Roots of Sustainable Resistance:

Fighting Plastic in Mangrove Habitats

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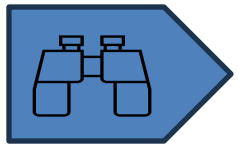
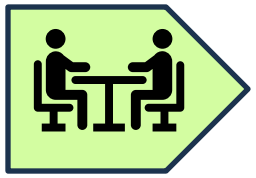


Learning Objectives

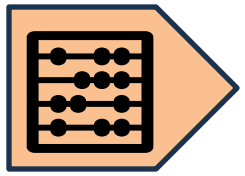
Module 1: Introduction to Mangrove

- Definition and features of mangroves
- Distributions and types of mangroves
- Salt Exclusion Mechanism



Module 2 - Role of Mangrove Plants

- Ecological Importance
- Challenges in the Indian context
- Major threats



Module 3 – Plastic Pollution

- Understanding plastic pollution
- Types of Plastic Pollution
- Ways plastic reaches the mangrove ecosystems

Module 4: Impact of Plastic on Mangroves

- Block roots and prevents growth
- Harm to Wildlife
- Chemical Pollution
- Reduced Growth and Health of Mangroves
- Disruption of Ecosystem Services
- Aesthetic and Cultural Impact

Module 5 – Initiatives to Protect Mangrove in India

- Government Policies and Rules
- National and State Initiatives
- Community and NGO efforts
- Role of Citizen

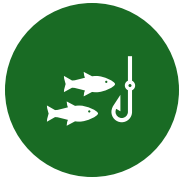
Module 6 - Action Plans

- Sundarbans Plastic Control Efforts (West Bengal)
- Mangrove Foundation – Maharashtra
- Gujarat Coastal Village Campaigns
- Goa - Plastic Pollution in Mangroves
- Andaman & Nicobar Islands Eco-Sensitive Zones
- Lakshadweep & Coastal Union Territories

References and Self-Assessment

Key learning objectives of the module

To emphasize the connection between mangroves and climate change mitigation, as well as the detrimental impact of plastic pollution on that function.



To motivate learners to recognize sources of plastic garbage impacting mangrove ecosystems (E.G. Fishing equipment, packaging materials, tourist activities).

To elucidate the ideas of bioaccumulation and microplastics in mangrove ecosystems.

To advocate for community-driven initiatives, including eco-clubs, clean-up campaigns, and localized waste management strategies.

To cultivate critical thinking on policy, conservation measures, and the dynamics of individual vs communal action.

To educate learners on the sustainable value of mangroves for biodiversity and coastal protection.

To link mangrove protection with sustainable development goals (sdgs) such as life below water, climate action, and responsible consumption
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Module 1: Introduction to Mangrove

- Definition and features of mangroves
- Distributions and types of mangroves
- Salt Exclusion Mechanism

About Mangroves:

Mangroves are extraordinary trees and shrubs that flourish in saline, coastal ecosystems where most flora would find it challenging to endure. They consist of approximately 80 species from several plant families that have evolved similar characteristics through convergent evolution.

Mangrove Habitat Distribution

- Found in 118 countries, covering 137,600 km^2.
- Primarily in tropical/subtropical coastal environments.
- Especially in intertidal zones.

*Real-time Pics @Raghab Ray

According to the India State of Forest Report 2023, Mangrove Cover in India

- Total Mangrove cover: 4,991.68 km^2, 0.15% of total geographical area.
- Very Dense Mangrove: 1,463.97 km^2, 29.33% of total.
- Moderately Dense Mangrove: 1,500.84 km^2, 30.07%.
- Open Mangroves: 2,026.87 km^2, 40.60%.

In comparison to the 2021 assessment,

- Net decrease: 7.43 km^2 in 2021, Gujarat: 36.39 km^2.
- Significant increase: 13.01 km^2, Andhra Pradesh followed by Maharashtra 12.39 km^2.

