International
Mangrove
Center

REPORT OF THE THIRD INTERNATIONAL MANGROVE CENTER WORKSHOP ON MANGROVE CONSERVATION AND RESTORATION (2025)

3–15 November 2025

Co-organized by

International Mangrove Center, Guangdong Neilingding Futian National Nature Reserve Administration Bureau, and the National Academy of Forestry and Grassland Administration

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1. Introduction

The International Mangrove Center (IMC) is an independent non-profit intergovernmental organization under the Ramsar Convention and one of the Ramsar Regional Initiatives (RRIs), having the mission to promote cooperation in mangrove conservation, restoration, and wise and sustainable use; to strengthen implementation of global biodiversity and climate commitments; and to serve as a hub for knowledge sharing, and technology transfer. The IMC is playing important roles in coordinating international efforts in conservation, restoration, research, technical support, capacity building, shared policy frameworks, and public awareness.

As a part of the IMC's framework, the Third IMC Workshop on Mangrove Conservation and Restoration 2025 was successfully organized from 3 to 15 November 2025 in Guangdong, Fujian, Zhejiang provinces, the People's Republic of China, hosted by the IMC and co-organized by the Guangdong Neilingding Futian National Nature Reserve Administration Bureau and the National Academy of Forestry and Grassland Administration (NAFGA). These intensive two-week workshops brought together government officials, technical experts, researchers, and practitioners from 14 countries, fostering cross-regional dialogue, technical exchange, and collaborative problem-solving.

The workshop featured in-depth lectures by leading international experts, field demonstrations of innovative restoration techniques, and hands-on training sessions in mangrove planting, monitoring, and management. Participants were also introduced to cutting-edge scientific tools, such as remote sensing for mangrove mapping, blue carbon and climate response, mangrove wetland migratory bird monitoring, and protection. Beyond technical knowledge, the workshop emphasized the importance of policy integration, international cooperation, and public awareness to ensure sustainable outcomes.

Importantly, the workshop created a dynamic platform for networking and partnership building, enabling participants to share best practices, exchange cultural perspectives, and develop joint initiatives tailored to their national and regional contexts. By combining academic rigor with practical field experience, the program not only enhanced participants' professional skills but also inspired a renewed commitment to advancing mangrove and adjacent wetlands conservation and restoration under the IMC's global mission.

1.1. Objectives

- Enhance knowledge and technical capacity by providing in-depth scientific and practical knowledge on mangrove conservation, restoration, blue carbon, and climate change response through expert lectures, field visits, and on-site training.
- Promote international cooperation and experience sharing; fostering dialogue and exchange of best practices among government officials, researchers, and practitioners.

1.2. Methodology

The workshop adopted a participatory approach, including:

- Expert lectures by leading international specialists.
- Case study discussions to share challenges and solutions.
- Field based training including to field visits to various mangrove and wetland sites in Guangdong, Fujian and Zhejiang provinces.
- Group discussions and cultural exchanges to strengthen collaboration and mutual understanding.

The workshop was implemented in accordance with the agenda program provided in **Annex 1**.

1.3. Target Participants

The workshop enrolled 22 participants from 14 countries such as Burkina Faso, China, Comoros, Cuba, Gabon, Guinea, Lao PDR, Lesotho, Liberia, Madagascar, Mozambique, Samoa, Sierra Leone, and Zimbabwe. These countries are rich in wetlands and mangrove resources. The participants were mid-to senior-level government officials, and technical experts from wetland conservation, forestry, and natural resource departments, with strong professional backgrounds and extensive experience. The full list of workshop participants is provided in **Annex 2**.

2. Results of the Workshop

2.1. Opening Session

At the opening ceremony, **Mr. Peng Peng**, Director of the IMC Interim Secretariat, delivering his remarks on behalf of Prof. Bao Daming, Director General of the IMC Interim Secretariat, emphasized the irreplaceable role of mangroves in coastal protection, biodiversity conservation, and climate change mitigation. He highlighted the International Mangrove Center's critical role as a global platform for knowledge exchange, technical cooperation, capacity building, and policy dialogue on mangrove conservation and sustainable management. Director Peng expressed his strong belief that, through this workshop, participants would gain new knowledge and insights into mangrove conservation and restoration. He noted that the program includes technical lectures and field visits to various mangrove and wetland sites in Guangdong, Fujian, and Zhejiang provinces, providing in-depth learning on China's experiences and fostering global cooperation in protecting the "blue-green lungs" of the planet. He further expressed hope that the workshop would serve as an important platform for sharing best practices and strengthening dialogue and cooperation, thereby advancing the conservation, restoration, and sustainable management of mangroves.

Figure 1: Mr. Peng Peng, Director of the IMC Interim Secretariat, delivering his remarks

Mr. Wu Xiaoping, Deputy Director of the Shenzhen Municipal Planning and Natural Resources Bureau, highlighted Shenzhen has consistently adhered to green principles, integrating ecological civilization into its overall development strategy, becoming the first in China to establish the Gross Ecosystem Product (GEP) framework. He added that Shenzhen has developed a sound and scientific framework for mangrove and wetland management and has created an international platform for knowledge sharing and cooperation. Mr. Wu reaffirmed Shenzhen's commitment to supporting the IMC's growth and strengthening its role as a global hub for mangrove conservation and cooperation.

Figure 2: Mr. Wu Xiaoping, Deputy Director of the Shenzhen Municipal Planning and Natural Resources Bureau, delivering his remarks

2.2. Technical Session

The workshop curriculum covered 13 thematic lectures that addressed policy frameworks, scientific principles, and practical experiences in mangrove and wetland conservation, restoration, and sustainable management. The sessions also highlighted emerging issues such as blue carbon and climate change mitigation, complemented by an introduction to China's national and cultural context.

2.2.1. Overview of the International Mangrove Center

The Director of the IMC Interim Secretariat, **Mr. Peng Peng**, presented an overview of the International Mangrove Center (IMC), highlighting the establishment and core mission of the IMC. The IMC was established in Shenzhen as the world's first independent, non-profit, and inter-governmental organization dedicated to mangrove conservation. It operates as an ecosystem-based Regional Initiative of the Ramsar Convention to support Contracting Parties. Following the adoption of the regional initiative proposal at the 62nd Ramsar Standing Committee Meeting in September 2023, the official Establishment Agreement was formally signed by 18 founding member states on November 6, 2024.

The IMC's mission focuses on driving international cooperation, joint actions, and the sustainable use of mangroves while supporting global environmental commitments such as the Paris Agreement and the 2030 Agenda for Sustainable Development. Its governance structure consists of the Council as the primary decision-making body, a Scientific and Technical Subgroup for advisory support, and the Secretariat located in Shenzhen for daily operations. Currently, the IMC has 20 Member States spanning Africa, Asia and Oceania, and Central and South America. To achieve its goals, the Center prioritizes capacity building, knowledge sharing, technology transfer, and the execution of pilot projects.

Recent operational milestones for the IMC include advancing capacity-building initiatives through international training workshops on mangrove conservation and restoration. The IMC has actively participated in major global environmental dialogues, including Ramsar COP15, the 2025 World Coastal Forum, and the IUCN World Conservation Congress, while concurrently fostering technical exchanges and resource mobilization. Furthermore, foundational documents such as the Charter, Rules of Procedure, and Strategic Plan have successfully completed the opinion solicitation phase. The IMC is currently preparing for the First Council Meeting, which is scheduled to be held in Shenzhen. Full details of the presentation are provided in **Annex 3.1.**

Figure 3: Mr. Peng Peng Delivering the Overview of the IMC

2.2.2. Promoting a New Type of International Relations in Forest Sector

This lecture was delivered by **Dr. Xia Jun, Department of International Cooperation, NFGA**, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.2.**

Dr. Xia Jun outlined the evolution of China's central forest department since 1949, noting its current mandate under the Ministry of Natural Resources following the 2018 government restructuring. Dr. Xia further detailed the scope of China's natural resources, highlighting that the nation possesses 247 million hectares of forest area with a 25.09% forest cover, alongside 263 million hectares of grassland and 56.35 million hectares of wetlands. He also emphasized the country's legislative framework, prioritizing the coordinated development between high-level conservation and high-quality development for the 2026-2030 period.

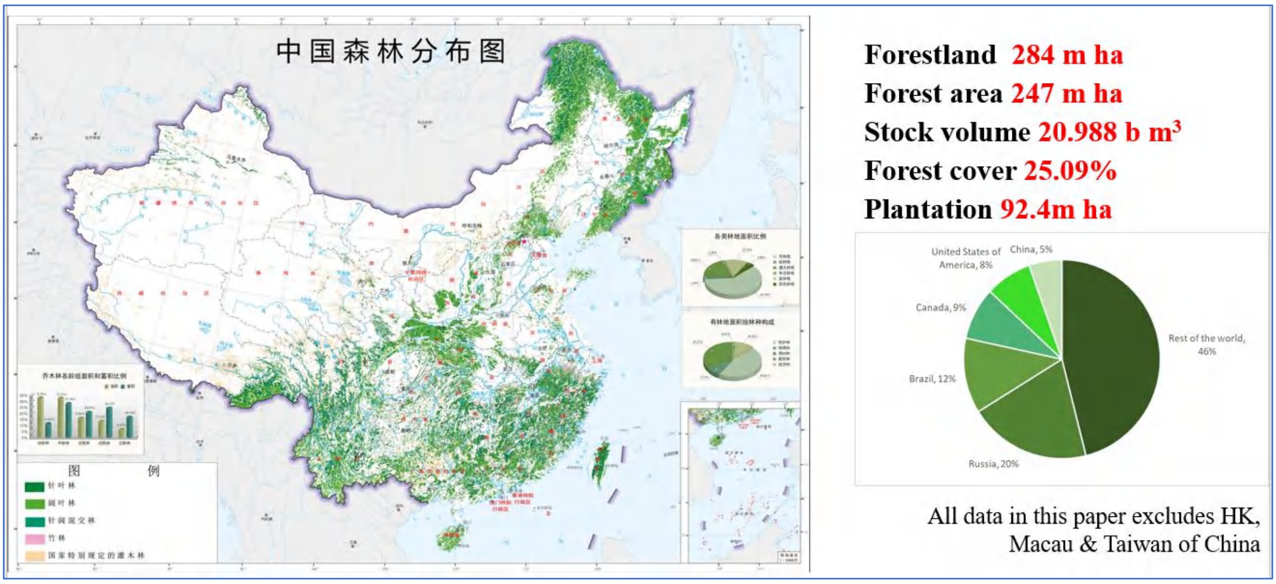


Figure 4: Forest Cover in Mainland China (excluding Hong Kong, Macau and Taiwan)

Dr. Xia further elaborated on the three phases of China’s international cooperation in the forest sector, reflecting a shift toward promoting a new type of international relations. He highlighted China’s transition from receiving multilateral assistance, such as the first European Commission project in 1981 and early World Bank funding, to becoming a provider of technical assistance and equipment to developing countries. Dr. Xia also detailed specific collaborative programs, including a long-standing Joint Working Group on Forestry with Finland, capacity-building courses for over 100 developing countries, and the establishment of international organizations headquartered in China, such as the International Network for Bamboo and Rattan (INBAR), the Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (APFNet), and the International Mangrove Center (IMC).

Dr. Xia emphasized that China’s commitment to global forest issues is demonstrated through its participation in international agreements and initiatives aimed at sustainable forest management and climate change mitigation, with the broader goal of promoting harmony between humans and nature. By implementing national programs for the protection of endangered species and promoting biodiversity, China underscores its global responsibility for forest conservation. The country also recognizes the importance of balancing economic development with ecological preservation, striving to achieve high-level conservation alongside high-quality development in its forest and grassland sectors as part of its long-term goals for sustainable environmental governance.

2.2.3. China’s Wetland Conservation and Ramsar Implementation

This lecture was delivered by **Ms. HU Xinxin, Department of Wetland Management, National Forestry and Grassland Administration (NFGA), China**, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.3.**

Ms. Hu Xinxin highlighted that the Convention on Wetlands, also known as Ramsar, was adopted in 1971 in Iran, focusing on the conservation and wise and sustainable use of wetlands. It aims to foster international cooperation among Contracting Parties, particularly concerning transboundary wetlands. As of now, there are 172 Contracting Parties to the Convention, with 2,546 designated wetlands covering a total area of approximately 257 million hectares. Over the years, the objectives of the Convention have evolved from primarily protecting waterfowl habitats to a broader focus on wetland ecosystem conservation.

She underscored that significant strides have been made in wetland conservation and management in China through policy and regulatory frameworks that align with Ramsar objectives. The document emphasizes the importance of international cooperation and strategic partnerships to enhance wetland conservation efforts. Events such as the 14th Conference of the Contracting Parties (COP14) celebrated China's 30th anniversary of accession to the Convention, highlighting the nation's commitment to sustainable wetland management.

Ms. Hu Xinxin emphasized that China's Ramsar implementation involves a strategic approach that integrates conservation practices with local and regional development, ensuring that wetland ecosystems are preserved while also meeting the needs of the communities that depend on them. This includes a robust governance structure comprising various committees and panels aimed at overseeing the implementation of wetland conservation strategies and ensuring effective communication and education regarding wetland importance.

2.2.4. The Global Wetland Outlook 2025 – Technical Notes: Valuing, Conserving, Restoring and Financing

This lecture was delivered by **Prof. ZHOU Haichao, Shenzhen University, China**, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.4**.

The lecture detailed the comprehensive calculations used to assess global wetland extent, historical loss, and degradation trends. Based on satellite data and existing spatial databases, the total estimated global wetland area is approximately 1.42 billion hectares, encompassing diverse ecosystems such as seagrasses, coral reefs, mangroves, and peatlands. However, the analysis reveals a concerning trend, with an estimated total loss of 411.5 million hectares since 1970, calculated using the Ecological Character State Index (ECSI) to quantify degradation rates across different wetland categories.

Prof. Zhou also explained the complex process of valuing wetland ecosystem services and estimating the financial scale required for conservation and restoration. The valuation methodology integrates data from the Ecosystem Services Valuation Database (ESVD) and Human Development Index (HDI) levels, utilizing the SPIQ-FS model to predict total global wetland value and the net present value of historical losses. Furthermore, the lecture highlighted the financial commitments needed to meet the Kunming-Montreal Global Biodiversity Framework (KM-GBF) targets. Meeting these targets requires restoring 30% of the lost area (123.45 million hectares) and conserving 30% of the remaining area (427.68 million hectares), though the exact costs vary significantly by wetland type.

Despite these vital calculations, Prof. Zhou acknowledged significant challenges and limitations in the current data. These include incomplete extent maps, a lack of comprehensive cost data for conservation, and regional biases, particularly a shortage of studies from low-income regions. The methodology also faces limitations in benefit transfer and the exclusion of opportunity costs. Concluding the lecture, Prof. Zhou emphasized that wetlands are critically undervalued and under protected. He issued a strong call to action for enhanced mapping, more localized valuation studies, and the integration of opportunity costs in planning, stressing that wetland conservation is an issue of global relevance.

2.2.5. Mangrove Ecological Character Maintenance

This lecture was delivered by **LYU Cai, Beijing Forestry University**, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.5**.

Wetlands, Mangroves, and Their Importance: The lecture introduced wetlands based on the Ramsar Convention definition, describing them as areas of marsh, peatland, or water, whether natural or artificial, permanent or temporary, with fresh, brackish, or salt water, including adjacent coastal and riverine systems. Wetlands were categorized into marine/coastal, inland, and artificial types, with further classification depending on hydrological and ecological characteristics. Within these systems, mangroves were highlighted as a unique type of coastal wetland with specialized adaptations to saline and tidal environments. Mangroves play a critical role in supporting ecosystem services and human well-being. They are among the most productive ecosystems, providing food, fiber, and livelihood support for coastal communities. Mangroves also store significant amounts of blue carbon, averaging about 394 tons per hectare, making them highly important for climate change mitigation. In addition, they reduce coastal flooding, stabilize shorelines, and protect infrastructure and human lives. Despite these benefits, wetlands have been declining globally, with up to 87% lost since 1700 and around 35% lost between 1970 and 2015. The main drivers of this loss include land conversion for aquaculture and agriculture, urban development, pollution, invasive species, overexploitation of resources, and climate change. These pressures continue to threaten the sustainability of mangrove ecosystems and their services.

Concept of Ecological Character (CE): The lecture emphasized the concept of ecological character is the fundamental concept that defines why a wetland is “the wetland.” It is the combination of the ecosystem’s components, process, and services at a given point in time. Critical Ecological Characters are those components or processes that are key to the site's identity. If they change beyond their natural range, they can cause significant negative consequences to the entire ecosystem. The CE concept is broken down into three interconnected pillars:

- **Ecological Components (C):** The biological (species, genetics, ecosystems), physical and chemical elements of the wetland (e.g., water, soil, mangrove trees, benthic organisms, fish).
- **Ecological Processes (P):** The dynamic functions that sustain the components, such as hydrological cycles, nutrient cycling primary production and species, migration and reproduction.
- **Ecosystem Services (S):** The benefits people receive from the wetland. These are categorized as Provisioning, Regulating, Cultural and Supporting.

