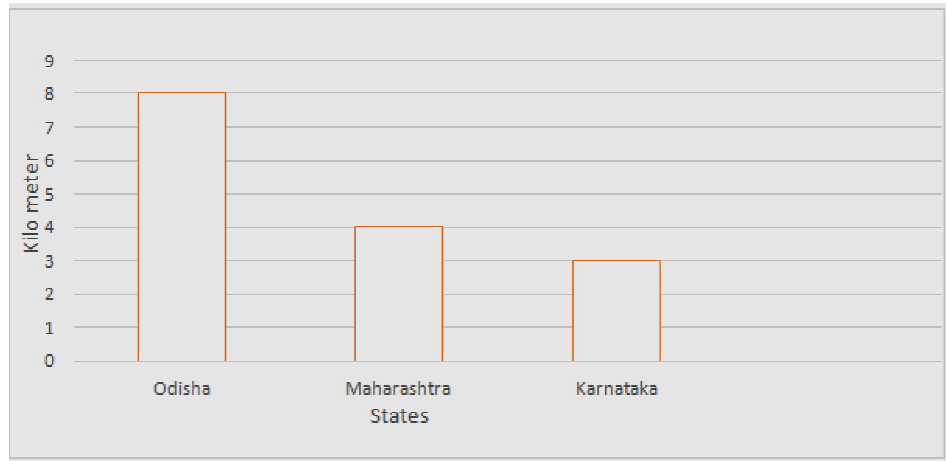
## I. INTRODUCTION

Mangroves are the meeting point of freshwater, oceans, and land. Only near beaches and in the intertidal zones can one find true mangroves, which are 54–75 species broad and taxonomically distinct from their terrestrial cousins. Mangrove forests are among the most complex ecosystems on earth, surviving in environments where the bulk of other plant life would be wiped off very fast. Due to their high level of environmental adaptability and ability to either exclude or expel salt, mangroves can endure overly salty waters and soils. As per the 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. as shown in Fig No. 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 No.1, 2 and table No. 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 1<sup>st</sup> 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**

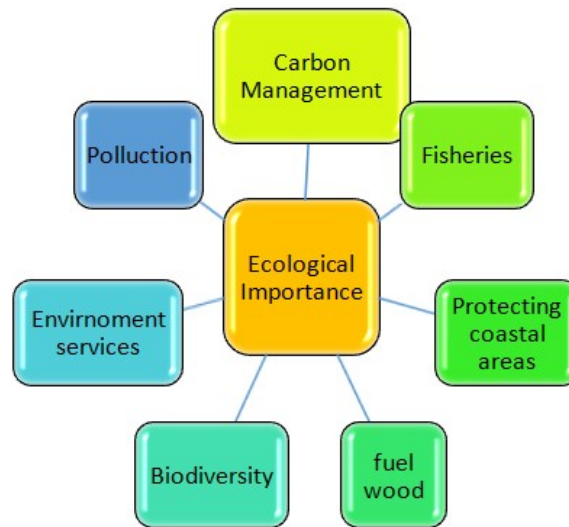
| State                        | Place  |
|------------------------------|--|
| <b>Gujrat</b>                | Gulf of Kutchh, Gulf of Khambhat, Dumas-Ubhrat   |
| <b>Andhra Pradesh</b>        | Coringa East Godavari Delta, Krishna Delta   |
| <b>Odisha</b>                | Bhaitarkanika, Mahanadi, Subarnarekha,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

**(Source : India State of Forest Report 2021)**

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 changes (Friess et al., 2020; Peneva-Reed et al., 2021).

## II. ECOLOGICAL IMPORTANCE OF MANGROVES



- 1. Carbon Management:** Mangroves are typically more productive than saltmarshes, seagrasses, macroalgae, coral reef algae, microphytobenthos, and phytoplankton on an area basis, according to recent advances in measuring photosynthetic productivity (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 et al (2002) calculated that the loss of around 35% of the world's mangroves has resulted in a net loss of  $3.8 \times 10^{14}$  gC stored as mangrove biomass in a recent examination of the destiny of fixed carbon in marine ecosystems.
- 2. Fisheries:** The ecological importance of mangroves in terms of timber and fisheries productivity is often not taken into account in budgets and mass balance estimates at the ecosystem level. Contrary to statistical data, mangroves are important breeding sites (Baran 1999). The slope of the relationship between fish and prawn landings and mangrove data varies between geographic areas as a result of variances in catch methods, forest structure and productivity, and the fisheries species in question (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). Mohsin & Ambak (1996) reported that 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. Due to the lack of long-term data,