Key features and adaptations:

- **Salt-tolerant**: Salt-filtering roots and leaves survive in brackish or hypersaline water.
- **Breathing roots**: Pneumatophores and stilt roots help oxygen-deprived soils absorb air.
- **Vivipary**: Their seeds germinate while connected to the parent tree, giving some advantages in harsh situations.
- **Microbial Interactions:** Mangroves provide a diverse habitat for marine and terrestrial creatures, including fish, crabs, mollusks, birds, and mammals.
- **Osmotic balance:** Compatible solutes and ions help mangroves maintain water balance.
- **Response to Environmental Stress:** Mangroves can adapt to fluctuating salinity and water levels, enabling them to withstand tidal cycles.

Types of Mangrove Species in India

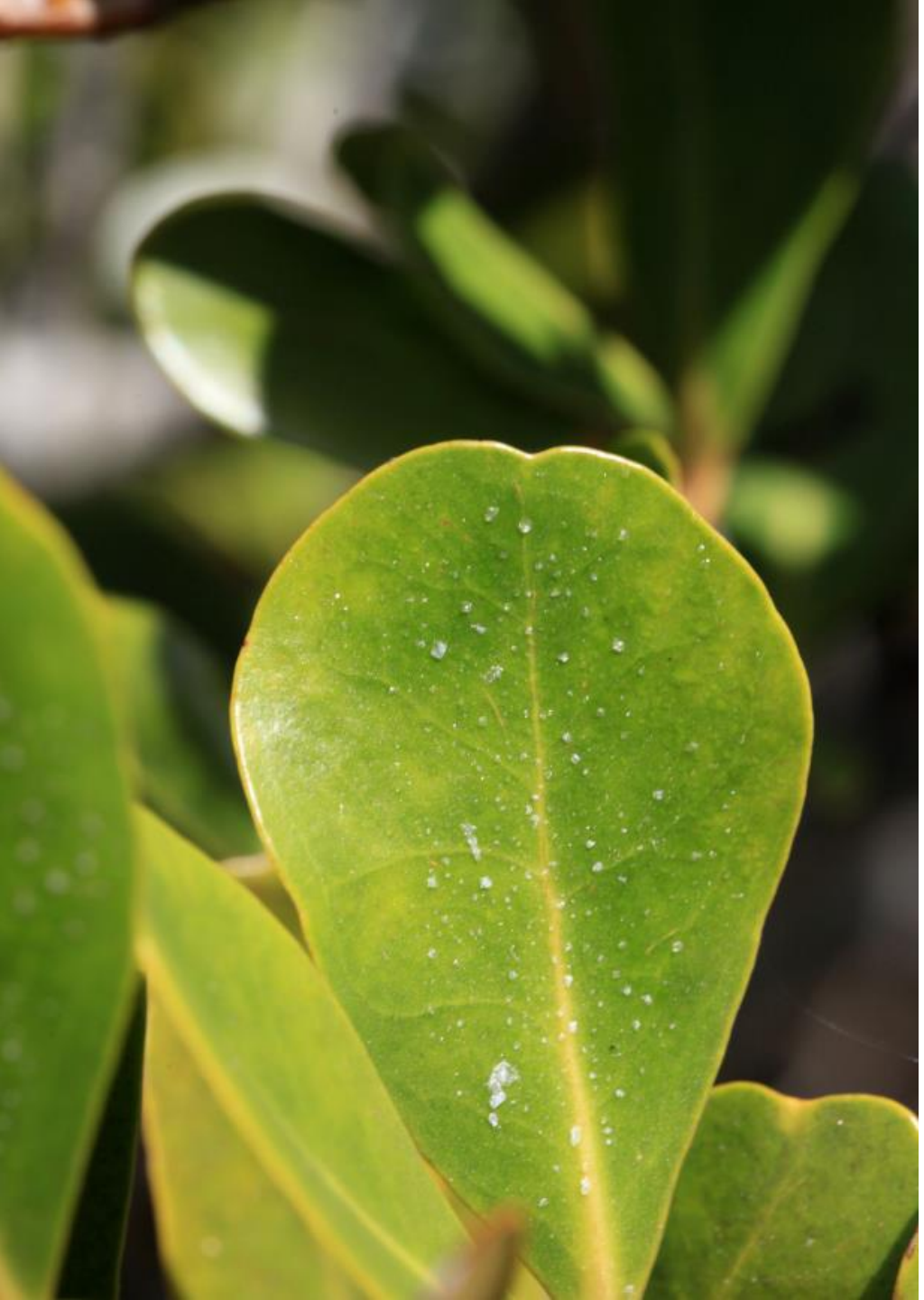
There are around 46 distinct species of mangroves in India. Several prevalent categories include