Ecological Character Description (ECD): The lecture addressed ECD is used as a key tool for documenting and managing wetlands. It provides a baseline description of a wetland’s ecological condition at a specific point in time, including its critical components, processes, and services. The ECD also defines the limits of acceptable change (LAC), which help determine whether observed changes fall within natural variability or indicate degradation. By establishing this baseline, the ECD supports effective monitoring, informs management planning, and guides decision-making.

It also helps identify critical elements that must be maintained to preserve the ecological integrity of the wetland.

Process of Ecological Character Maintenance: The lecture provided a structured and practical framework for maintaining the ecological character of mangrove/wetland ecosystems, emphasizing the integration of assessment, monitoring, and adaptive management. The process begins with establishing a multi-stakeholder committee and defining monitoring objectives. It then involves determining monitoring requirements and developing indicators for ecological character, threats, and management effectiveness. Based on these indicators, monitoring actions are prepared and implemented, followed by data collection, organization, and analysis. The results are used to inform management decisions, and the monitoring plan is regularly reviewed and updated. This cyclical process ensures that changes in ecological character are continuously assessed and addressed in a timely manner.

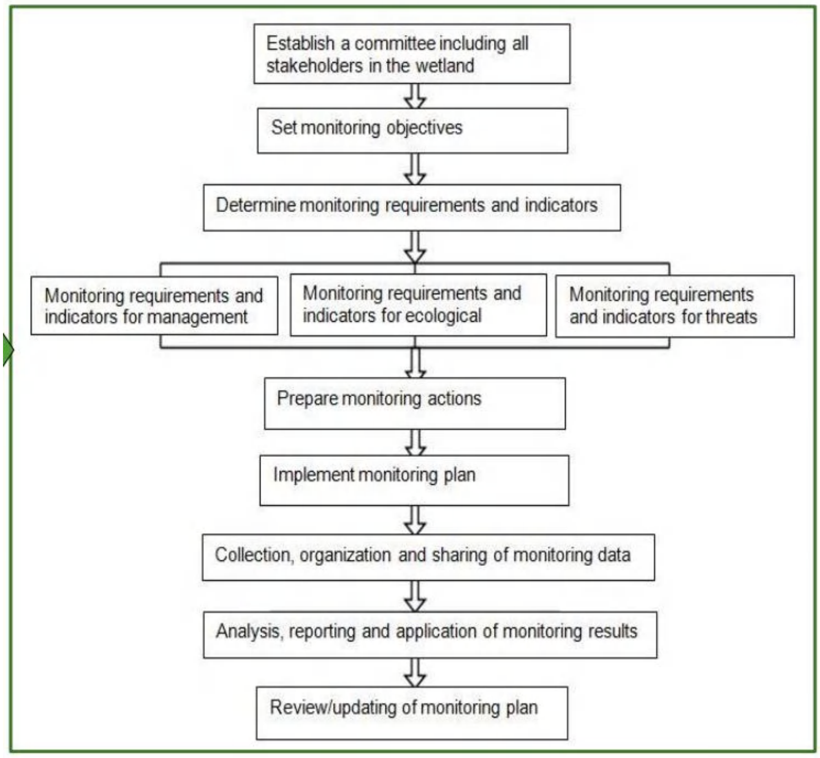


Figure 5: Monitoring Framework for Maintaining Mangrove/Wetland Ecological Character

2.2.6. Mangrove Habitat Dynamics, Connectivity, and Complexity

This lecture was delivered by **Dr. A. Aldrie Amir, Associate Professor, Institute for Environment and Development, University of Kebangsaan Malaysia**, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.6.**

The lecture began by contextualizing mangroves within the broader framework of global wetland habitats. Wetlands, including coastal systems like mangroves, salt marshes, and seagrass beds, were highlighted as critical ecosystems. Mangroves provide essential ecosystem services, including high net primary production, erosion prevention, and long-term carbon sequestration. Protecting and restoring these ecosystems through carbon offset projects can significantly reduce greenhouse gas emissions while offering multiple co-benefits, such as supporting rich biodiversity.

Habitat Dynamics and Ecosystem Processes: The lecture emphasized that mangrove ecosystems are highly dynamic and strongly influenced by tidal hydrology, which regulates sediment transport, propagule dispersal, and nutrient exchange. Mangrove root systems play a crucial role in trapping sediments and facilitating soil accretion, enabling adaptation to sea-level rise. It also highlighted natural forest dynamics, particularly canopy gap processes, where the balance between gap formation and recovery maintains ecosystem resilience; if disturbance exceeds recovery, ecosystem collapse may occur.

Ecological Connectivity: Mangroves were presented as intermediary ecosystems that link terrestrial and marine environments, connecting rivers, estuaries, mudflats, seagrass beds, and coral reefs. This connectivity supports essential ecosystem services, including functioning as nursery habitats for marine species and filtering land-based pollutants, thereby sustaining broader coastal productivity and biodiversity.

Structural and Functional Complexity: The lecture highlighted that the ecological value of mangroves is driven by their structural and functional complexity. The dense network of prop roots and pneumatophores creates a three-dimensional habitat that supports high biodiversity and enhances coastal protection by dissipating wave energy. Below ground, anoxic conditions slow decomposition and result in high carbon accumulation, reinforcing the role of mangroves as major global carbon sinks.

Threats and Disturbances: Both anthropogenic and natural disturbances were identified as key pressures on mangrove ecosystems, including coastal reclamation, aquaculture expansion, pollution, excessive sedimentation, storms, and drought. These disturbances can disrupt ecological processes, reduce resilience, and threaten long-term ecosystem stability.

Restoration and Way Forward: The lecture concluded by emphasizing that effective mangrove restoration must go beyond simple tree planting. Ecological Mangrove Restoration (EMR) prioritizes restoring natural hydrology to enable natural regeneration, while Community-Based Ecological Mangrove Restoration (CBEMR) ensures local participation, integrates traditional knowledge, and aligns ecological goals with socio-economic benefits. Supporting mechanisms such as carbon financing, policy enforcement, research, and public–private partnerships are essential. The lecture further advocated for an integrated approach that strengthens collaboration among scientists, managers, and communities, enhances technical capacity, and translates scientific knowledge into practical conservation and restoration actions.

2.2.7. Migratory Bird Flyways in Mangrove Wetlands

This lecture was delivered by **Prof. Zhou Haichao, Shenzhen University, China**, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.7**.

The lecture provided an in-depth overview of the current status of migratory birds, emphasizing their ecological importance and distribution, particularly in China. Migratory birds are defined as species that regularly move between breeding and wintering grounds, relying on specific habitats along their migration routes. China supports a significant proportion of global bird diversity, with migratory birds forming an important component, including both waterbirds and terrestrial species. Importantly, four of the world's nine major migratory flyways pass through China, highlighting the country's global significance in migratory bird conservation. Shenzhen Bay, located along the East Asian–Australasian Flyway and the West Pacific Flyway, serves as a critical wintering and stopover site. The lecture stressed that mangrove wetlands play a key role in maintaining biodiversity by providing feeding habitats, breeding grounds, and resting areas essential for migratory birds' survival.

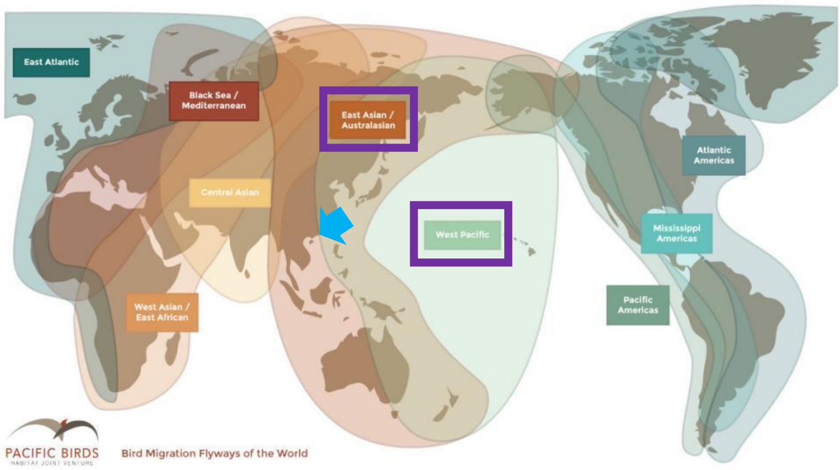


Figure 6: Major Global Flyways for Migratory Birds

Migratory Bird Monitoring and Population Trends: The lecture presented both methodological approaches and empirical data, including the global census of the Black-faced Spoonbill (Platalea minor). Standard survey techniques such as bird banding (ringing), satellite tracking, and field observation are used to collect data on migration routes, population size, and habitat use. The global synchronized census of Black-faced Spoonbills provides a clear example of how such monitoring supports conservation. According to the 2025 census, the global population reached 7,081 individuals, showing a significant recovery trend compared to historical records from 1989 to 2025 **(see Figure 7)**. The graphical data presented in the lecture illustrated a steady population increase over time, reflecting the success of long-term conservation efforts. In addition, 328 individuals were recorded in the Shenzhen Bay (Shenzhen–Hong Kong) area, confirming its importance as a key wintering site. The distribution map further demonstrated that approximately 90% of the overwintering population is concentrated in China (including Taiwan), indicating a high geographic dependence on this region. These survey results highlight the importance of consistent monitoring programs in detecting population trends, evaluating conservation effectiveness, and identifying critical habitats for protection.

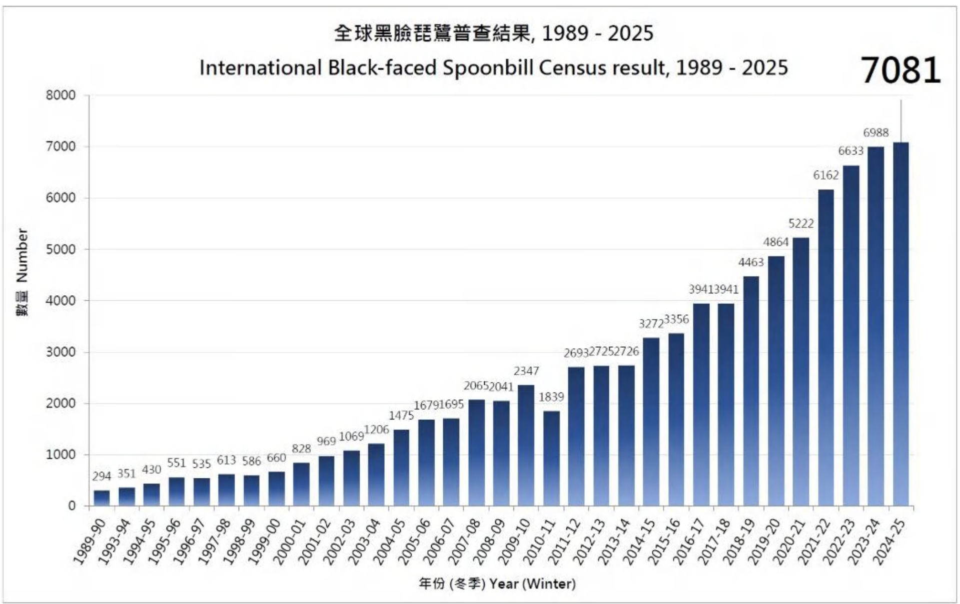


Figure 7: Global Census of the Black-faced Spoonbill 1989-2025

Avian Influenza and Disease Transmission: The lecture placed strong emphasis on avian influenza (AI) as a critical issue linked to migratory birds. Wild birds were described as natural reservoirs of avian influenza viruses and can act as "silent spreaders," often carrying the virus without obvious symptoms. Migratory birds function as cross-regional vectors, enabling the transmission of pathogens across large geographic areas and even between continents. The lecture introduced the "migratory birds–poultry–markets" transmission chain, in which wild birds introduce viruses, poultry populations amplify them, and trade systems facilitate rapid global spread. A case study from Shenzhen Bay showed that during the 2024–2025 wintering season, one out of 368 fecal samples collected from Black-faced Spoonbills tested positive for highly pathogenic avian influenza (H5N1). Genetic tracing revealed that the virus strain originated from North America and involved multiple host species, demonstrating transcontinental transmission pathways. This finding highlights that migratory birds can act as carriers and "sentinel species," signaling potential ecological and public health risks.

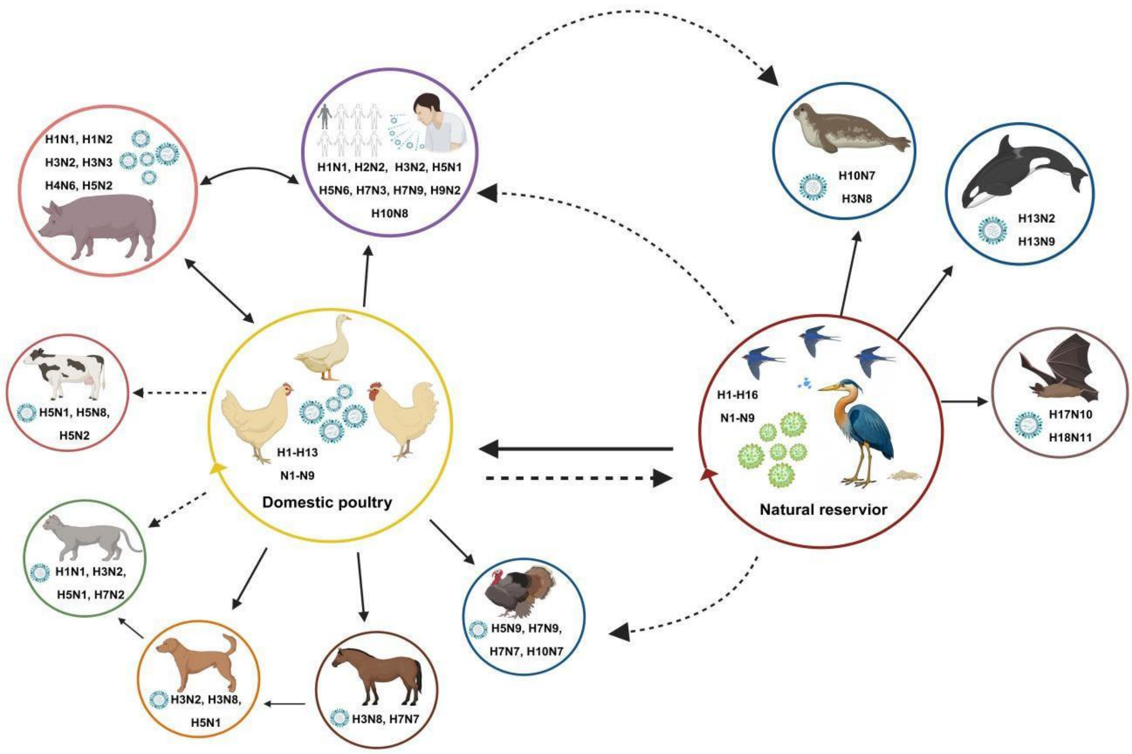


Figure 8: Chain of Avian Influenza Virus Spread

Habitat Importance and Conservation Strategies: The lecture outlined key strategies for the restoration and conservation of migratory bird habitats in mangrove wetlands. It emphasized the need for systematic conservation approaches that prioritize the protection and restoration of wetland ecosystems, particularly breeding, stopover, and wintering habitats. Stopover sites were identified as especially critical, as they allow migratory birds to replenish energy, recover immune function, and sustain long-distance migration. Recommended strategies include securing food resources, restoring degraded habitats, designating protected stopover areas, and reducing habitat degradation and pathogen spread. The establishment of ecological corridors was also highlighted as a means to connect fragmented habitats, enhance gene flow, reduce overcrowding, and lower disease transmission risks.

Monitoring Systems, Collaboration, and Way Forward: The lecture emphasized strengthening monitoring systems through bird banding stations and collaborative research programs, alongside improving public awareness through education and outreach activities. Cross-departmental collaboration and data-sharing mechanisms were identified as critical gaps in current management systems, requiring coordinated efforts among conservation, research, and public health institutions.

The lecture concluded by stressing that migratory bird conservation requires international cooperation, as ecological processes and disease risks transcend national boundaries.