**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

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 has reported (2017) carried out research on Ethnoecological Study of Mangroves along the Estuaries of Rajapur and Devgad talukas, 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)

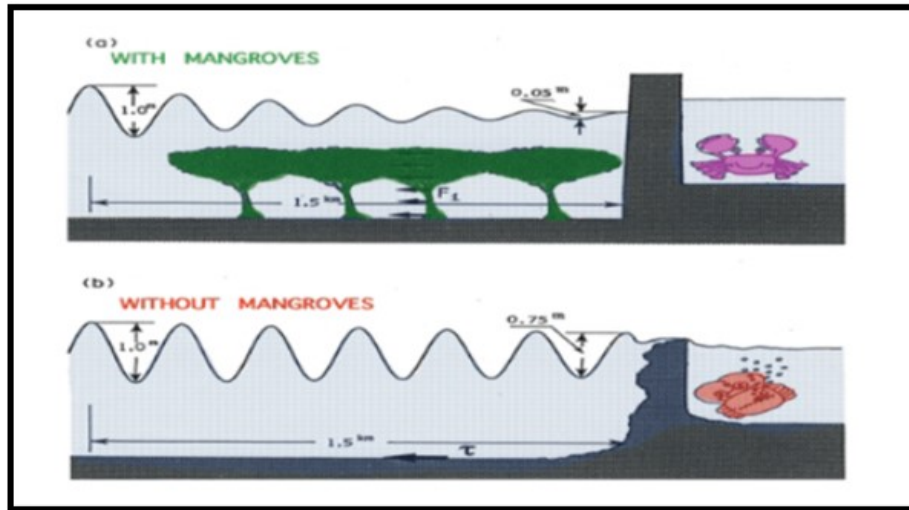
3. **Protecting Coastal Areas:** In the given figure No. 4 which shows that a boat jetty across the Vellar estuary (south-east coast of India) was broken into pieces by 26<sup>th</sup> December 2004 tsunami along with a mangrove forest which was raised artificially.



**Figure 4:** boat jetty at Vellar estuary broken into pieces  
Source: Importance of Mangrove Ecosystem ( K. Kathiresan 2012)

- **Tsunamis:** Mangrove forests provide coastal protection from the effects of the 26<sup>th</sup> wave. This was made clear by the tsunami that hit the Indian Ocean region in December 2004. 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). Wave attack and towing flow, two tsunami-related physical phenomena, are necessary for mangroves to mitigate tsunami danger. However, mangroves' "drag force" is what enables them to adapt to towing flows, limiting coastal erosion. When a wave attacks, vegetation features must be applied to respond. As a result, the protective function of mangroves is influenced by two factors: (i) Tsunami wave characteristics, such as wave height, wave period, and depth of water (ii) vegetation characteristics, such as density, height, species composition, forest density, diameter of mangrove roots and trunks, and elevation of habitats (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. (1997a), 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. A 100 m wide belt of 30 trees from 10 trees may reduce the maximum tsunami flow pressure by more than 90% if the wave height is less than 4-5 m. would offer tsunami protection in the event that the height of a m<sup>2</sup>) 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.
- **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 devastating flood that struck Bangladesh in 191 would have been greatly reduced if

the 300 km<sup>2</sup> mangrove land had not been cleared for shrimp farming and rice cultivation earlier.



**Figure 5:** 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)

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 (Fig 5).

Groundwater Salt concentrations have been frequently undergone alterations along the edge between salt flats and mangroves. This shows how mangrove systems can significantly lower the salinity of 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. (K. Kathiresan et al., 2012)

- **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 29<sup>th</sup> October, 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 during 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.

Between 1891 and 1970, the Bay of Bengal experienced about 346 cyclones, including 133 severe ones, as opposed to the Arabian Sea's 98, including 55 severe cyclones. When these lightning-quick cyclones hit the coast, strong tides overrun the shoreline, severely injuring and disrupting coastal life. However, mangrove species, such as *Rhizophora* spp., seem to operate as a defence against this natural tragedy. (McCoy et al., 1996). Over 30, 000 people died when the recent storm "Nargis" hit the coast of Myanmar (Burma) on May 3, 2008, leaving severe effects in its wake. The destruction of mangroves, according to scientists, exposed Myanmar to the fury of nature.. The significance of mangroves as the first line of defence against storms and cyclones is thus reinforced once again by Cyclone "Nargis."