Mangrove Species	Common Name	Key Features
Rhizophora mucronata	Red Mangrove	Strong wood, stilt roots, and water-friendly growth
Avicennia marina	Black Mangrove	Salt-excretion leaves and pencil-like breathing roots
Bruguiera gymnorhiza	Large-Leaf Mangrove	Knee roots, often located inland
Sonneratia alba	Mangrove Apple	Round, large fruits and prop roots
Ceriops tagal	Spurred Mangrove	Knee roots, located in transitional areas

Where Are Mangroves Found in India?

In India, mangroves grow along the coast where rivers and estuaries meet the sea. Important mangrove areas:

- **Sundarbans (West Bengal)** – The largest mangrove forest in India and the world.
- **Gujarat** — Along the Gulfs of Kutch and Khambhat.
- **Maharashtra -** Thane Creek, and places along the coast of Mumbai.
- **Goa -** Near Mandovi and Zuari River estuaries.
- **Kerala** – In backwaters like Ashtamudi and Vembanad Lakes.
- **Andhra Pradesh and Odisha -** Eastern coast near river deltas.
- **Tamil Nadu -** Pichavaram mangroves near Chidambaram.
- **Andaman and Nicobar Islands** – Extensive mangrove forests throughout.



Salt Exclusion Mechanism

- Mangroves have evolved their root morphology to exclude salt through filtration.
- Root membrane only allows water molecules to pass through while preventing salt (sodium chloride) to penetrate .
- Mangroves can exclude up to 95% of salt they absorb from seawater with a special filter in root.
- Additional salt that passes through the membrane are excreted via salt glands in leaves.
- These salts in crystal forms are visible on leaf surface.
- Some salts are lost by transpiration from the leaf surface.

Module 2 - Role of Mangrove Plants

- Ecological Importance
- Challenges in the Indian context
- Major threats

Ecological Importance of Mangroves

Mangroves play a vital role in maintaining the health of coastal ecosystems. Here are the key ecological benefits they provide:

- **1. Coastal Protection**
- Mangrove roots stabilize soil and prevent coastal erosion.
- Natural hurricane, cyclone, and tidal wave blockers.
- Reduce severe weather harm to surrounding towns

- **2. Habitat for Wildlife**
- Provide shelter, food, and breeding grounds for a diverse range of **marine and terrestrial animals**:
  - Fish, crabs, shrimps, oysters
  - Birds like herons, egrets, kingfishers
  - Even large animals like the **Bengal tiger** in the Sundarbans
- Operate as nurseries for commercially significant fish species.

3. Carbon Sequestration

- Mangrove roots and soil absorb airborne carbon dioxide.
- They hold 4–5 times more carbon than terrestrial forests.
- Reduce greenhouse gases to combat climate change.

4. Water Purification

- Mangroves filter pollutants and sediments from rivers and runoff before reaching the sea.
- Water quality improves as coral reefs and seagrass meadows thrive.

5. Support for Fisheries and Livelihoods

- Mangroves provide fishing, crabbing, honey, and timber to coastal populations.
- Mangroves boost local economy and food security.