2.2.8. Bird Watchers: Valuable Partners to Mangrove Managers

This lecture was delivered by **Dr. WANG Habin, China Wildlife Conservation Association**, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.8.**

Bird Watchers as Key Stakeholders in Mangrove Management: This lecture highlighted the significant role that bird watchers (birders) can play in supporting mangrove conservation and management. Birders were described as a large, well-equipped, and highly dedicated community with strong species identification skills and extensive field experience. In China alone, there are approximately one million bird watchers who are well connected through social networks and mobile applications, enabling rapid data sharing and collaboration. Their motivation, financial independence, and willingness to travel long distances make them valuable contributors to biodiversity monitoring efforts.

Mangrove Ecosystems as Ideal Sites for Bird Watching and Data Collection: The lecture emphasized that mangrove ecosystems are particularly attractive to bird watchers due to their diverse microhabitats, including mudflats, shallow waters, and aquaculture ponds, which support high bird diversity and abundance. These environments provide ideal conditions for bird observation, making mangroves important sites for both recreation and ecological data collection. Birders generate large volumes of observational data, including species presence, abundance, age structure, breeding status, and spatial distribution, which can be transformed into meaningful ecological indicators such as population trends, habitat quality, and biodiversity status.

From Bird Observation Data to Scientific Information: A key focus of the lecture was how birders' data can be systematically analyzed and applied to conservation management. Through basic statistical approaches and hypothesis testing, bird observation data can inform decision-making, such as identifying critical habitats, assessing tourism impacts, and monitoring population changes over time. The lecture provided practical examples demonstrating how comparative data between sites or conditions can guide conservation actions and improve management effectiveness.

Bird Watchers in Conservation, Outreach and Enforcement: The lecture further addressed that bird watchers also play an important role in public outreach and conservation awareness. They contribute high-quality photos and media for promotion, participate in citizen science campaigns, and help disseminate information to the broader public. Furthermore, birders can support law enforcement by reporting illegal activities such as poaching. Effective collaboration between mangrove managers and birders requires clear communication, training, logistical support, and recognition of contributions. Overall, the lecture concluded that integrating bird watchers into conservation programs can significantly enhance data collection, public engagement, and management outcomes.

Collaboration Framework between Birders and Mangrove Managers: The lecture concluded by emphasizing the importance of structured collaboration between mangrove managers and bird watchers. As outlined in the "division of labor" framework, managers are responsible for designing projects, defining methodologies, and analyzing data, while birders contribute through field observations and data collection. Successful collaboration requires clear communication, training, logistical support, and recognition of contributions. Integrating bird watchers into conservation programs can significantly enhance monitoring systems, improve public engagement, and strengthen overall management effectiveness.

2.2.9. Mangrove: Pollution, Wastewater Treatment, and Bioremediation

This lecture was delivered by **Prof. Nora F.Y. Tam, City University of Hong Kong, China**, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.9**.

The lecture provided an in-depth overview of pollution pressures on mangrove ecosystems, emphasizing both the ecological importance of mangroves and their role in wastewater treatment and bioremediation. Mangroves were described as highly valuable ecosystems that provide diverse habitats for fish, crabs, shrimps, mollusks, and migratory birds. They function as natural “green kidneys,” filtering pollutants and maintaining biodiversity in stressed coastal environments.

In terms of municipal wastewater, the lecture highlighted that sewage discharge, while often considered harmful, can provide nutrients such as nitrogen and phosphorus that enhance mangrove productivity. Constructed mangrove wetlands, such as those in Futian, Shenzhen, demonstrated strong treatment performance over a 10-year period, reducing COD, BOD, TN, NH_3-N, and TP by 50–77% depending on species. More than 70% of samples met discharge standards for COD and BOD, showing that mangroves can serve as effective nature-based solutions for wastewater treatment. The **Figure 9** shows plant height over a 27-month period under different wastewater irrigation treatments, applied in two phases: the first irrigation period included Control (no wastewater), NW (normal wastewater), 5NW (five-fold diluted wastewater), and 25NW (twenty-five-fold diluted wastewater); the recovery period had no wastewater irrigation, during which growth slowed across all treatments; and the second irrigation period included Control, NW, 25NW, and 75NW (seventy-five-fold diluted wastewater). The results showed that plants receiving municipal wastewater grew taller than the control, with the strongest growth observed under the 25NW treatment, which consistently outperformed all other treatments across both irrigation periods. During the recovery phase, growth slowed but the relative advantage of 25NW remained. When irrigation resumed, plants exposed to 25NW accelerated sharply in height, reaching close to 100 cm by the end of the experiment.

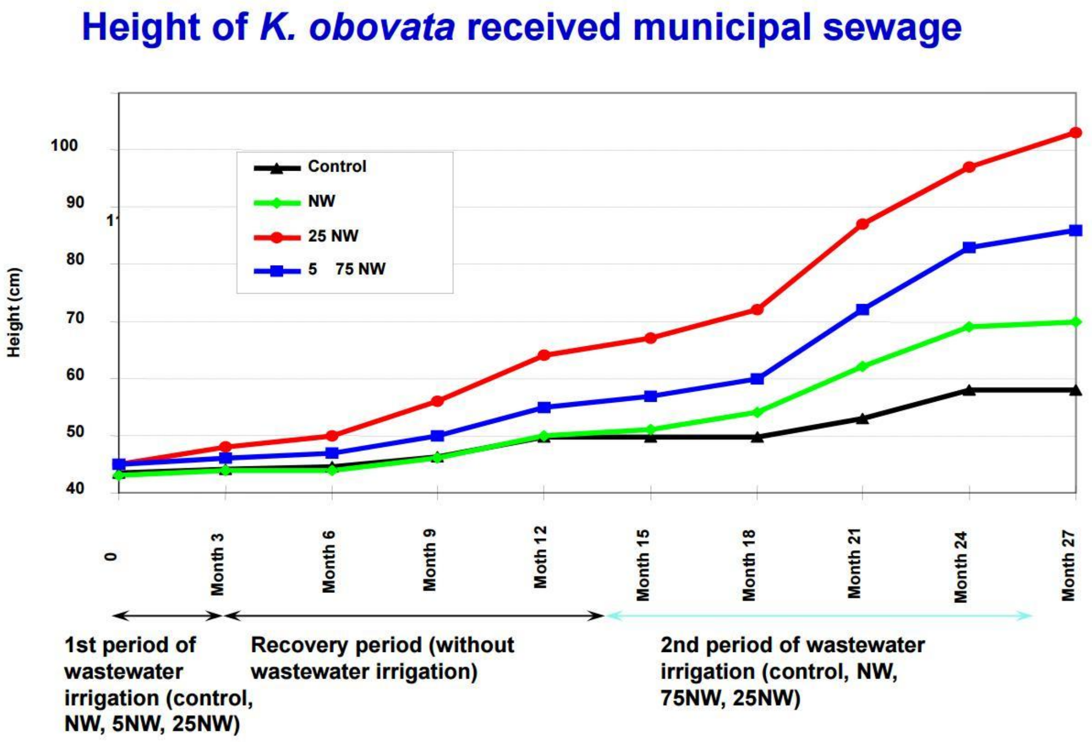


Figure 9: Height Growth of Mangrove (*Kandelia obovate*) under Different Municipal Wastewater Irrigation Treatments

Industrial wastewater was identified as a more serious challenge, introducing heavy metals and persistent organic pollutants (POPs) into mangrove soils and sediments. The lecture presented evidence that over 90% of heavy metals are retained in sediments, with only limited uptake by plants (<6%). Species-specific tolerance was observed, with *Bruguiera gymnorrhiza* and *Kandelia obovata* showing higher resilience compared to more sensitive species. Root-level exclusion and the formation of iron plaque on root surfaces were emphasized as key mechanisms that immobilize metals and reduce translocation to aerial tissues. **Figure 10** shows graphical evidence of how mangroves immobilize heavy metals through the formation of iron (Fe) plaque on their root surfaces. The scatter plots demonstrated a strong positive correlation between Fe plaque concentration and the immobilization of zinc (Zn) and manganese (Mn) in *Bruguiera gymnorrhiza*. As Fe plaque levels increased, the amount of Zn and Mn bound within the plaque also rose significantly, with regression coefficients showing high explanatory power (R^2=0.797*** for Zn and R^2=0.862*** for Mn). Data points from different treatments—freshwater (FW), five-fold diluted municipal wastewater (5MW), and ten-fold diluted municipal wastewater (10MW)—all followed this trend, confirming that Fe plaque consistently acts as a barrier regardless of wastewater concentration. This visual evidence reinforces the lecture's conclusion that iron plaque formation is a critical mechanism for mangrove resilience under industrial wastewater stress. By binding metals such as Zn and Mn (and similarly Cr, Ni, Pb, Cu, and Cd), Fe plaque reduces their mobility and prevents translocation into aerial tissues. This mechanism explains why mangrove species like *Bruguiera gymnorrhiza* and *Kandelia obovata* exhibit higher tolerance to heavy metal contamination: their roots effectively trap pollutants at the soil interface, safeguarding photosynthetic tissues and maintaining growth.

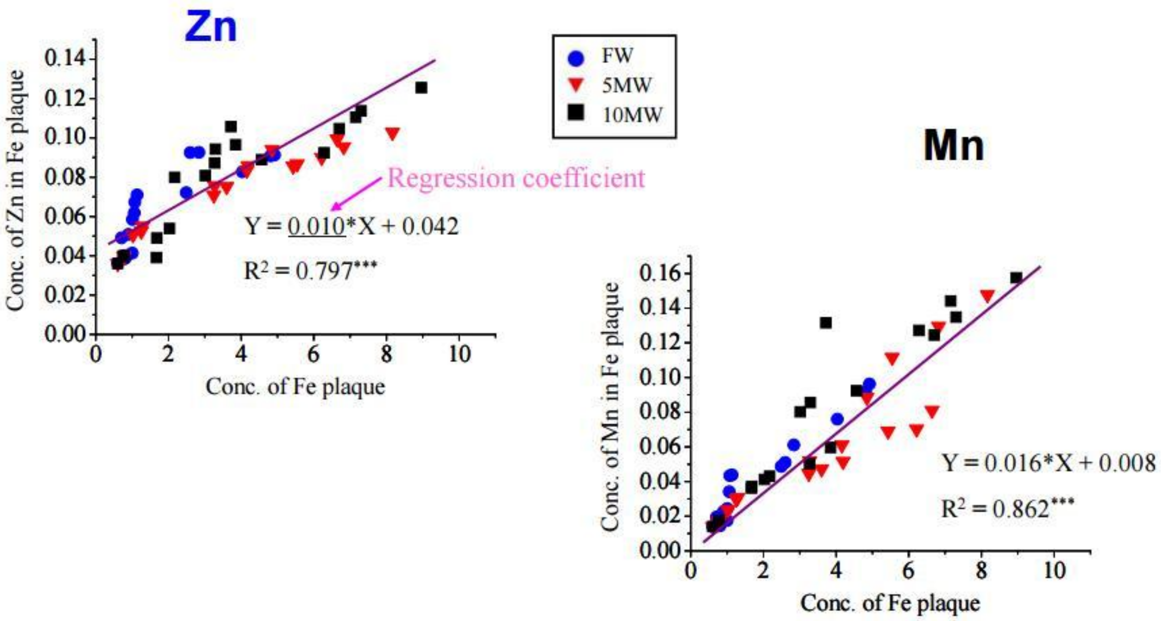


Figure 10: Relationship between Concentration of Fe plaque (mg/g dw) and Zn (left) and Mn (right) on Root Surface of *Bruguiera gymnorrhiza*

Microbial bioremediation was presented as a complementary strategy. Mangrove rhizospheres host diverse microbial communities capable of adsorbing and transforming heavy metals. Novel strains isolated from Shenzhen Futian demonstrated high tolerance and adsorption capacity, and immobilization in hydrogel matrices further enhanced removal efficiency. The lecture recommended integrated approaches combining phytoremediation, microbial inoculation, and nanotechnology to maximize pollutant removal while safeguarding ecosystem health.

Mangroves as Natural Filters for PAHs, PBDEs, and Microplastics: Persistent organic pollutants such as PAHs, PBDEs, plastics, and microplastics were also discussed. Sediment surveys revealed widespread contamination, including hotspots in Mai Po and other Hong Kong sites. Mangroves were shown to tolerate PAHs better than other wetland plants, with *Bruguiera gymnorrhiza* being the most resistant species. For PBDEs, *Avicennia marina* demonstrated higher tolerance. Tidal cycling was highlighted as a critical factor in pollutant degradation, with alternating aerobic and anaerobic conditions enabling complementary microbial pathways for debromination and ring-cleavage. The lecture emphasized the adaptive traits that allow mangroves to survive in polluted environments, including specialized root systems, high tannin and polyphenol concentrations, and strong antioxidant enzyme activity. These traits enable mangroves to immobilize contaminants, reduce oxidative stress, and maintain ecological function under adverse conditions.

The lecture concluded by stressing that mangroves are indispensable for coastal resilience and pollution control, but their tolerance capacity is finite. Effective management requires source control of industrial discharges, restoration of degraded wetlands, and integration of biological and technological remediation strategies to ensure long-term sustainability of mangrove ecosystems.

2.2.10. Mangroves, Blue Carbon, and Climate Change Mitigation

This lecture was delivered by **Dr. Guanghui Lin, Tsinghua University & Hainan International Blue Carbon Research Center, China**, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.10**.

Climate Change and Its Consequences: The lecture emphasized that climate change is one of the most critical challenges of the 21st century, primarily driven by human activities. The current high-carbon development model has created systemic environmental risks, accelerating global warming and intensifying climate feedback mechanisms that increase both the speed and irreversibility of climate change. These processes have led to a range of serious consequences, including rising sea levels, more frequent and intense heat waves, heavy rainfall events, and prolonged droughts. The lecture further highlighted that these environmental changes pose significant threats to human security and global stability, underscoring the urgency of implementing effective mitigation strategies.

Blue Carbon as Nature-based Solution for Mitigating Climate Change: The lecture defined Blue Carbon as the organic carbon captured and stored by oceanic and coastal ecosystems, with a primary focus on mangroves, tidal salt marshes, seagrass meadows, and kelp forests. It was highlighted that this concept gained significant prominence following reports issued by United Nations agencies in 2009, which underscored the critical role these ecosystems play in the global carbon cycle. The lecture emphasized that Blue Carbon represents a powerful Nature-based Solution (NbS), leveraging natural processes to sequester atmospheric carbon dioxide (CO_2) for long-term storage in plant biomass and, most importantly, in oxygen-poor soils. To contextualize this, the presentation included a key figure illustrating the global carbon cycle. Furthermore, the lecture addressed the growing scientific interest in this field, citing bibliometric analyses that show a marked increase in publications on Blue Carbon, confirming its rising importance in climate science and policy.

Mangrove Wetlands as a Premier Blue Carbon Ecosystem: The lecture emphasized that mangrove wetlands are among the most effective Blue Carbon ecosystems due to their exceptional carbon sequestration capacity and the wide range of co-benefits they provide. A key highlight was their role in coastal protection − notably, evidence from the 2004 Indian Ocean tsunami demonstrated that mangrove forests effectively dissipated wave energy and reduced shoreline damage, and help defend over US$ 11 billion worth of property globally each year.

The lecture also addressed that average global carbon stocks (Mg C ha^{-1}) across major coastal and tropical ecosystems. Mangrove forests show the highest total carbon storage, over 1,000 Mg C ha^{-1}, with most carbon stored in soils, followed by below-ground roots and above-ground biomass. This far exceeds the carbon stocks of subtropical tidal marshes, tropical seagrass beds, tropical humid evergreen forests, and tropical peat swamp forests (**see Figure 11**).