- **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.
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”:** Mangroves are one of the tropical woods with the highest carbon content. Mangroves reduce atmospheric CO<sub>2</sub> through photosynthesis. The problems brought on by "greenhouse gases" and global warming might be lessened as a result. Mangroves fix more CO<sub>2</sub> than phytoplankton in tropical waters. (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.
  - **Screening the Solar UV-B Radiation:** Mangroves have protection from solar UV-B radiation and intense sunlight. 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. India is home to two mangrove species that are in danger of extinction. 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.

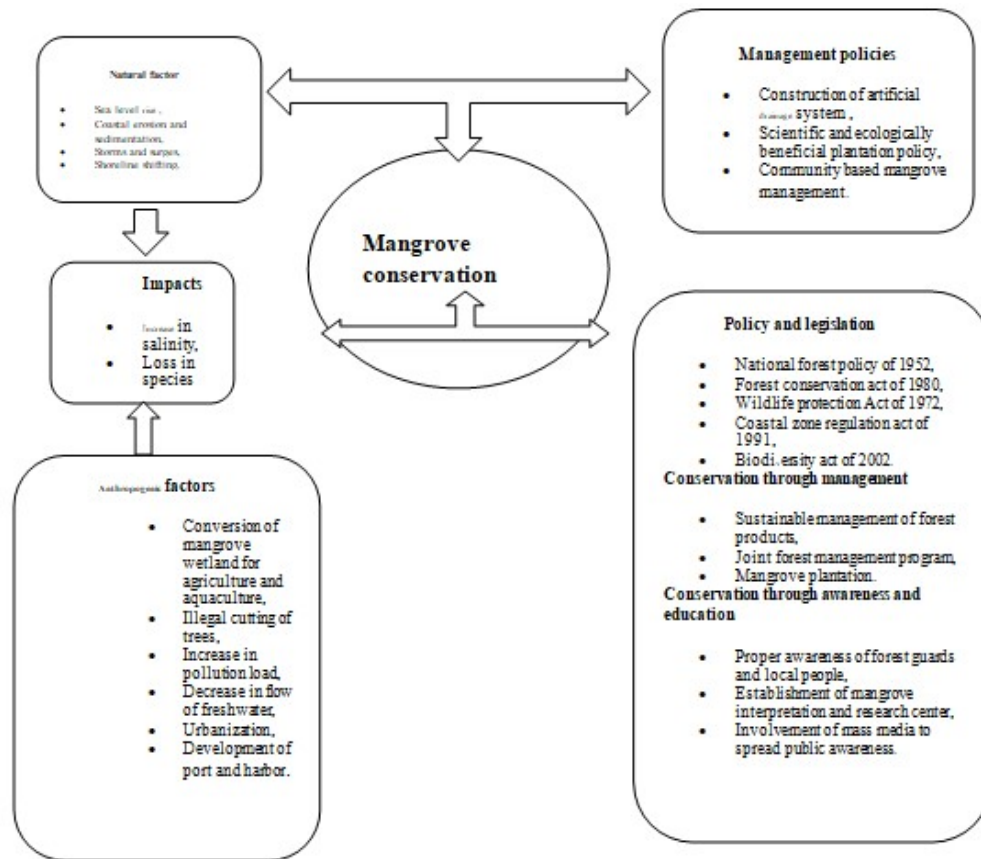
**Table 2: Total Number of Species in Mangrove Ecosystems of India**

| <b>Cate<br/>gory</b> | <b>Type group</b>                          | <b>No.of<br/>species</b> | <b>% of total<br/>species</b> |
|----------------------|--|--------------------------|-------------------------------|
| <b>Flora</b>         | Mangroves                                  | 39                       | 4.2                           |
|                      | Mangroves associates                       | 86                       | 9.3                           |
|                      | Sea grass vegetation                       | 11                       | 1.2                           |
|                      | Marine Algae (Phytoplankton+<br>Sea weeds) | 557                      | 60.1                          |
|                      | Bacteria                                   | 69                       | 7.5                           |
|                      | Fungi                                      | 103                      | 11.2                          |
|                      | Actinomycetes                              | 23                       | 2.5                           |
|                      | Lichens                                    | 32                       | 3.4                           |
| <b>Fauna</b>         | 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                           |
| <b>Total</b>         |  | 4,011                    | 100                           |

(Source: Sahu et al., (2015), Mangrove Area Assessment in India: Implications of Loss of Mangroves. J Earth Sci Clim Change.