6. Biodiversity Hotspots

- Many plant and animal species are found only in mangroves promotes rich biodiversity.
- They are among Earth's most productive ecosystems

7. Natural Flood Control

- Mangrove forests reduce floods and high tides.
- Support groundwater recharge and agricultural saltwater management.

8. Cultural and Educational Value

- Mangroves are considered culturally important and sacred for many communities.
- Sustainable tourism and environmental education utilize mangroves.

Challenges in Indian context

- **Government fragmentation**: Forest, environment, and fishing agencies overlap, causing weak enforcement.
- **Limited Community Involvement:** Some locations exclude locals, diminishing efficacy.
- **Information Gaps:** Lack of real-time mapping and monitoring limits restoration planning and implementation.
- **Restoration Failures:** Replanting fails due to species selection and hydrological neglect.
- **Insufficient Funding:** Many state mangrove conservation efforts lack funds and expertise.
- **Climate vulnerability mapping:** India has no mangrove ecosystem vulnerability index for future climates.
- **Lack of awareness:** Many coastal dwellers, especially urbanites, are ignorant of mangroves' long-term ecological benefits.
- **Conflicts with Development:** Politics and economics may prioritize infrastructure (ports, roads, SEZs) above the environment.
- **Cyclone Damage**: Frequent cyclones (e.g., Amphan, Yaas) uproot trees and alter tidal patterns, affecting regeneration.

Major Threats

Infrastructure & Development Pressures: Construction of the Mumbai Trans Harbour Link and Navi Mumbai Airport has cleared mangroves.

Pollution: Mangroves in Gujarat and West Bengal are threatened by industrial effluents and plastic garbage.

Oil Spills: Risk of oil contamination choking mangrove roots and marine life.

Urban Expansion: Mumbai's mangroves are threatened by slums, traffic, and real estate developments.

Aquaculture & Shrimp Farming: Mangroves have been cleared for shrimp farms in Andhra Pradesh and Tamil Nadu.

Climate Change: Rising sea levels and salinity affect 4.5 million people of the Sundarbans.

Illegal Logging: Odisha and West Bengal slash mangroves for fuelwood and building.

Mining activities : Mangroves are threatened by illegal sand mining in rivers and coastal areas

Module 3 – Plastic Pollution

- Understanding plastic pollution
- Types of Plastic Pollution
- Ways plastic reaches the mangrove ecosystems

Plastic Pollution

- The term “plastic pollution” refers to the existence of plastic debris in the air, water, or soil.

- Plastics are created from non-biodegradable compounds and endure hundreds of years.

- Mangroves and other coastal ecosystems are particularly vulnerable to the accumulation of plastic trash, which threatens wildlife and ecosystems when not properly disposed of.

Type	Examples
Single-use plastics	Plastic bags, straws, wrappers, cups, cutlery
Plastic bottles	Water and soft drink bottles
Fishing gear	Fishing nets, ropes, lines left in the ocean
Packaging material	Plastic film, bubble wrap, food containers
Microplastics	Tiny plastic particles from broken items or clothes (e.g. synthetic fibers)
Macroplastics	Large plastic items like bags, fishing nets.

Ways plastic reaches the mangrove ecosystems

From Rivers and Drainage system:

- Plastic from rivers and land enters the sea.
- Plastic may enter mangrove habitats from river shores.

From Coastal Towns and Cities:

- Garbage near beaches and coasts pollutes mangroves.
- Littering, waste management, and recycling are major causes.

From Fishing Activities:

- Lost fishing nets, ropes, and plastic containers pollute water.
- These can get stuck in mangrove roots or float into the forest during high tide.

Tides and Ocean Currents

- Tides carry plastic rubbish toward the shore.
- Beach-area tides transport garbage into mangrove ecosystems.

Tourism and Recreational Activities

- Tourists leave plastic bottles, bags, and packaging on beaches and waterways.
- Without treatment, contaminants may enter mangroves.