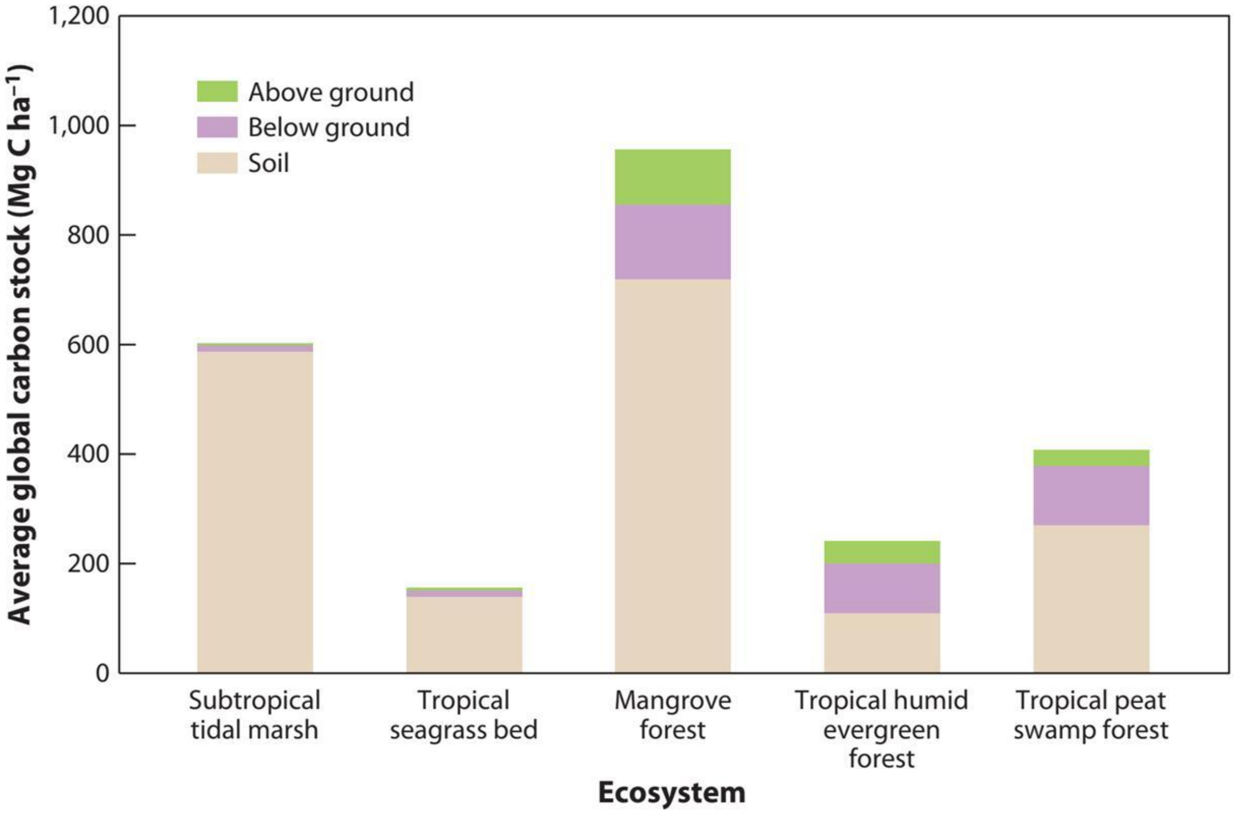


Figure 11: Average global carbon stock across ecosystems

Applying Mangrove Blue Carbon for Climate Mitigation: The lecture detailed how the scientific understanding of mangrove Blue Carbon is applied through measurement and carbon markets. It was stressed that long-term monitoring data, particularly from eddy covariance towers, confirms that mangroves are exceptionally strong carbon sinks. A pivotal finding addressed was that reforestation of degraded mangrove habitats (e.g., abandoned fish ponds) provides a greater Blue Carbon benefit than afforestation on unvegetated tidal mudflats. The lecture explicitly recommended focusing restoration efforts on degraded sites while leaving healthy mudflats intact. The transition to practical application was demonstrated through examples of carbon trading projects, such as China's first Verified Carbon Standard (VCS) project in Zhanjiang. A major milestone highlighted was the official release of China's CCER (China Certified Emission Reduction) Methodology for Mangrove Afforestation in October 2023, which provides a national framework for generating carbon credits. A detailed example from the Indus Delta Blue Carbon Project was used to illustrate the complex long-term accounting of net CO_2 removals.

2.2.11. Conservation, Restoration and Carbon Potential of ARID Mangroves

This lecture was delivered by **Mr. Kashif Khan Durrani, Divisional Forest Office/ Deputy Provincial Director Upscaling of Green Pakistan Program**, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.11.**

The lecture provided an overview of the critical aspects of preserving mangrove ecosystems, particularly in arid regions. It emphasized the importance of regular research and cooperation among national and international organizations to maintain the sustainability of these ecosystems.

Continuous monitoring through various methods, such as satellite imagery and drone footage, is highlighted as essential for tracking health, species diversity, and addressing issues like pollution, encroachment, and climate change. Community involvement is also crucial, with local populations encouraged to participate in conservation efforts and awareness programs.

Conservation Strategies and Ecosystem Management: The lecture emphasized key conservation measures, including legal protection through designated protected areas, enforcement of environmental laws, and the establishment of buffer zones to reduce impacts from development and pollution. Continuous monitoring using satellite imagery, drones, and field surveys was highlighted as essential for assessing ecosystem health and addressing threats such as pollution, encroachment, and climate change. Community involvement and the promotion of alternative livelihoods were identified as critical for reducing pressure on mangrove resources.

Restoration Processes and Community Engagement: Mangrove restoration was presented as a structured process involving seed collection, nursery development, and field planting, supported by local labor and community participation. Post-planting protection and monitoring are crucial to ensure successful regeneration, while community engagement and incentives enhance long-term sustainability of restoration efforts.

Carbon Potential and Climate Change Mitigation: The lecture highlighted the significant carbon storage capacity of mangroves and their role in climate change mitigation. It outlined the process of developing carbon projects, including baseline assessment, validation, and carbon credit issuance, enabling mangrove conservation to generate economic benefits through carbon markets.

Carbon Financing and Way Forward: The Delta Blue Carbon initiative was presented as a major example, demonstrating large-scale carbon sequestration and financial returns while supporting local communities. The lecture concluded by emphasizing the need for an integrated approach combining conservation, restoration, community participation, and carbon financing to ensure the long-term sustainability of arid mangrove ecosystems.

2.2.12. Shenzhen Mangrove Conservation Carbon Sink Project – Development and Trading Practice

This lecture was delivered by **Xie Xinli** from Development Research Center for Natural Resource and Real Estate Assessment, Shenzhen, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.12.**

This lecture highlighted how policy frameworks, market mechanisms, and innovative financial tools are integrated to realize the value of ecosystem services, particularly blue carbon, within China's broader carbon neutrality strategy.

Policy Framework and Ecosystem Value Realization: The lecture emphasized the strong national and ministerial policy support for ecological conservation and carbon market development. China's policy direction promotes the realization of ecosystem product value, integration of carbon sink trading into national markets, and the development of ecological compensation mechanisms. Shenzhen was selected as a pilot city to operationalize these policies, focusing on creating institutional and technical systems for ecosystem valuation and carbon trading.

Carbon Sink Trading Mechanism and Pilot Implementation: A key focus was the establishment of a full-chain carbon sink trading system using the Futian Mangrove National Nature Reserve as a pilot site. The system includes carbon sink ownership registration, methodology development, carbon verification, valuation, auction design, and trading registration. The project integrates biodiversity conservation, climate change mitigation, and community benefits, positioning mangrove carbon sinks as high-quality ecological products.

Carbon Accounting, Valuation, and Market Pricing: The lecture presented a scientific approach to carbon accounting and valuation. In the pilot area, mangrove conservation generated approximately 38,745 tons of carbon sequestration over a 10-year period. A market-based valuation methodology was developed, incorporating cost-benefit analysis and comparative market approaches, leading to a reserve auction price of RMB 183 per ton. The final transaction price reached RMB 485 per ton, demonstrating strong market demand and the premium value of blue carbon projects.

Innovative Trading Practices and Financial Instruments: The lecture highlighted several innovative mechanisms, including open auction trading, issuance of carbon sink certificates, and registration within natural resource systems. It also introduced financial innovations such as carbon sink index insurance and carbon pledge financing ("carbon-for-loans"), which expand funding channels and reduce investment risks. These mechanisms demonstrate how ecological assets can be integrated into financial markets.

Application Scenarios and Institutional Innovation: Beyond trading, the lecture explored practical applications of carbon sinks, including carbon neutrality for major events, judicial carbon sinks as compensation for environmental damage, and integration into ecological restoration frameworks. These approaches expand the use of carbon sinks beyond voluntary markets into governance, legal, and public policy domains.

Scaling Blue Carbon through Market-Based Mechanisms: The lecture concluded that Shenzhen's pilot demonstrates a scalable model for integrating ecosystem conservation with market-based mechanisms. By combining policy support, scientific methodologies, and financial innovation, mangrove carbon sink projects can generate ecological, economic, and social benefits, contributing to climate goals and sustainable development.

2.2.13. Introduction to China and Its Culture

In addition to the technical thematic lectures, participants gained insights into Chinese history and culture through the lecture on "Introduction to China and its Culture" was delivered by **Ms. Wu Xuerui, Vice President of NAFGA, China**. The lecture offered key insights into China's cultural context, with the key highlights as follows. Full details of the presentation are provided in **Annex 3.12.**

Geography : The lecture showcased China's vast geographical scale, describing it as the third-largest country in the world by land area (9.6 million km²). It highlighted the unique topographical feature of the land descending in "three stairs" from west to east. The first stair consists of plateaus and mountains with altitudes over 4000 meters. The second stair comprises plateaus and basins with altitudes from 1000 – 4000 meters. The third stair consists of plains and low hills with altitudes below 1000 meters. Additionally, the lecture noted that China is rich in water resources, possessing more than 1,500 significant rivers. Among them, the Yangtze (6,300 km) and Yellow Rivers (5,464 km) are celebrated as the "mother rivers" of Chinese civilization. The country's diverse and spectacular landscapes are underscored by its 19 UNESCO World Natural Heritage sites, covering a total area of over 80,000 km^2, which showcase its commitment to environmental conservation and protection.

History : The lecture presented China as one of the world's oldest continuous civilizations, with a recorded history of over 5,800 years that originated in the Yellow and Yangtze River basins.

Chinese history was divided into three major periods: Ancient times (ending in 1840 with the First Opium War), the Modern period (1840-1949), characterized as a semi-colonial and semi-feudal society, and the Contemporary era (from the founding of the People's Republic of China in 1949 to the present), defined as a period of socialist revolution and construction. This long, uninterrupted historical narrative framed China's enduring cultural identity and developmental journey.

Political System : The lecture emphasized China's political system as operating under the leadership of the Communist Party of China (CPC). The presentation outlined three fundamental components: The People's Congress system as the fundamental political system, the system of Multi-party Cooperation and Political Consultation where eight democratic parties participate under CPC leadership, and the system of Regional Ethnic Autonomy to address the needs of minority populations. The administrative structure was detailed as a three-tier system consisting of provinces, counties, and townships. This structure was presented the stable framework that guides all national policies, including environmental initiatives.

Economy : The lecture credited China's massive economic growth to the "reform and opening-up" policy initiated in 1978 under Deng Xiaoping. This transformation was highlighted by the dramatic rise in GDP, with China having become the world's second-largest economy (reaching 134.9 trillion RMB in 2024). The policy's success was visually symbolized by the before-and-after development of cities like Shenzhen, demonstrating the shift that provides the financial and infrastructural capacity for large-scale national projects.

Diplomacy : China's foreign policy was described as being rooted in the purposes of maintaining world peace and promoting common development, with the Five Principles of Peaceful Coexistence as its core tenet *(1. Mutual respect for each other's sovereignty and territorial integrity, 2. mutual non-aggression, 3. mutual non-interference in each other's internal affairs, 4. equality and mutual benefit, and 5. peaceful coexistence*.) The lecture introduced the concept of "Major Country Diplomacy with Chinese Characteristics," which embodied the traditional ideal of "the world is for all" and was operationalized through the vision of building a **"Community with a Shared Future for Mankind."** A key instrument of this diplomacy was the Belt and Road Initiative (BRI), launched in 2013 to enhance global connectivity. The lecture concluded with specific examples of China's international cooperation, including high-level meetings with countries like Cambodia, Iran, Madagascar, Sierra Leone, and Zimbabwe, which showcased the diplomatic approach that fostered the bilateral and multilateral partnerships essential for economic development, environmental protection, and sustainable living.

2.3. Sharing National Experiences in Wetlands and Mangrove Management

During this session, participating countries presented detailed national reports on the status of mangroves and wetlands, outlining their ecological characteristics, governance frameworks, conservation practices, and priority actions. The reports demonstrated significant variation between coastal countries with extensive mangrove ecosystems and landlocked countries focusing on inland wetlands.

Countries with substantial mangrove resources, including China, Cuba, Gabon, Guinea, Liberia, Madagascar, Mozambique, Samoa, Sierra Leone, and the Union of the Comoros, highlighted ongoing efforts in mangrove conservation and restoration through national strategies, legal frameworks, and large-scale projects. These included the implementation of national action plans, establishment of protected areas and nurseries, application of advanced monitoring technologies such as remote sensing and drones, and promotion of community-based restoration linked to sustainable livelihoods. Innovative approaches such as blue carbon initiatives, ecosystem-based adaptation, and integration of mangrove conservation into national development agendas were also emphasized.

Despite these efforts, many countries reported persistent challenges, including deforestation driven by wood extraction and agriculture, urban expansion, pollution, hydrological changes, and increasing climate-related risks such as cyclones, erosion, and sea-level rise. Institutional constraints such as limited financial resources, weak enforcement, data gaps, and land tenure conflicts were also commonly highlighted. In response, countries proposed forward-looking actions, including strengthening governance and policy enforcement, expanding protected areas, enhancing monitoring systems, improving community engagement, and fostering international cooperation.

In contrast, landlocked countries such as Burkina Faso, Lao PDR, Lesotho, and Zimbabwe focused on inland wetland ecosystems that play critical roles in water security, biodiversity conservation, and local livelihoods. Their reports emphasized governance improvements through national policies and institutional arrangements, ecosystem restoration, invasive species control, and community-based management. Key challenges included encroachment, overexploitation, land-use pressures, invasive species, and limited coordination. Proposed way forward actions centered on capacity building, awareness raising, strengthening regulatory enforcement, and promoting sustainable livelihood alternatives.

Overall, the reports underscore both the progress made and the ongoing challenges in wetland and mangrove conservation globally, highlighting the need for integrated, multi-stakeholder, and adaptive management approaches. A detailed summary of these country reports is provided in the **Table 1**.

Table 1: Summary of country experiences in wetlands/mangrove conservation and management

Country	Status of Mangroves/ Wetlands	Conservation / Management Practices	Challenges	Way Forward
Burkina Faso Annex 4.1	• Landlocked country, focusing on inland wetland conservation; • Ratified Ramsar Convention on October 27, 1990 • 25 Ramsar sites covering 1.94 million ha	• Establishment of 5 national water agencies and a dedicated water police • Large-scale reforestation (970 ha at Samendéni Ramsar site) • Ecosystem-based adaptation (EBA) projects valued at over $7M • Regular mechanical control of invasive species like water hyacinth	• Limited financial resources, • Incomplete wetlands inventory	• Not specified
China Annex 4.2	• Mangroves distribute across 5 provinces (excluding Hong Kong, Macao, Taiwan) • Total mangrove area: 30,300 ha • 20,500 ha within protected areas (including 7 Ramsar sites)	• Mangrove Conservation and Restoration Action Plan (2020–2025) with the targets of replanting 9,050 ha and restoring 9,750 ha • 8,800 ha planted nationwide • Enforcement of 2 national laws and 5 provincial regulations • Implementation of “sky–space–ground” monitoring system, using remote	• Not specified	• Achieve restoration targets • Expand wetland and marine nature parks

	• 37 native mangrove species identified	sensing, drone patrols to track mangrove distribution and invasive species monitoring		
Comoros Annex 4.3	• Comoros consists of 4 islands, covering area of 2,236 km² • 3 Ramsar sites, covering 16,030 ha • 120 ha of mangroves, with about 75 % of located on the south coast of Moheli Island, especially in the region of Damou and Mapiachingo • 9 Mangrove species recorded	• Implementation of ReSea Project (IUCN) to restore mangroves, using local knowledge • Engagement of youth as “guardians of nature” and integration into blue economy • Community-based mangrove restoration initiatives	• Diffuse pollution from agriculture and inadequate wastewater/rainwater management • Accumulation of non-biodegradable household waste (plastics, tires) and sand • Anthropogenic pressures including urban planning and plant pests • Vulnerability to climate change impacts	• Deepen studies on mangrove vulnerability to climate change • Identify and map specific sites for restoration • Improve national waste management system • Strengthen community participation.
Cuba Annex 4.4	• Total mangrove area of 450,000 ha, representing 5% of national forest cover • Largest mangrove complex of over 3,000 km² located on the northern coast • 4 mangrove species: *Rhizophora, Avicennia, Laguncularia, Conocarpus*	• Mangrove conservation and management under the Environmental Protection Law (1997) and Forestry Law (1998) • Implementation of the My Coast Project (2021–2029) for large-scale mangrove and wetland restoration along 1,300 km of coastline • Mangrove restoration techniques: hydrological restoration, diverse planting methods (cuttings, enclosures, niches, island method), and natural regeneration with post-restoration monitoring	• Urbanization, tourism, agriculture pressures • Hydrological disruption	• Continue “My Coast” project implementation • Scale up coastal habitat restoration
Gabon Annex 4.5	• Total mangrove area of 174,700 - 400,000 ha, contributing 1.18% to global mangrove extent • 6 mangrove species • Among the tallest mangroves in the world	• Mangrove conservation and management under National environmental, forest, and protected area laws • Implementation of the Angondjé–Ntom Mangrove Restoration Project, restoring 17 ha and securing 1,000 ha under 20 years protection • Establishment of nurseries, reforestation activities, and monitoring programs	• Aquaculture • Pollution • Urban development • Erosion • Climate change • Loss of biodiversity knowledge	• Strengthen nurseries and monitoring • Enhance education and partnerships • Improve mangrove inventory and restoration standards
Guinea Annex 4.6	• 182,472 ha of mangroves, representing approximately 25% of West	• Enhancement of local livelihoods to reduce pressure on mangrove resources through solar-tarpaulin salt	• Wood exploitation for energy and construction • Rice farming and	• Develop national mangrove restoration and conservation