### III. CONSIDERATION FOR PREVENTIVE MEASURES

**1. Strategies on Mangrove Managements in India:** The current management approach for mangroves involves governmental conservation policy, community education, and sustainably using forest resources through cooperative management. ( Fig no. 7). The oldest records of forest management and conservation may be found in two documents from the British colonial administration: the National Forest Policy of 1894 and the Forest Conservation Act of 1927. Under the National Forest Policy, which the Indian government adopted in 1952, Indian woods were separated into four categories: protected forests, national forests, village forests, and tree lands. (Source: A Review of Threats and Vulnerabilities to Mangrove Habitats: With Special Emphasis on East Coast of India)



**Figure 7: Managements**

**Figure 7: Managements Strategies on mangrove in India**

Source: Chaudhuri et al.(2015).

**2. 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)

3. **Non- Legislative Management:** Numerous pieces of literature contend that many coastal populations in India, which is still growing, nevertheless rely on the mangroves' supplies for survival. It is essential to support the economic growth of those who depend on mangroves since one ecological service is typically provided at the expense of another. Mangrove maintenance is expensive since so many livelihoods rely on the provisioning services provided by this ecosystem. Community-based management is currently playing a vital role in ensuring the restoration and maintenance of this ecosystem, working alongside scientific groups and the forest department. 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)
4. **Mangrove Sacred Groves: Traditional Conservation:** India has a long-standing tradition of protecting its woods by reinforcing them with holy groves. A group of people maintains sacred groves in the forest because of their fervent religious convictions. There are several woodland areas where hunting and logging are not permitted. While some of these groves are based on tiny regional and folk religions, others are linked to sacred deities who may be worshipped by local inhabitants. However, India doesn't have many sacred mangrove groves. *Avicennia marina* is the sole species of sacred mangrove that may be found in inland mangrove ecosystems all over the world. **Source:**Tripathy N, Singh RS, Bakhori V, Dalal C, Parmar D, et al. (2013)
5. **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)

#### IV. 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
- 2. 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
- 3. 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
- 4. 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
- 5. Threats from Unsustainable Tourism:** A and N islands are significantly at risk from this Unsustainable 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
- 6. Climate Change:** 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. Suparbhangra and Lohacharra two islands in the Indian Sundarbans, have flooded as a result of sea level rise, and a dozen of additional islands are also experiencing the same issue, according to a recent observation (fig No. 8) Samyuktha et al 2018.



**Figure 8:** Mangroves 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)

7. **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. Sahu et al 2015.
8. **Reduction of Fresh Water and Tidal Water Flows:** Mangroves are well-established in a number of locations where considerable amounts of fresh water influx occur. The amount of freshwater that enters mangrove swamps is constrained by the construction of dams and barriers along upper portions of rivers. Tidal water is kept out of mangrove wetlands near the river mouth by the construction of embankments and siltation. These areas become more saline due to decreased tidal and freshwater inflow, which prevents mangrove germination, growth, and regeneration. For instance, mangroves are predominantly dying in Pichavaram, South India, due to hyper salinity and other related problems like rising temperatures, a lack of precipitation, and inefficient tidal water flushing. As fresh water imports have decreased, populations of species like *Heritiera fomes* and *Nypa fruticans* are dwindling in the Sundarbans. Sahu et al., 2015
9. **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 spp.* 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 trifoliata*, as well as other aquatic weeds *Eichhornia crassipes* and *Salvinia*, colonising mangrove water. Sahu et al., 2015

## V. 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 CO<sub>2</sub> 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.

## VI. CONCLUSION

The current chapter examines the state of mangroves in India as well as some direct and indirect advantages for the local fishing population. The threats to India's mangrove ecosystems serve as another reminder of how important coastal and marine environments are. In the framework of conservation, it is crucial to take into account the significance of environmental security, active community involvement, and reducing the risk of natural disasters. Such methods need to be employed more extensively in light of anticipatory adaptation measures, which are crucial to successful and effective management. Most studies agree that mangrove ecosystems are among the most fragile in the world. Mangrove regions are in danger of going extinct because of the continual increase in artificial stressors in coastal areas and the unpredictability of the climate. Effective governance, climate change adaptation and mitigation methods, better planning for the rehabilitation of degraded mangroves, and community awareness raising are all urgently required to conserve, protect, and restore the unique mangrove wetland ecosystems. Research, management, public education, and rehabilitation of mangrove forests are urgently needed; however, it is critical that scientists provide a fair assessment of mangrove loss that takes these global challenges into consideration when evaluating the true state of the world's mangroves.

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