Module 4: Impact of Plastic on Mangroves

- Block roots and prevents growth
- Harm to Wildlife
- Chemical Pollution
- Reduced Growth and Health of Mangroves
- Disruption of Ecosystem Services
- Aesthetic and Cultural Impact

Dead Mangroves sitting on litters

*Real time Pics @Raghab Ray

(A) Block Roots and Prevents Growth

- Weighing down branches and roots with plastic may damage young or weak plants.
- Floating plastic disrupts normal development patterns by entangling roots.
- Heat from plastic piles may dry up mangrove soil and damage vegetation.
- Plastic accumulation lowers soil oxygen, impacting root respiration.

(B) Harm to Wildlife

- Birds and animals live in mangroves may get entangled or drown in plastic rings, nets, and straps.
- Plastic may hinder digestion, causing internal injury or death.
- Animals eating plastic may contaminate larger species and seafood eaters.
- Sharp plastic may infect and harm turtles and fish.

(C) Chemical Pollution

- BPA, phthalates, and flame retardants in plastics harm mangrove plants and marine life
- Heavy metals and pesticides released by plastic decomposition may affect the mangrove ecosystem.
- Chemicals may affect plant and animal reproduction and growth.
- Mangroves bioaccumulate and biomagnify environmental pollutants into the food chain

(D) Reduced Growth and Health of Mangroves

- Pollution makes mangrove plants more susceptible to pests and diseases.
- Plastic-littered soil may damage seedlings and slow regrowth.
- Poor mangrove health reduces carbon storage, causing climate change.
- Low mangrove cover affects bird and habitat-dependent species shade and cooling.

(E) Disruption of Ecosystem Services

- Waste affects mangroves, which filter water, support fisheries, and store carbon.
- Mangrove loss reduces fish and crab, affecting coastal populations.
- Loss of mangroves causes more frequent and severe coastal floods.
- Mangrove root damage reduces soil retention.
- Carbon emissions from plastic-polluted mangroves contribute to global warming.

(F) Aesthetic and Cultural Impact

- Plastic pollution undermines mangrove beauty.
- Polluted mangroves impede tourism, eco-tourism, and recreational activities.
- Mangrove-related traditions may experience identity loss.
- Pollution disturbs spiritual harmony.
- Pollution damages cultural treasures and practices.
- Plastic-filled environments restrict learning opportunities on conservation and biodiversity.

Module 5 – Initiatives to Protect Mangrove in India

- Government Policies and Rules
- National and State Initiatives
- Community and NGO efforts
- Role of Citizen