	Africa's mangrove • 5 mangrove species • Importance of biodiversity hotspot in West Africa (11 reptile, 5 mammals, 38 bird, 11 fish species) • 4 seagrass beds	extraction, protective dike construction for rice fields, improved fish-smoking stoves, and community plantations of fast-growing species	soil acidification due to seawater intrusion • Salt extraction impacts • Fish smoking using mangrove wood	programs • Establish surveillance posts and inspection trails in mangroves • Establish research and seed quality improvement center
Lao PDR Annex 4.7	• Inland wetlands (Landlocked country) of 1,082,600 ha, representing 5% of the national territory • 2 designated Ramsar sites: Xe Champhone (12,400 ha) and Beung Kiat Ngong (2,360 ha)	• Wetland conservation and management under mandate of the Ministry of Agriculture and Environment, following the implementation of the national water, environment, forestry, land, and wetland legislation and strategies • Establishment of Ramsar National Committee (est. 2011) and provincial committees • Development of river basin management plans (2022) and management plans (2023) for Ramsar sites • Wetland demarcation • Promotion of community-based management linked to livelihood improvement	• Encroachment • Hunting and overharvesting • Invasive species • Habitat degradation, • Hydrological modification • Climate change • Pollution	• Awareness raising and capacity building, • Strengthen regulation enforcement, • Improve livelihoods to reduce pressure • Expand Ramsar Sites designation
Lesotho Annex 4.8	• Inland wetlands (Landlocked country) of11,700 km² • 29 wetlands protected areas & 18 protected natural springs.	• Wetland conservation and management under Water Act (2008), Wetlands Policy (2007), National Wetlands Strategy • Promotion of community engagement, rehabilitation, monitoring.	• Degradation • Overgrazing • Burning • Poor land-use planning • Lack of coordination	• Improved collaboration • Promote science-based planning • Awareness campaigns • Systematic monitoring
Liberia Annex 4.9	Mangroves cover of roughly 30% coastline; with species include *Rhizophora racemosa, R. mangle, Avicennia spp., Laguncularia.*	• Mangrove conservation and management under Environmental Protection and Management Law, Environmental Protection Agency Act 2002, and Wetland Policy Document 2014 • Establishment of the National Wetlands Taskforce • Mainstreaming mangrove conservation into the national development agenda • Implementation of a national mangrove inventory and	• Plastic pollution • Illegal construction • Erosion, declining fish catches • Mangrove loss.	• Strengthen policies • Restore species diversity • Promote alternative livelihoods • Enhance community engagement.

		strengthened blue carbon ecosystems management to support sustainable local livelihoods		
Madagascar Annex 4.10	• 390,000 ha of mangroves, representing approximately 2% of the global mangrove area • Predominantly distributed along the west coast of the country • 9 mangrove species • 303 Mt CO_2 stored, with an estimated economic value of USD 82.6 million annually • Approximately 8,000 ha restoration potential	• Implementation of the National Mangrove Strategy (2022–2032) • Establishment of a restoration committee (2016) and a mangrove thematic group (2024) • Implementation of hydrological restoration measures • Development of local mangrove nurseries and drone-assisted seeding techniques • Support for local livelihoods, including crab farming, artisanal fisheries, and ecotourism	• Limited infrastructure and site accessibility • Weak data collection and management systems • Land tenure conflicts and weak enforcement • Limited financial resources for conservation and restoration	• Expand protected areas, • Empower women and youth • Strengthen governance, • International cooperation (IMC, MCF, HiBC).
Mozambique Annex 4.11	• Total mangrove area **approximately** 396,080 ha • 9 species); concentrated in Zambezi Delta. • 2 Ramsar sites: Marromeu Complex (2004), Lake Niassa (2011). • Nearly 180 ha of mangroves restored	• Mangrove conservation and management under the Environmental Law (1997), Forest Law (2023), Biodiversity Law (2017) • Establishment and implementation of National Mangrove Action Plan (2020–2024) • Establishment of mangrove nursery with capacity of 60,000 seedlings • Local community engagement, with involving 2000 members and schools	• Wood extraction, • Urbanization, • Cyclones, • Floods, charcoal production.	• Promote long-term sustainability, • Enhance blue carbon research, • Expand community plantations, • Integrate mangroves into school education
Samoa Annex 4.12	• Total Mangrove Area of 1217.85 ha; • 5 species *(Rhizophora, Bruguiera, Xylocarpus, Acrostichum, Pemphis)*	• Implementation of the MESCAL project for climate resilience • Establishment of protected reserves and sanctuaries • Rehabilitation and seedling replanting programs • Promotion of scientific mapping and research	• Pollution • Land reclamation for settlement • Excessive cutting and clearing mangroves • Natural disasters (Cyclone, tsunami)	• Develop and enforce specific mangrove protection laws • Ban habitat destruction • Expand public education and awareness • Continue resource mapping and monitoring

Sierra Leone Annex 4.13	• A total of mangrove area approximately 150,000 ha • Approximately 60,000 ha lost (1990–2020). • 7 species (*Rhizophora* dominant) • 200 ha of mangrove degraded area restored	• Management of 4 Marine Protected Areas (MPAs) • Community-led restoration creating "green jobs" for 100 women and youth • Innovative tracking of mangrove growth using Android-based application • Collaboration between National Protected Area Authority (NPAA) and local stakeholders	• Deforestation for firewood, house construction • Rice farming and harvesting • Mining (sand, stone, zircon) • Urbanization	• Restore 20,000 ha of mangroves by 2030 • Provide GIS, remote sensing and other monitoring tools • continue to provide capacity building
Zimbabwe Annex 4.14	• Inland wetlands only (landlocked country); approximately 11,700 km² total coverage • 7 Ramsar sites, including Victoria Falls, Driefontein).	• Implementation of National Wetlands Policy and "Catch them young" school policies • Environmental Monitors recruited from local community members • Creation of Environment Courts for law enforcement • Annual World Wetlands Day commemorations and community training	• Land tenure changes leading to uncontrolled grazing and cultivation • Tragedy of the Commons" resulting in fence removals and habitat modification • Eutrophication and spread of invasive species (water hyacinth) • Low local buy-in for certain conservation initiatives	• Strengthen collective action through mandatory community participation • Enforce environmental laws • Promote climate change mitigation and sustainable livelihoods • Improve ecosystem awareness

2.4. Field Visits and On-site Teaching

A key highlight of the training workshop was the series of carefully structured field visits and on-site teaching sessions, which provided participants with direct exposure to China's integrated and multi approaches to mangrove and wetland conservation. These visits spanned from advanced urban governance and planning institutions in Shenzhen to nationally protected mangrove reserves and large-scale ecological restoration sites across Fujian and Zhejiang provinces, illustrating a comprehensive continuum of management approaches—from policy-driven spatial planning and strict nature reserve protection to engineered restoration and multifunctional urban wetland systems. Participants gained practical insights into innovative practices such as ecological redline planning, "sponge city" development, digital monitoring systems, habitat-specific conservation, and blue carbon-oriented restoration, alongside wildlife rescue and "One Health" monitoring frameworks. Collectively, the visits demonstrated how China operationalizes the integration of biodiversity conservation, climate resilience, and sustainable development across different ecological and administrative contexts, offering valuable lessons for scalable and adaptive mangrove management globally.

Urban Planning and Natural Resource Bureau of Shenzhen Municipality

The participants visited to the Urban Planning and Natural Resources Bureau of Shenzhen Municipality. The visit highlighted how Shenzhen integrates urban development with ecological protection, demonstrating practical approaches to mangrove conservation and restoration, as well as the protection of habitats for migratory birds. Participants observed the bureau's planning strategies, including spatial planning, ecological protection red lines, sustainable land use, and "sponge city" and "park city" initiatives, showing how urban growth can coexist with healthy coastal ecosystems. The use of digital governance tools, public participation, and transparent planning at the Shenzhen Planning Building further illustrated how cities can balance development with ecosystem and biodiversity conservation, offering lessons applicable to mangrove and migratory bird habitat restoration in other regions.

Figure 12: Participants visited to the Urban Planning and Natural Resource Bureau of Shenzhen Municipality.

The Interim Secretariat of International Mangrove Center

The participants paid a visit to the Interim Secretariat of the International Mangrove Center (IMC), located in Hetao Technology Innovation Center, Futian District, Shenzhen. The visit provided an opportunity for participants to familiarize themselves with the working environment and facilities of the interim Secretariat. It also allowed for direct interaction with IMC staff, facilitating informal exchanges, strengthening professional connections, and enhancing mutual understanding.

Figure 13: Participants visited to the Interim Secretariat of International Mangrove Center

Futian Mangrove Ramsar Site in Shenzhen

The participants visited the Futian Mangrove Ramsar Site in Shenzhen, Guangdong, coordinated by Dr. Xu Hualin, scientists from the site. The visit provided crucial information, revealing that the Ramsar Site is an internationally protected wetland, distinct from the public-facing Futian Mangrove Ecological Park. Its core consists of the strictly managed Futian National Nature Reserve. The management of this core area falls under the direct authority of the Shenzhen Municipal Government's Administration of the Futian National Nature Reserve, which enforces a legal framework integrating Chinese national law with international commitments under the Ramsar Convention. This stringent management system limits public access to minimize human disturbance and focuses conservation efforts on preserving vulnerable species and critical habitats for over 20,000 migratory birds. A key milestone was the 2023 expansion of the Ramsar boundary, which formally incorporated the Ecological Park. This strategic move acknowledged the park's essential ecological role and unified the management of both areas under a single international conservation framework, despite their separate daily operations, thereby solidifying the entire area as a model of integrated urban conservation.

Figure 14: Participants visited to the Futian Mangrove Ramsar Site in Shenzhen

OCT National Wetland Park in Shenzhen

The participants visited the OCT National Wetland Park in Shenzhen. The visit provided valuable insights into a model of urban ecological restoration, demonstrating how a formerly degraded coastal zone—once characterized by fish ponds, polluted waterways, and hardened seawalls—has been successfully transformed into a functional and biodiverse wetland ecosystem covering approximately 68.5 hectares. The park, designated as a National Urban Wetland Park in 2014, operates under a public–private partnership model led by the OCT Group in collaboration with municipal authorities, ensuring compliance with environmental regulations while promoting ecosystem-based management. Its integrated design combines mangroves, freshwater marshes, reed beds, and tidal flats to deliver critical ecological services such as habitat provision, water purification, and coastal protection. Conservation efforts focus on habitat reconstruction, biodiversity enhancement, and long-term ecological monitoring, with the site now supporting over 200 bird species, including globally threatened migratory species along the East Asian–Australasian Flyway. A key feature of its management approach is the strict regulation of public access through designated boardwalks and protected core zones, minimizing disturbance while enabling environmental education. As a result, the park stands as a leading example of how urban development and ecological restoration can be effectively integrated, serving both as a critical habitat node and a living laboratory for sustainable urban wetland management.

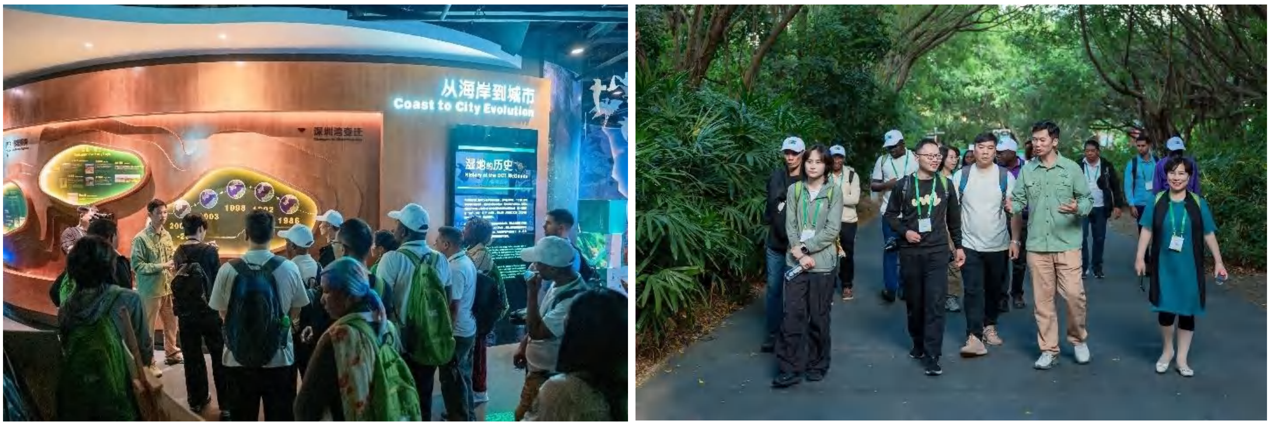


Figure 15: Participants visited to the OCT National Wetland Park in Shenzhen

Shenzhen Terrestrial Wildlife Rescue and Wildlife-Borne Disease Monitoring Station

Participants also visited the Shenzhen Terrestrial Wildlife Rescue and Wildlife-Borne Disease Monitoring Station, where they learned about Shenzhen's integrated approach to wildlife conservation, ecological health, and public safety under the "One Health" framework. Ms. CHEN Dan, Officer at Shenzhen Natural Reserve Management Center, highlighted the station's dual role in rescuing, rehabilitating, and releasing injured or confiscated wildlife, particularly migratory birds and threatened species, and in monitoring wildlife-borne diseases such as avian influenza through systematic surveillance and early warning mechanisms. This visit provided the participants a deeper understanding of how wildlife rescue, disease monitoring, and habitat conservation are interconnected, especially for migratory birds that rely on mangrove and wetland ecosystems along flyways. The experience demonstrated how strengthening wildlife health monitoring and rescue systems contributes to biodiversity conservation, ecosystem resilience, and the long-term success of mangrove restoration and migratory bird protection efforts.

Figure 16: Participants Visited Shenzhen Terrestrial Wildlife Rescue and Wildlife-Borne Disease Monitoring Station

Baguang Heritiera Wetland Park in Dapeng, Shenzhen

The participants visited the Baguang Heritiera Wetland Park in Shenzhen, coordinated by Ms. OU Wei, Vice Principal, Baguang Nature School, China. The visit provided important insights into a specialized conservation model focused on the protection of a rare and ancient coastal forest ecosystem, centered on the *Heritiera littoralis* species. Located in the Baguang area of Dapeng New District, the wetland park encompasses approximately 98 hectares, comprising a mosaic of coastal habitats including the core *Heritiera littoralis* forest, mangroves, tidal flats, and associated intertidal ecosystems. The site is managed under the authority of the Shenzhen Municipal Government, with a science-based, habitat-specific management approach that prioritizes in-situ conservation and long-term ecological research. The visit highlighted that the park's primary conservation objective is the protection of one of the largest and best-preserved naturally regenerating populations of *Heritiera littoralis* in China, with over 200 ancient trees—some estimated to be more than 300 years old—individually registered and safeguarded. Management interventions include strict control of public access, habitat restoration through the planting of native species, and continuous monitoring of tree health, ecosystem dynamics, and biodiversity. The park supports a specialized range of flora and fauna adapted to this unique habitat, including mangrove associates, intertidal invertebrates, fish nurseries, and various waterbirds, thereby functioning as a critical genetic reservoir and biodiversity hotspot despite its relatively moderate species richness.

Figure 17: Participants Visited Baguang Heritiera Wetland Park in Dapeng, Shenzhen

Zhangjiangkou Mangrove Forestry National Nature Reserve in Fujian Province

The participants visited the Zhangjiangkou Mangrove Forestry National Nature Reserve. The visit provided critical insights into a large-scale, strictly protected mangrove ecosystem, highlighting one of the most intact and representative natural mangrove forests in southeastern China. Located at the estuary of the Zhangjiang River in Fujian Province, the reserve encompasses approximately 2,360 hectares, comprising an extensive mosaic of mangrove forests, tidal flats, waterways, and shallow marine areas. The visit revealed that the reserve operates under the highest level of national protection, managed within China's National Nature Reserve system under the supervision of the National Forestry and Grassland Administration, with on-the-ground management conducted by a dedicated reserve administration bureau. Conservation efforts focus on maintaining ecosystem integrity and safeguarding biodiversity within this pristine mangrove estuary. The reserve supports a highly diverse assemblage of mangrove species and serves as a critical sanctuary for numerous threatened and migratory waterbirds along the East Asian–Australasian Flyway, including globally significant species such as the Black-faced Spoonbill and Spoon-billed Sandpiper. Its complex habitats also function as essential nursery grounds for fish, crustaceans, and other aquatic organisms, reinforcing its role in sustaining coastal and marine food webs.

A key milestone in its development was its elevation to National Nature Reserve status in 2003, which significantly strengthened its legal protection and conservation capacity. The site is also internationally recognized for its importance to migratory bird conservation and coastal ecosystem services, including carbon sequestration and natural coastal defense.

Figure 18: Participants Visited Zhangjiangkou Mangrove Forestry National Nature Reserve

Xiamen Xiatanwei Mangrove Park in Xiamen City, Fujian

The participants visited the Xiamen Xiatanwei Mangrove Park. The visit provided key insights into a large-scale, purpose-built coastal restoration project, demonstrating how degraded coastal land has been transformed into a functional mangrove ecosystem. Located in Xiang'an District, the park covers approximately 404 hectares, making it one of the largest artificial mangrove restoration sites in Fujian Province. The visit highlighted that the park is a government-led initiative focused on active ecological engineering, combining mangrove afforestation, habitat creation, and coastal protection. Its management balances ecosystem restoration with regulated public access, integrating biodiversity enhancement, disaster risk reduction, and environmental education. The site has shown significant ecological recovery, with increasing populations of waterbirds, aquatic species, and mangrove vegetation, indicating a rapidly developing and resilient ecosystem.

Figure 19: Participants Visited Xiamen Xiatanwei Mangrove Park

Quanzhou Bay Estuarine Wetland Provincial Nature Reserve in Quanzhou City, Fujian

The participants visited the Quanzhou Bay Estuarine Wetland Provincial Nature Reserve. The visit provided key insights into a large-scale estuarine ecosystem, highlighting its role as a critical habitat where riverine and marine systems converge. Covering approximately 7,689 hectares, the reserve comprises extensive intertidal mudflats, mangroves, salt marshes, and shallow coastal waters.

The visit revealed that the reserve is managed as a Provincial Nature Reserve with an ecosystem-based approach, emphasizing the protection of migratory waterbirds and the ecological integrity of the estuary. Its zonation system supports strict conservation in core areas while allowing regulated research and limited use in outer zones. The site is internationally significant for supporting over 100,000 migratory waterbirds annually along the East Asian–Australasian Flyway.

A key milestone was its establishment in 2003, followed by international recognition as an important wetland for migratory birds. The reserve serves as a vital global stopover site and a model for balancing biodiversity conservation with development pressures in a highly urbanized coastal region.

Figure 20: Participants Visited Quanzhou Bay Estuarine Wetland Provincial Nature Reserve

Fujian Minjiang River Estuary Wetlands in Fuzhou City, Fujian

The participants visited the Fujian Minjiang River Estuary Wetlands National Nature Reserve. The visit provided key insights into a nationally significant estuarine wetland ecosystem, highlighting its role as a critical habitat for migratory waterbirds at the confluence of the Minjiang River and the East China Sea. The core protected area covers approximately 2,380 hectares, consisting of extensive tidal flats, marshes, and shallow coastal waters. The visit revealed that the site is managed under China’s highest protection status as a National Nature Reserve, applying a strict zonation system with core areas dedicated to habitat preservation and minimal human disturbance. Conservation efforts focus on safeguarding key feeding and roosting grounds for globally threatened species, alongside active measures such as habitat restoration and control of invasive species. A key milestone was its designation as a National Nature Reserve in 2007, elevating its conservation status and international recognition. The site serves as a globally important sanctuary for endangered migratory birds, including the Chinese Crested Tern and Black-faced Spoonbill, and stands as a leading example of science-based estuarine wetland conservation.

Figure 21: Participants Visited Fujian Minjiang River Estuary Wetlands

Yanpu Bay Mangrove Forest in Cangnan County, Zhejiang

The participants visited the Yanpu Bay Mangrove Forest. The visit provided key insights into a unique northern mangrove ecosystem, recognized as the natural northernmost distribution of mangroves in China. The core mangrove area covers approximately 200 hectares, consisting of intertidal flats, tidal creeks, and associated coastal wetland habitats. The visit highlighted that the site is managed under a habitat-specific conservation approach led by local and provincial authorities, focusing on the in-situ protection and natural regeneration of cold-tolerant mangrove species, particularly *Kandelia obovata*. Conservation efforts include maintaining hydrological conditions, preventing land reclamation and pollution, and supporting long-term ecological monitoring. The mangrove ecosystem also provides habitat for waterbirds, intertidal invertebrates, and juvenile fish, contributing to local biodiversity and coastal productivity.

Figure 22: Participants Visited Yanpu Bay Mangrove Forest

Xinmeizhou Mangrove Wetland Park in Longgange City, Zhejiang

The participants visited the Xinmeizhou Mangrove Wetland Park. The visit provided key insights into a large-scale, purpose-built urban wetland restoration project, demonstrating how degraded coastal land has been transformed into a multifunctional mangrove ecosystem within a rapidly developing city. Located in Longgang, the park covers approximately 607 hectares, making it a defining component of the city’s coastal landscape. The visit highlighted that the park is managed as a city-led ecological infrastructure project, combining active mangrove afforestation, habitat engineering, and urban planning. Its management model integrates coastal protection, biodiversity enhancement, and public use, with extensive planting of native mangrove species and the creation of tidal channels and wetland habitats. The site is already showing ecological recovery, attracting waterbirds, aquatic species, and establishing a functioning wetland ecosystem.

Figure 23: Participants Visited Xinmeizhou Mangrove Wetland Park

Dongtou Mangrove Ecological Park in Wenzhou City, Zhejiang

The participants visited the Dongtou Mangrove Ecological Park. The visit provided key insights into a coastal rehabilitation project focused on reintroducing mangrove ecosystems on modified shorelines within the Dongtou Archipelago. The park covers a targeted restoration area of around 100 hectares, consisting of engineered intertidal zones, tidal creeks, and newly established mangrove stands. The visit highlighted that the park is managed as a district-led ecological restoration initiative, emphasizing active mangrove planting, site preparation, and coastal stabilization. Conservation efforts focus on establishing cold-tolerant species such as *Kandelia obovata*, improving hydrological conditions, and creating suitable habitats to support biodiversity recovery. As a developing ecosystem, the site is already attracting waterbirds, intertidal organisms, and juvenile fish, indicating early-stage ecological functionality.

Figure 24: Participants Visited Dongtou Mangrove Ecological Park

Ximen Island Marine Special Reserve in Yueqing City, Zhejiang

The participants visited the Ximen Island Marine Special Reserve. The visit provided key insights into an integrated coastal and marine protected area, highlighting its role in conserving the northernmost mangrove ecosystem alongside rich intertidal and marine biodiversity. The reserve covers approximately 3,080 hectares, including the island, extensive mudflats, and surrounding shallow waters. The visit revealed that the site is managed under a Marine Special Protected Area framework, applying a zoned, multiple-use approach that combines strict protection of core mangrove habitats with regulated activities such as sustainable fisheries and research in surrounding zones. Conservation efforts focus on protecting and expanding *Kandelia obovata* mangroves, maintaining habitat connectivity, and safeguarding productive benthic ecosystems that support shellfish and fish populations. The extensive mudflats also serve as important feeding and roosting grounds for waterbirds, including egrets, herons, and migratory shorebirds such as plovers and sandpipers, which rely on the abundant benthic organisms.

Figure 25: Participants Visited Ximen Island Marine Special Reserve

2.5. Group Work and Discussion Panel

2.5.1. Challenges and Priorities in Mangrove Conservation and Restoration

The group discussion on challenges and priorities in mangrove conservation and restoration was facilitated by LIN Guanghui of Tsinghua University, with the objective of fostering an interactive exchange of views and experiences among participants, enabling them to share perspectives, raise key issues, and reflect on their respective national contexts. The outcomes of this discussion are summarized as below:

Priorities of Mangrove Conservation and Restoration

During the discussion, participants emphasized the importance of governance and policy frameworks. Liberia and Gabon highlighted the need to implement existing legislation and draft new laws to protect mangrove ecosystems and wetlands. At the international level, conventions stressed that law enforcement was essential to sustain conservation priorities, while broader strategies called for integrating mangrove protection into land use planning, urban-rural development, and market-driven innovation.

Financing was identified as another critical priority. Strategies included mobilizing private involvement, developing carbon credit incentives, and exploring diverse funding sources. Burkina Faso and Comoros emphasized mobilizing finances for inventories and community projects, while regional initiatives such as the Greater Bay Area proposed capital market development to support conservation.

Research and technology were seen as central to advancing mangrove restoration. Priorities included conducting research on blue carbon, establishing standardized guidance and accounting methods, and exploring selective breeding to improve species resilience. Innovative technologies such as e-DNA, pharmaceutical applications, and supply chain management hubs were also considered essential. Inventories of mangrove ecosystems were repeatedly identified as foundational steps for effective management.

Community involvement and education were highlighted as equally important. Liberia and Gabon stressed the need for public awareness campaigns targeting all levels of society, including policymakers. Education for stakeholders and decision makers, eco-tourism initiatives, and AI-driven awareness programs were proposed to strengthen engagement. Comoros emphasized the development of observation sites to involve local communities directly.

Restoration and sustainable management priorities included balancing economic and ecological needs, expanding mangroves after human and natural disasters, and strengthening wetland functions. Addressing livelihood concerns through community projects was seen as a way to align conservation with social well-being. Tidal conservation and restoration, along with clean cooking initiatives linked to carbon credits, further connected ecological priorities with sustainable energy solutions.

Energy and alternative resources were recognized as part of the conservation agenda. Charcoal alternatives, bamboo-based fast-growing energy systems, and integrating blue carbon into the broader blue economy were highlighted as innovative pathways to reduce pressure on mangrove ecosystems.

Main Challenges of Mangrove Restoration

Despite these priorities, participants identified significant challenges to mangrove restoration. Environmental and technical obstacles included pollution from heavy metals, pesticides, and chemicals, as noted in Gabon, and the lack of appropriate technology for restoration in Comoros. Mangrove degradation from unsustainable practices and the issue of “damage circulation” identified in convention discussions further complicated restoration efforts.

Governance and enforcement challenges were also pressing. Liberia reported encroachment into mangroves by local communities, as well as weak enforcement against solid waste and industrial discharge. Gabon emphasized the urgent need for wetlands and mangrove inventories to guide management decisions. These challenges reflected gaps in institutional capacity and regulatory enforcement that hindered effective restoration.

Financial and resource constraints were widespread. Limited funding was a recurring theme across multiple countries, with high dependence on traditional resources exacerbating the problem. Mobilizing adequate financial support for inventories, community projects, and technological innovation remained a major barrier to scaling up restoration efforts.

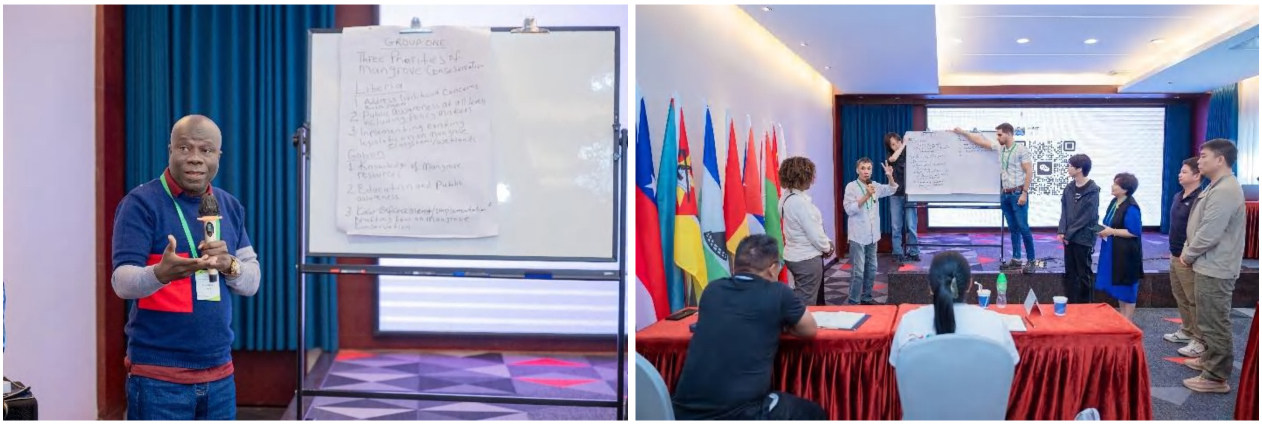


Figure 26: Group presentation on challenges and priorities

2.5.2. Strategic Priorities for IMC

The group discussion on the needs and priority activities of the International Mangrove Center (IMC) was facilitated by Prof. Zhou Haichao from Shenzhen University, China. The discussion focused on three main areas: (1) participants’ expectations from IMC workshop, (2) topics considered most beneficial for knowledge exchange and capacity building, and (3) strategic priorities to strengthen IMC’s role in mangrove conservation and restoration globally. Participants shared insights based on their experiences in mangrove/wetland management, biodiversity conservation, community engagement, policy implementation, and scientific research. The outcomes are intended to inform IMC’s planning, programming, and partnerships, with an emphasis on practical support, technology adoption, and international collaboration. The key outcomes from the discussion are summarized below:

Expectations:

- **Knowledge and Skills**
  - Gain practical expertise in mangrove and wetland conservation and restoration
  - Learn advanced monitoring technologies, including intelligent systems, ecological sensors, and camera-based monitoring
  - Understand biodiversity conservation, migratory birds, and fisheries management in mangrove ecosystems

- **Networking and Exchange**
  - Enhance communication and international experience sharing
  - Learn about policy-making, funding mechanisms, and emerging Blue Carbon markets
  - Benchmark and standardize conservation/restoration methodologies
- **Practical Exposure**
  - Participate in site visits to showcase best practices (e.g., China's east coast, Dongtou, Futian Ramsar site, Fujian Minjiang River Estuary)
  - Access financial, technical, and expert support for national and local projects

Most Beneficial Topics:

- Mangrove conservation, restoration, and biodiversity maintenance
- Habitat dynamics, connectivity, and complexity
- Country presentations and knowledge-sharing sessions
- Onsite visits, lectures, and field trips to IMC member countries
- CEPA activities (community education and awareness)
- Active participation of local communities and volunteers
- High-tech monitoring systems (cameras, ecological sensors, bird monitoring)
- Identifying mangrove species for invasive species eradication
- Pollution, wastewater treatment, and bioremediation roles of mangroves
- Alignment of national policies with international conventions (e.g., Ramsar Convention)
- Greater awareness among younger generations about mangroves and wetlands

Proposed Future Priorities to IMC Activities Over the Next Five Years

- **Capacity Building:** Organize a variety of educational and professional development programs, including workshops, scholarships, exchange programs, and continuous training initiatives. These activities aim to strengthen the technical knowledge, practical skills, and leadership capacities of personnel involved in mangrove and wetland conservation across IMC member countries.
- **International Cooperation:** Strengthen partnerships with regional and global organizations, governments, research institutions, and NGOs. Promote active participation in international conventions, forums, and networks to facilitate knowledge exchange, collaborative research, and coordinated conservation actions.
- **Pilot Projects:** Implement targeted pilot projects in areas such as mangrove restoration, wetlands management, and Blue Carbon research. These projects are designed to test innovative approaches, demonstrate best practices, and provide practical guidance that can be scaled up across different ecological and socio-economic contexts.
- **Financial & Technical Support:** Develop sustainable funding mechanisms and provide technical assistance to IMC member countries. This includes facilitating access to financial resources, technology transfer, and expertise to support local and national initiatives for mangrove conservation, ecosystem restoration, and climate resilience.
- **Membership Expansion:** Promote the designation of additional Ramsar sites and expand IMC membership, particularly in underrepresented regions such as Asia and Africa. Expanding the network will enhance regional collaboration, increase knowledge-sharing opportunities, and strengthen collective efforts toward global wetland conservation.
- **Research & Innovation:** Conduct research to identify new species suitable for specific environments, including those with high carbon sequestration potential. Promote innovative conservation techniques, ecological monitoring methods, and adaptive management strategies that support biodiversity protection and climate mitigation objectives.