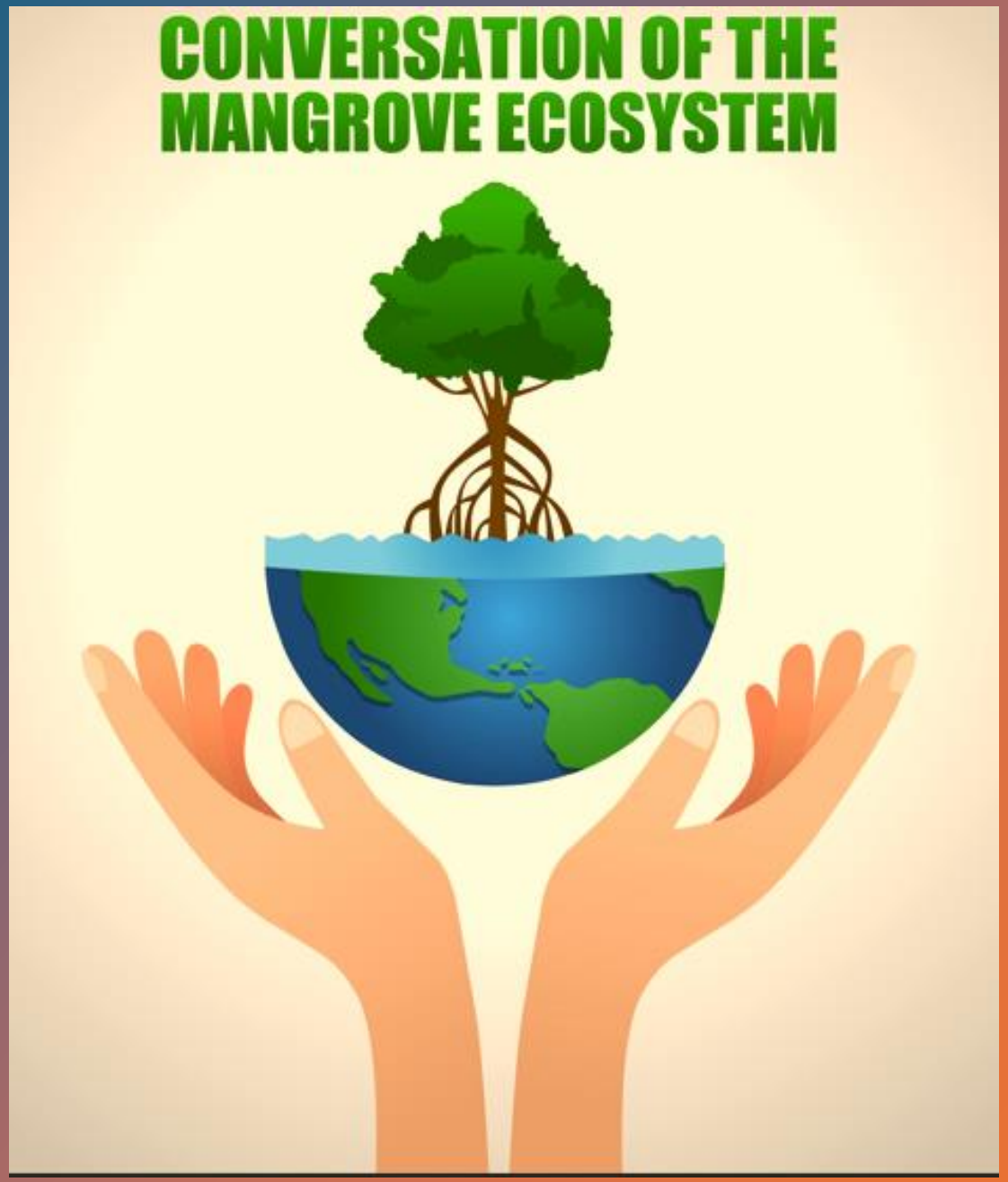
(A) Government Policies and Laws

1. Plastic Waste Management Rules (2016 & Amendments)

The Ministry of Environment, Forest, and Climate Change (MoEFCC) established these guidelines.

Key points:

- Ban certain single-use plastic items like straws, plates, and utensils.
- Plastic producers must recycle and collect under Extended Producer Responsibility (EPR).
- Urban municipalities must sort and dispose of plastic waste.



2. State-Level Plastic Bans

- Goa and other coastal states have decreased plastic near eco-sensitive areas like mangroves.
- Gujarat, Maharashtra, and West Bengal have mangrove conservation laws.

  Example: Maharashtra Mangrove Cell safeguards Mumbai and adjacent mangrove habitats.

3. Coastal Regulation Zone (CRZ) Rules

- These regulations safeguard coastal areas, especially mangroves, from harm.
- They restrict building and garbage disposal near mangrove zones.

(B) National and State initiatives

1. National Coastal Mission (NCM)

- Focuses on conserving coastal ecosystems, including mangroves.
- Promotes community participation in mangrove protection.
- Focuses on disaster risk reduction and climate resilience

2. Swachh Bharat Abhiyan

Launched in 2014 by the Ministry of Housing and Urban Affairs / the Ministry of Jal Shakti

- Minimizes plastic and waste dumping, a serious danger to mangrove health.
- Encourages coastal cleanliness in mangrove-rich regions like Mumbai, Goa, Kerala, and Tamil Nadu.
- Promotes eco-awareness among locals, visitors, and industries near mangroves.