- **Strategy Expansion:** Broaden the scope of IMC's strategy to include other wetland types beyond mangroves, such as floodplains, estuaries, and freshwater wetlands. This ensures that IMC addresses the full range of wetland ecosystems, their ecological functions, and their socio-economic benefits.
- **Community Engagement:** Enhance engagement with local communities through incentives, education, and participatory programs. Strengthen community networks to foster sustainable resource management, active involvement in conservation activities, and the long-term success of restoration projects.
- **Infrastructure Support:** Provide the necessary facilities, tools, and technical resources to support effective mangrove and wetland management. This includes equipment for ecological monitoring, restoration activities, research, and operational management to improve efficiency and effectiveness in conservation efforts.

Figure 27: Group presentation on expectations, beneficial topics, and priorities

2.6. Closing Session

The closing ceremony of the third Workshop on Mangrove Conservation and Restoration was held on 15 November 2025, marking the successful completion of the two-week program.

Prof. Bao Daming, Director General of the Interim Secretariat of IMC, delivered the closing remarks at the Workshop on Mangrove Conservation and Restoration held in Wenzhou City on 15 November 2025. He congratulated participants on the successful completion of the two-week workshop and commended their active engagement in technical discussion and field visits, and expressed appreciation to the organizers, and host governments for their strong support. He also congratulated Wenzhou City on its Ramsar International Wetland City accreditation and acknowledged Zhejiang Province's efforts in mangrove conservation and restoration. Prof. Bao Daming highlighted key thematic areas, including multilateral environmental agreements, China's mangrove action plan, migratory bird protection, and blue carbon initiatives, as well as the value of field visits to Ramsar sites and mangrove reserves in Guangdong, Fujian, and Zhejiang Provinces. Prof. Bao Daming underscored the strong spirit of international collaboration among participants from 14 countries and outlined IMC's future priorities, including capacity building, knowledge sharing, small grant projects, remote sensing–based monitoring, blue carbon initiatives, and international cooperation. Finally, he encouraged participants to act as ambassadors for mangrove conservation and to apply their knowledge in their home countries.

Following, **Mr. Li Yongsheng**, Deputy Director General of The Forestry Administration of Zhejiang Province, delivered his remarks. He congratulated participants on completing the program and expressed appreciation to the experts and organizers for their contributions. He highlighted Zhejiang Province's strong commitment to ecological conservation and sustainable development, including its efforts in coastal and wetland ecosystem protection, habitat restoration, and science-based management. He noted the province's active involvement in the Ramsar

Convention on Wetlands and its achievement in the Wetland City Accreditation of the Ramsar Convention, reflecting Zhejiang's integrated approach to balancing urban development with wetland conservation and promoting community participation. Mr. Li Yongsheng emphasized the ecological importance of mangroves and wetlands, including coastal protection, carbon sequestration, and biodiversity conservation. He encouraged participants to continue knowledge sharing, strengthen technical capacity, and translate workshop discussions into practical actions. He concluded by wishing participants success in applying their learning and promoting global collaboration in mangrove and wetland conservation.

The closing session concluded with a certificate awarding ceremony, where Prof. Bao Daming, Mr. Hu Ping, Director of the Neilingding Futian National Nature Reserve Administration Bureau of Shenzhen Municipality, and Mr. Li Yongsheng jointly presented certificates to the participants. This formal recognition symbolized both the successful completion of the training and the collective responsibility of participants to advance mangrove protection in their respective countries and regions.

Figure 28: Group Photo of Participants at the Closing Session of the IMC Workshop

3. Conclusion

The Third International Mangrove Center (IMC) Workshop on Mangrove Conservation and Restoration (2025), held from 3 to 15 November 2025 in China, successfully achieved its objectives of strengthening technical capacity, promoting international cooperation, and advancing a shared understanding of mangrove conservation, restoration, and sustainable use. Through a comprehensive and well-structured program that combined expert lectures, national experience sharing, field-based learning, and group discussions, the workshop provided participants with both scientific knowledge and practical insights tailored to their respective national and regional contexts.

The technical sessions delivered by leading experts addressed a wide range of interconnected themes, including international policy frameworks under the Ramsar Convention, China's legal and institutional approaches to wetland conservation, ecological principles of mangrove dynamics and connectivity, migratory bird conservation along global flyways, pollution control and bioremediation, and the growing importance of mangrove blue carbon in climate change mitigation. These sessions emphasized the multifunctional value of mangroves in supporting biodiversity, protecting coastlines, sustaining livelihoods, and contributing to carbon sequestration. Particular attention was given to science-based and ecosystem-based restoration approaches, especially the importance of restoring natural hydrological processes and maintaining ecological character to ensure long-term sustainability.

Field visits and on-site teaching sessions further reinforced these concepts by exposing participants to a diverse range of real-world management models across different regions of China. These included strictly protected national nature reserves and Ramsar Sites, urban wetland parks, large-scale restoration initiatives, and innovative practices such as ecological planning and blue carbon projects. The visits demonstrated how mangrove conservation can be effectively integrated with urban development, environmental governance, public engagement, and sustainable financing mechanisms. They also highlighted the importance of long-term monitoring, adaptive management, and strong institutional coordination in achieving effective and lasting conservation outcomes.

The sharing of national experiences revealed both common challenges and diverse responses among participating countries. Coastal countries emphasized pressures such as deforestation, aquaculture expansion, pollution, and climate-related impacts, while landlocked countries highlighted the importance of inland wetlands for water security, biodiversity conservation, and local livelihoods. Across all contexts, key priorities emerged, including the need to strengthen governance frameworks, enhance technical and institutional capacity, improve data and monitoring systems, promote community participation, and mobilize sustainable financing. These exchanges reaffirmed the critical role of the IMC as a global platform for knowledge exchange, capacity building, and collaborative action.

In conclusion, the workshop not only enhanced participants' technical competencies and professional networks but also strengthened a collective commitment to advancing mangrove and wetland conservation at national, regional, and global levels. Building on the outcomes of this workshop, continued efforts under the International Mangrove Center will be essential to support applied research, pilot initiatives, policy implementation, and capacity development. Sustained collaboration among governments, research institutions, local communities, and international partners will be crucial to scaling up effective conservation and restoration efforts, thereby contributing to biodiversity conservation, climate resilience, and sustainable development worldwide.

Annexes

Annex 1: Workshop Agenda

Date	Day	Time	Activities	Lecturer/Moderator/Institute	Location
Nov 2nd	Sun	All Day	Arrival & Registration	Mr. JIANG Yi, Program Officer, National Academy of Forestry and Grassland Administration (NAFGA), China	From Airport to ShenZhen Lido Hotel (Guangdong province)
Nov 3rd	Mon	08:30-09:30	Opening Ceremony	Mr. JIANG Yi, Program Officer, NAFGA, China	Planning Building，Shenzhen City **Dress code: IMC shirt*
		09:30-09:40	Group Photo	Mr. JIANG Yi, Program Officer, NAFGA, China	Planning Building，Shenzhen City
		09:40-10:00	Tea Break	Mr. JIANG Yi, Program Officer, NAFGA, China	Planning Building，Shenzhen City
		10:00-10:30	Guided Learning: Overview of the International Mangrove Center	Prof. Peng Peng, Director of the Interim Secretariat, International Mangrove Center	Planning Building, Shenzhen City
		10:30-11:30	On-Site Teaching 1: Visit Shenzhen Planning Building & Global Wetlands Outlook Salon	Prof. ZHOU Haichao, Shenzhen University, China	Planning Building, Shenzhen City
		12:00-13:00	Welcoming Luncheon	Prof. BAO Daming, Director General of the Interim Secretariat, International Mangrove Center	Dining Hall on 2F, ShenZhen Lido Hotel
		14:00-14:45	Lecture 1: (Live Lecture)	Mr. XIA Jun, Director of Department of International Cooperation, NAFGA, China	Meeting Room on 3F, ShenZhen Lido Hotel

Date	Day	Time	Activities	Lecturer/Moderator/Institute	Location
		15:00-16:30	Lecture 2: Introduction to China and the Chinese Culture	Prof. WU Xuerui, Vice President, NAFGA, China	Meeting Room on 3F, ShenZhen Lido Hotel
Nov 4th	Tues	9:00-10:30	Lecture 3: Mangrove Ecological Character Maintenance	Prof. LYU Cai, Beijing Forestry University, China	Meeting Room on 3F, ShenZhen Lido Hotel
		10:30-12:00	Lecture 4:Mangrove Habitat Dynamics, Connectivity and Complexity	Prof. A. Aldrie Amir, Universiti Kebangsaan Malaysia, Malaysia	Meeting Room on 3F, ShenZhen Lido Hotel
		14:00-15:30	On-Site Teaching 2: Visit the Interim Secretariat of International Mangrove Center	Mr. WU Tong, Interim Secretariat of International Mangrove Center	Hetao Innovation Center, Shenzhen City
		15:30-17:00	On-site Teaching 3: Guangdong Shenzhen Futian Mangrove Ramsar Site	Dr. XU Hualin, Scientist of Futian Mangrove Site, China	Neilingding Futian National Nature Reserve, Shenzhen City
Nov 5th	Wed	9:00-10:30	Lecture 5: Bird Watchers, Valuable Partners in Mangrove Management and Conservation	Dr. WANG Haibin, China Wildlife Conservation Association	Meeting Room on 3F, ShenZhen Lido Hotel
		10:30-12:00	Discussion1: Mangrove Conservation Cases and Experience Sharing (5 countries)	Mr. JIANG Yi, Program Officer, NAFGA, China	Meeting Room on 3F, ShenZhen Lido Hotel

Date	Day	Time	Activities	Lecturer/Moderator/Institute	Location
		14:00-14:45	Lecture 6: China's Wetland Conservation & Ramsar Implementation	Ms. HU Xinxin, Department of Wetland Management, National Forestry and Grassland Administration (NFGA), China	Meeting Room on 3F, ShenZhen Lido Hotel
		15:00-17:00	On-site Teaching 4: OCT National Wetland Park	Mr. JIANG Yi, Program Officer, NAFGA, China	OCT National Wetland Park, Shenzhen City
Nov 6th	Thus	09:30-11:00	Discussion2: Mangrove Conservation Cases and Experience Sharing (7 countries)	Mr. JIANG Yi, Program Officer, NAFGA, China	Meeting Room on 3F, ShenZhen Lido Hotel
		13:00-15:00	On-site Teaching 5: Shenzhen Terrestrial Wildlife Rescue and Wildlife-Borne Disease Monitoring Station	Ms. CHEN Dan, Shenzhen Natural Reserve Management Center	Shenzhen Natural Reserve Management Center, Shenzhen City
		15:00-17:00	Mangrove talk	Ms. YU Yun, Shenzhen Press Group, China	Shenzhen International Garden and Flower Expo Park, Shenzhen City
		18:00-20:00	Discover Mangroves	Ms. YU Yun, Shenzhen Press Group, China	Shenzhen International Garden and Flower Expo Park, Shenzhen City
Nov 7th	Fri	09:00-10:30	Lecture 7: Pollution, Wastewater Treatment and Bioremediation	Prof. Nora Fung-yee TAM, City University of Hong Kong, China	Meeting Room on 3F, ShenZhen Lido Hotel

Date	Day	Time	Activities	Lecturer/Moderator/Institute	Location
		10:30-12:00	Discussion3: Mangrove Conservation Cases and Experience Sharing (5 countries)	Mr. JIANG Yi, Program Officer, NAFGA, China	Meeting Room on 3F, ShenZhen Lido Hotel
		14:00-17:00	On-site Teaching 6: Baguang Exhibition Hall & Baguang Heritiera Wetland Park	Ms. OU Wei, Vice Principal, Baguang Nature School, China	Shenzhen Baguang & Baguang Heritiera Wetland Park, Shenzhen City
Nov 8th	Sat	09:00-10:30	Lecture 8: Mangrove Conservation and Climate Change	Prof. LIN Guanghui, Tsinghua University, China	Meeting Room on 3F, ShenZhen Lido Hotel
		10:30-12:00	Panel Discussion 1: Priorities and Challenges in Mangrove Conservation and Restoration	Prof. LIN Guanghui, Tsinghua University, China	Meeting Room on 3F, ShenZhen Lido Hotel
		14:00-15:30	Lecture 9:Conservation, Restoration and Carbon Potential of Arid Mangroves	Mr. Kashif Khan DURRANI, Divisional Forest Officer of Forest and Wildlife Department of Sindh, Ministry of Climate Change, Pakistan	Meeting Room on 3F, ShenZhen Lido Hotel
		15:30-17:00	Self study	Mr. JIANG Yi, Program Officer, NAFGA, China	ShenZhen Lido Hotel, Shenzhen City
Nov 9th	Sun	09:00-13:00	From Shenzhen to Yunxiao (high-speed train)	Mr. JIANG Yi, Program Officer, NAFGA, China	Yunxiao City (Fujian province)
		13:00-14:00	Lunch	Mr. JIANG Yi, Program Officer, NAFGA, China	Yunxiao City
		14:00-16:30	On-Site Teaching 7: Zhangjiangkou Mangrove Forestry National Nature Reserve	Commentator, Zhangjiangkou Mangrove Forestry National Nature Reserve	Zhangjiangkou Mangrove Forestry National Nature Reserve, Zhangzhou City
		18:30-19:30	Dinner	Mr. JIANG Yi,	Vienna Hotel,

Date	Day	Time	Activities	Lecturer/Moderator/Institute	Location
				Program Officer, NAFGA, China	Zhangzhou City
Nov 10th	Mon	09:00-10:30	From Zhangzhou to Xiamen	Mr. JIANG Yi, Program Officer, NAFGA, China	Xiamen City
		11:30-12:30	Lunch	Mr. JIANG Yi, Program Officer, NAFGA, China	Chenggong Hotel, Xiamen City
		14:00-17:00	On-Site Teaching 9: XIAMEN XIATANWEI Mangrove Park	Commentator, XIAMEN XIATANWEI Mangrove Park	XIAMEN XIATANWEI Mangrove Park, Xiamen City
		17:30-18:30	Dinner	Mr. JIANG Yi, Program Officer, NAFGA, China	Chenggong Hotel, Xiamen City
Nov 11th	Tues	08:30-10:00	From Xiamen to Quanzhou	Mr. JIANG Yi, Program Officer, NAFGA, China	Quanzhou City
		10:00-12:00	On-Site Teaching 10: Quanzhou Bay Estuarine Wetland Provincial Nature Reserve	Commentator, Quanzhou Bay Estuarine Wetland Provincial Nature	Quanzhou Bay Estuarine Wetland Provincial Nature, Quanzhou City
		12:30-13:30	Lunch	Mr. JIANG Yi, Program Officer, NAFGA, China	Shanlirenjia Restaurant, Quanzhou City
		13:30-16:00	From Quanzhou to Fuzhou	Mr. JIANG Yi, Program Officer, NAFGA, China	Haishang Mingzhu Hotel, Fuzhou City
		17:30-18:30	Dinner	Mr. JIANG Yi, Program Officer, NAFGA, China	Haishang Mingzhu Hotel, Fuzhou City
Nov 12th	Wed	9:00-11:00	On-Site Teaching 11: Fujian Minjiang River Estuary Wetlands	Commentator, Fujian Minjiang River Estuary Wetlands	Fujian Minjiang River Estuary Wetlands, Fuzhou City

Date	Day	Time	Activities	Lecturer/Moderator/Institute	Location
		12:00-13:00	Lunch	Mr. JIANG Yi, Program Officer, NAFGA, China	Haishang Mingzhu Hotel, Fuzhou City
		14:00-17:00	From Fuzhou to Cangnan	Mr. JIANG Yi, Program Officer, NAFGA, China	Cangnan County (Zhejiang province)
		17:00-18:00	Dinner	Mr. JIANG Yi, Program Officer, NAFGA, China	JI Hotel Cangnan Longgang, Cangnan County
Nov 13th	Thu	09:00-10:30	On-Site Teaching 12: Yanpu Bay Mangrove Forest	Commentator, Yanpu Bay Mangrove Forest	Yanpu Bay Mangrove Forest, Cangnan County
		10:30-11:30	From Cangnan to Longgang	Mr. JIANG Yi, Program Officer, NAFGA, China	Longgang City
		12:00-13:00	Lunch	Mr. JIANG Yi, Program Officer, NAFGA, China	Manju Hotel, Longgang City
		14:00-16:30	On-Site Teaching 13: Xinmeizhou Mangrove Wetland Park, Longgang Exhibition Hall	Commentator, Xinmeizhou Mangrove Wetland Park, Longgang Exhibition Hall	Xinmeizhou Mangrove Wetland Park, Longgang City
		17:30-18:30	Dinner	Mr. JIANG Yi, Program Officer, NAFGA, China	Manju Hotel, Longgang City
Nov 14th	Fri	08:30-10:00	From Longgang to Wenzhou	Mr. JIANG Yi, Program Officer, NAFGA, China	Wenzhou City