3. Namami Gange

Launched in 2014 by the Ministry of Jal Shakti

- In West Bengal's lower Ganga delta, cleaner river water promotes healthier mangrove habitats.
- Mangrove-compatible tree species may be used in brackish and estuary afforestation.
- Reduced solid and liquid trash in rivers, reducing plastic and chemical burden in mangroves.

4. Mangrove Plantation Programs

Launched in 2010, supported by the World Bank and MoEFCC. Focused on Gujarat, Odisha, and West Bengal

- Focused on restoring degraded mangrove areas and planting new mangrove saplings.
- Supports climate-resilient mangrove plantations in vulnerable coastal areas
- Focus on restoring cyclone-damaged mangrove areas

(C) Community Actions and NGO Efforts

1. Community Participation

- Local organizations, school volunteers, and fishermen plant and clean mangroves in cities like Mumbai, Goa, and Chennai.
- Schools and colleges' Eco-Clubs provide waste segregation, tree planting, and mangrove tours.
- Some communities maintain mangrove forests sustainably using traditional methods.

Example: Sundarbans villagers self-restrict mangrove tree cutting.

2. NGOs' efforts

- WWF India, Mangrove Foundation (Maharashtra), and TERI educate, clean, and conserve mangroves.
- Some track and share plastic waste solutions via apps or social media.
- NGOs use seminars, street plays, rallies, and social media to talk about plastic pollution and mangroves.

(D) Role of Citizens

- Avoid single-use plastics and opt for alternatives like cloth bags or metal bottles.
- Support or participate in mangrove cleanups.
- Segregate and recycle garbage at home.
- Raise awareness of mangrove protection, particularly in coastal regions.

Module 6 - Action Plans

- Sundarbans Plastic Control Efforts (West Bengal)
- Mangrove Foundation – Maharashtra
- Gujarat Coastal Village Campaigns
- Goa - Plastic Pollution in Mangroves
- Andaman & Nicobar Islands Eco-Sensitive Zones
- Lakshadweep & Coastal Union Territories

Sundarbans Plastic Control Efforts (West Bengal)

- NGOs like WWF-India and the West Bengal Forest Department conduct village and riverside clean-ups.
- Awareness initiatives educate communities and schools about plastic's impact on mangroves.
- Some villages utilize plastic-free packaging and cloth bags for fishing and markets

Mangrove Foundation – Maharashtra

- Helps remove plastic from mangrove wetlands in Mumbai suburbs (Vasai, Navi Mumbai).
- Encourages community-based eco-tourism for employment creation and awareness.
- Trains fisherfolk and women's groups to sustain biodiversity and manage plastic trash.

*Real-time Pics @Raghab Ray

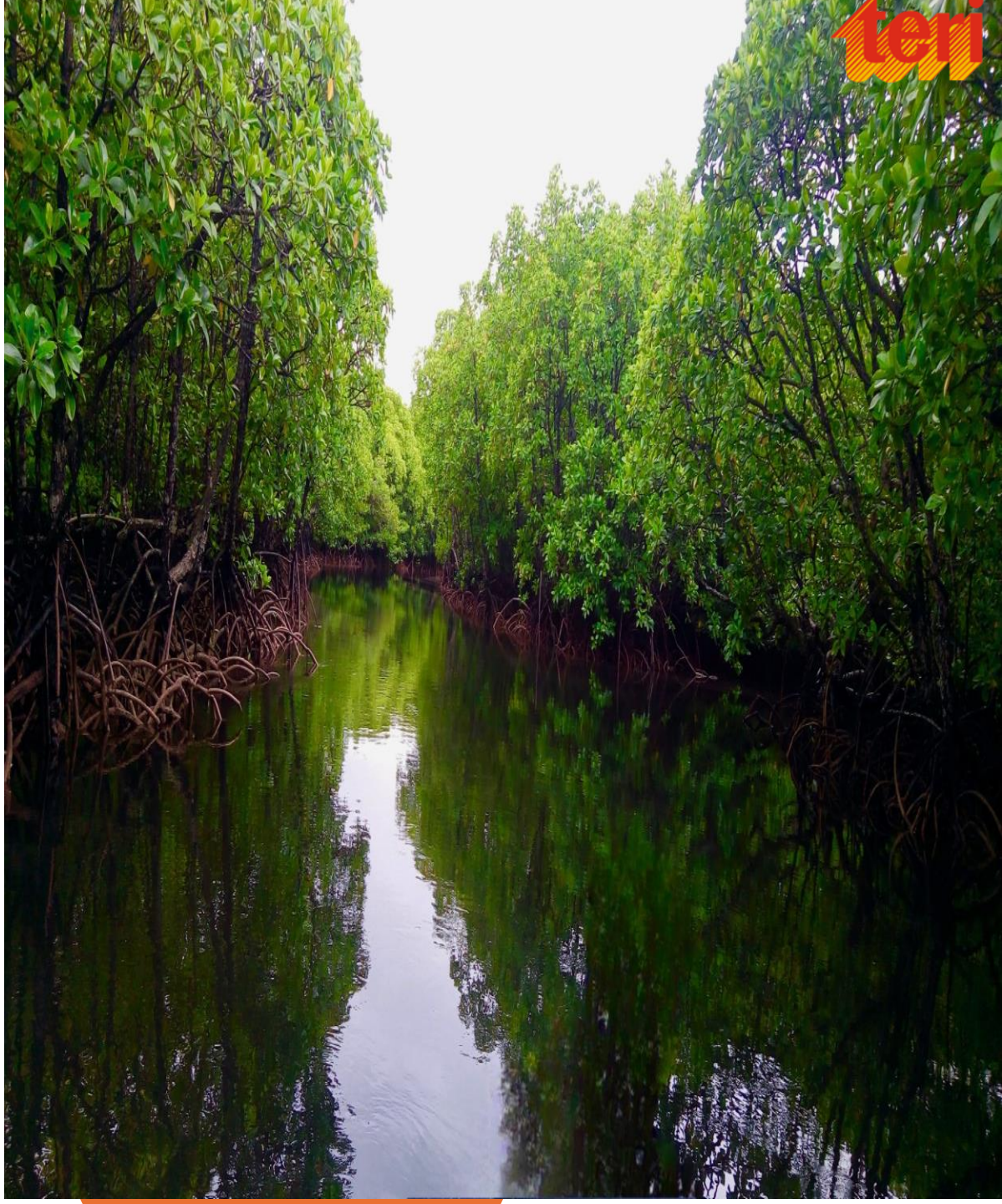
Gujarat Coastal Village Campaigns

- State-led mangrove conservation in communities around Gulf of Kutch and Khambhat.
- Marine National Park and NGOs organize awareness walks and plastic cleanups.
- Incentives for fishermen cooperatives to adopt biodegradable nets.

Plastic Pollution in Mangroves — Goa

- Goa was one of the first Indian states to ban single-use plastic.
- The Goa Forest Department restores Bardez and Tiswadi mangroves.
- Mangrove seedlings are planted for restoration.
- Goa Foundation and SAND clean beaches and mangroves.

***Real-time Pics @Raghab Ray**



Andaman & Nicobar Islands Eco-Sensitive Zones

- Plastic prohibitions in mangrove-rich areas like Havelock and Neil.
- Tour operators and hotels are urged to use eco-friendly materials and attend cleanups.
- Schoolchildren engage in coastal conservation efforts.

Lakshadweep & Coastal Union Territories

- Coastal regulations restrict plastic use during the tourism season to protect sensitive marine habitats and mangroves.
- Training for resort staff and boat operators on waste segregation and reef-safe practices.
- Beach-mangrove cleanup events are organized monthly by student and fisher groups

*Real-time Pics @Raghab Ray

SAVE OUR MANGROVES

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