Date	Day	Time	Activities	Lecturer/Moderator/Institute	Location
		10:00-11:30	On-Site Teaching 14: Dongtou Mangrove Ecological Park	Commentator, Dongtou Mangrove Ecological Park	Dongtou Mangrove Ecological Park, Wenzhou City
		12:00-13:00	Lunch	Mr. JIANG Yi, Program Officer, NAFGA, China	Yuli Kitchen Restaurant， Wenzhou City
		13:00-14:30	From Wenzhou to Yueqing	Mr. JIANG Yi, Program Officer, NAFGA, China	Yueqing City
		14:30-15:30	On-Site Teaching 15: Ximen Island Marine Special Reserve	Commentator, Ximen Island Marine Special Reserve	Ximen Island Marine Special Reserve, Yueqing City
		17:30-18:30	Dinner	Mr. JIANG Yi, Program Officer, NAFGA, China	Zhouyi International Hotel, Wenzhou City
Nov 15th	Sat	09:00-10:00	Lecture 10: Monitoring and Protection of Migratory Birds in Mangrove Wetlands	Prof. ZHOU Haichao, Shenzhen University, China	Yizhou Hall, Zhouyi International Hotel
		10:00-11:30	Panel Discussion 2: Needs of Mangrove Restoration Research and Pilot Project	Prof. ZHOU Haichao, Shenzhen University, China	Zhouyi Hall, Zhouyi International Hotel
		11:30-11:40	Tea Break	Mr. JIANG Yi, Program Officer, NAFGA, China	Zhouyi Hall, Zhouyi International Hotel
		11:40-12:30	Closing Ceremony	Prof. BAO Daming Director General of the Interim Secretariat, International Mangrove Center	Zhouyi Hall, Zhouyi International Hotel **Dress code: IMC shirt*

Date	Day	Time	Activities	Lecturer/Moderator/Institute	Location
		14:00-17:00	Self study	Mr. JIANG Yi, Program Officer, NAFGA, China	Zhouyi International Hotel, Wenzhou City
		18:00-19:30	Farewell Dinner	Prof. BAO Daming Director General of the Interim Secretariat, International Mangrove Center	Zhouyi International Hotel
Nov 16th	Sun	All Day	Departure	Mr. JIANG Yi, Program Officer, NAFGA, China	Wenzhou City

Annex 2: List of Participants

No.	Name	Nation	Gender	Position / Organization
1	Arzoumbila PEDABGA	Burkina Faso	Male	Program Officer, Secratariat Permanet du Conseil National pour le Developpement Durable
2	Ahamada RAHAMATA	Comoros	Female	Director, National Park of Comoros / Ramsar National Focal Point
3	Yosviel GONZALEZ RODRIGUEZ	Cuba	Male	Mangrove Researcher, Environmental Investigation and Service Center
4	Jean Fortune NTOUNA KAMBANGOYE	Gabon	Male	Deputy DG, Ministry of Water and Forest General Management of Aquatics Ecosystems
5	Abdoul Gadiri DIALLO	Guinea	Male	Director, Division of Forestry Development and Afforestation
6	Souphasay KOMANY	Lao PDR	Male	Deputy Director, Division of Reservoir Management, Department of Water Resources
7	Motoho MASEATILE	Lesotho	Male	Director, Department of Water Affairs
8	Levi Z PIAH	Liberia	Male	Division Chief, Environmental Protection Agency of Liberia
9	Julien Noël RAKOTOARISOA	Madagascar	Male	Director, Ministry of Environment and Sustainable Development (Mangrove Management NFP)
10	Andoniaina NARISOA EP RAZAFIMANDIMBY	Madagascar	Female	Deputy Director, Ministry of Environment and Sustainable Development (NFP)
11	Andriamandimbisoa Ratsimandresy RAZAFIMPAHANANA	Madagascar	Male	Senior Project Coordinator, Wildfowl and Wetlands Trust (WWT)
12	Jacinta LAISSONE	Mozambique	Female	Provincial Delegate, National Environmental Quality Control Agency
13	Daisy LUI	Samoa	Female	Forestry Officer, Forestry Department
14	Yatta Hellen KAMARA	Sierra Leone	Female	Manager, Wetlands and Marine Ecosystem Department / Ramsar NFP
15	Robert RWAFA	Zimbabwe	Male	Manager, Provincial Environmental Department
16	GAO Aimei	China	Female	Level I Consultant, Department of Ecological Restoration, Ministry of Natural Resources

17	MA Xiaohui	China	Female	Senior Engineer, National Forestry and Grassland Administration Investigation and Planning Institute
18	WAN Zemin	China	Male	Cadre, East China Survey and Planning Institute of National Forestry and Grassland Administration
19	SHU Wenjing	China	Female	Assistant Engineer, Central South Survey and Planning Institute of National Forestry and Grassland Administration
20	LU Xiang	China	Male	Cadre, Zhejiang Institute of Subtropical Crops
21	ZHANG Yunpeng	China	Male	Engineer, Fujian Provincial Forestry Investigation and Planning Institute
22	CHEN Fangyue	China	Female	Program Officer, Interim Secretariat of the International Mangrove Center

Annex 3: Technical Lectures

Annex 3.1: Overview of the International Mangrove Center


01 Significance 意义
International Mangrove Center
World' s first independent, non-profit, and inter-governmental international organization in mangrove conservation, serves as an ecosystem-based RRI of the Convention on Wetlands.
IMC是全球首个独立、非盈利的政府间红树林保护国际组织，是《湿地公约》框架下基于生态系统的区域倡议（RRI）
Serve and support Contracting Parties of the Ramsar Convention, particularly global south countries.
服务并支持《湿地公约》缔约方落实各项环境协议
5


02 Development
发展历程


02 Development 发展历程
Proposal at COP14
习总书记重要指示
• November 5, 2022, In COP14, the Chinese President Xi Jinping proposed establishing the International Mangrove Center in Shenzhen.
• 2022年11月5日，习近平总书记在《湿地公约》第十四届缔约方大会开幕式致辞提出：“在深圳建立国际红树林中心“
COP14 2022
7


02 Development 发展历程
RRI Proposal Adopted
区域动议提案通过
• On Sept. 6, 2023, the regional initiative proposal for establishing the IMC in Shenzhen was endorsed via Decision sc 62-22 at the 62nd Standing Committee Meeting of the Ramsar Convention.
• 2023年9月6日，《湿地公约》第六十二次常委会会议通过第sc 62-22号决定，正式批准在深圳建立国际红树林中心的区域倡议提案
Convention on Wetlands
62nd meeting of the Standing Committee
8


02 Development 发展历程
国际红树林中心成立协定正式签约
Official Signing of the Establishment Agreement of the International Mangrove Center
The Signing Ceremony of the EA of the IMC 国际红树林中心成立协定签署仪式
• On November 6, 2024, 18 founding member states signed the agreement and unveiled the plaque for the IMC.
• 2024年11月6日，国际红树林中心成立协定签署仪式在深圳举行，首批18个成员国代表正式签署协定并为国际红树林中心揭牌
9


03 Structure
组织架构


03 Mission 使命
Mission
To promote international cooperation and joint actions in mangrove conservation, restoration, and wise and sustainable use;
Strengthen the implementation of the Convention, and other relevant current and future environmental commitments, including but not limited to the Kunming-Montreal Global Biodiversity Framework, the Paris Agreement, the 2030 Agenda for Sustainable Development along with its Sustainable Development Goals (SDGs).
使命
IMC的使命是推动红树林保护、修复、合理与可持续利用方面的全球合作与共同行动。加强《公约》以及当前和未来其他相关环境承诺的履行，包括落实《昆明—蒙特利尔全球生物多样性框架》《巴黎协定》《2030年可持续发展议程》及其可持续发展目标


03 Objectives 目标
Promote knowledge sharing and strengthen joint research cooperation
推动在红树林保护、修复、合理与可持续利用方面的知识共享与合作研究
Enhance technology transfer and scientific and technical cooperation, and training
强化红树林保护、修复、合理与可持续利用方面的技术转让、科技合作与培训
Develop education, information, communication, and public awareness mechanisms
建立红树林和邻近湿地的教育、信息、交流和公众意识机制
Build and/or enhance capacity, and conduct pilot projects
开展并/或加强红树林保护、修复、合理与可持续利用方面的能力建设与试点项目
1
2
3
4


03 20 Member States
Central & South America
北美&中美
Cuba
古巴
Nicaragua
尼加拉瓜
Panama
巴拿马
Guinea
几内亚
Gabon
加蓬
Lesotho
莱索托
Burkina Faso
布基纳法索
Comoros
科摩罗
Africa
非洲
Liberia
利比里亚
Libya
利比亚
Madagascar
马达加斯加
Mozambique
莫桑比克
Sierra Leone
塞拉利昂
Sudan
苏丹
Zimbabwe
津巴布韦
Asia & Oceania
亚洲&大洋洲
Cambodia
柬埔寨
China
中国
Laos
老挝
Pakistan
巴基斯坦
Samoa
萨摩亚
3 Central & South America
北美&中美
12 Africa
非洲
5 Asia & Oceania
亚洲&大洋洲
13

03 Observers 观察员
UNEP
IUCN
WWF
Ramsar
BirdLife INTERNATIONAL
WWT
Wetlands
INTERNATIONAL WATER WASTE INFRASTRUCTURE
14

03 Operations 运作
The Council
理事会
Governing and decision-making body of the IMC. Composed of Member States, with each Member State designating one delegate.
Hold regular plenary sessions. Convene interim meetings as needed.
IMC治理与决策机构，由成员国组成，每个成员国指定一名代表
定期举行全体会议，根据需要召开临时会议
Scientific and Technical Subgroup 科技小组
Advisory body of the IMC.
Members of the Subgroup shall be recommended by Member States and selected by the Council.
IMC咨询机构
小组成员应由成员国推荐，并由理事会选定
The Secretariat
秘书处
Located in Shenzhen, China
Executing body of the IMC
Responsible for daily operations, under the authority and guidance of the Council.
位于中国深圳
IMC执行机构
负责日常运作，在理事会的领导和指导下开展工作

03 IMC Secretariat 秘书处
IMC
International Mangrove Center
16


03 IMC Secretariat 秘书处
Futian National
Nature Reserve
福田国家级自然保护区
IMC Secretariat (3,000㎡)
IMC 秘书处
China Mangrove Museum (35,000 ㎡)
中国红树林博物馆


04 Current Work
近期工作


04 Capacity Building 能力建设
Workshop on Mangrove
Conservation and Restoratio
July/November, 2024, June/September, 2025
国际红树林中心
红树林保护与修复国际研讨班
2024年7月、11月；2025年6月、9月
19


04 Ramsar COP 15 《湿地公约》COP15
IMC at COP 15
Side Event
主题边会
Awarded Regional
Initiative Certificate
授予湿地公约区域动议证书
Exhibition
主题展览
Zimbabwe
Joined the IMC
津巴布韦加入IMC
20


04
2025 World Coastal Forum
2025全球滨海论坛
IMC Thematic Workshop
IMC主题研讨会
21


04
IUCN World Conservation Congress IUCN世界自然保护大会
IMC 主题展览
IMC Thematic Exhibition
22


04
UN GEONOW 2025
第二届联合国地信周
UN GEONOW 2025
海岸带监测与生物多样性保护
Coastal Monitoring and Biodiversity Protection
UN GEONOW
Thematic Dialogue
专题对话
23


04
Projects & Resource Mobilization
项目及融资
Technical Exchanges 技术交流
UNDP
联合国开发计划署
WWF
世界自然基金会
CWA
中国湿地保护协会
MCF
红树林基金会
24


04 Council Meeting 理事会
First Council Meeting
第一次理事会
01
First Council Meeting 第一次会议
The first council meeting is scheduled to be held in Shenzhen, China 第一次理事会将在深圳举行
02
Document Preparation 文件准备
Charter, Rules of Procedure, and Strategic Plan have completed the opinion solicitation phase.
《章程》《议事规则》与《战略计划》已完成意见征询
03
Nominations of Council Member and FP
理事会成员及联络员提名
15 countries have nominated their council members and focal points
China' s nominations for council member, and FP are in progress
已有15个国家提名了理事会成员及国家联络人。
中方理事及联络人提名程序正在进行中。
25


04 Official Website
IMC Website www.imc.int Officially Launched on July 17
Home
About
Our Work
Resources
IMC Event during COP15
IMC Hosts Side Event on Global Mangrove and Wetland Conservation During Ramsar COP15


Thank you!
International Mangrove Center

Annex 3.2: Promoting a New Type of International Relations in Forest Sector

Promoting a new type of international relations, what China's forest sector has done

Dr. XIA Jun

Department of International Cooperation, NFGA/NPA

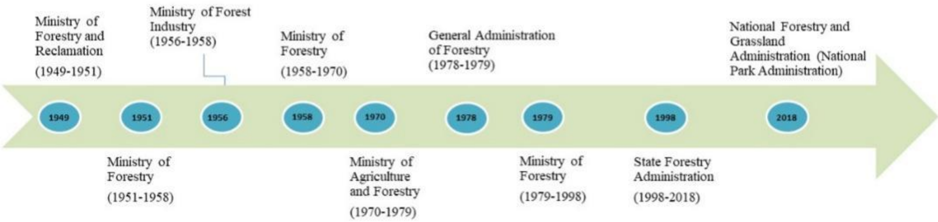
November, 2025

Outline

1. **A glimpse of China's forest sector**
2. **Efforts in promoting a new type of international relations, from past to present and future**
3. **Our stance on global forest issues**
4. **Q & A**

1. A glimpse of China's forest sector

Evolution of China's central forest department since 1949



1. A glimpse of China's forest sector

National Forestry and Grassland Administration/National Park Administration **is formed after China's government restructuring in 2018. It is under the Ministry of Natural Resources, mandated with:**

- **protection, management and utilization of forest, grassland, wetland, desert and terrestrial wildlife resources;**
- **conservation and rehabilitation of forest and grassland ecosystems;**
- **desertification prevention and control; and**
- **supervision and management of natural protected area system, with national parks as the mainstay**

NFGA

National Forestry and Grassland Administration/National Park Administration

1. A glimpse of China's forest sector/forest resources

Legislation

***Forest Law*, first introduced in 1984, last revision in 2019, came into force July, 2020**

Priorities for the next five years: 2026-2030

- entering the new phase of coordinated development between high-level conservation and high-quality development

Comprehensive Protection and Management of All Ecological Elements

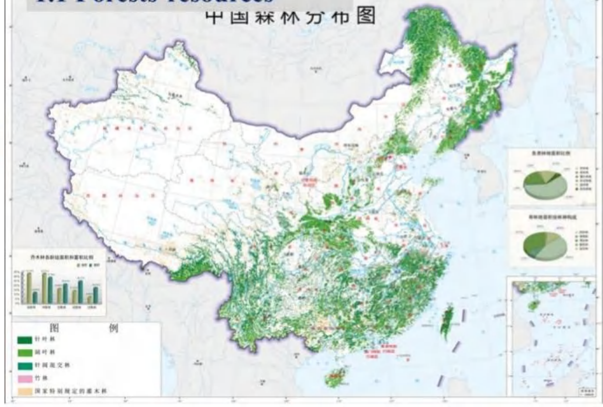
Integrated Development of the Entire Forest and Grassland Industry Chain

Differentiated Management and Control Across All Forest and Grassland Spaces

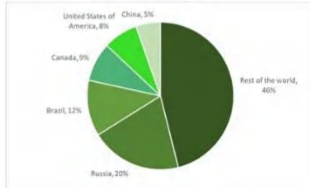
Comprehensive Land Consolidation Across All Regions

1. A glimpse of China's forest sector

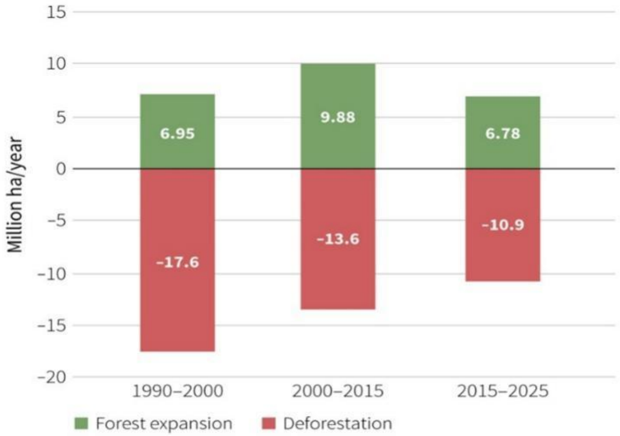
1.1 Forests resources



Forestland 284 m ha
Forest area 247 m ha
Stock volume 20.988 b m^3
Forest cover 25.09%
Plantation 92.4m ha



All data in this paper excludes HK, Macau & Taiwan of China



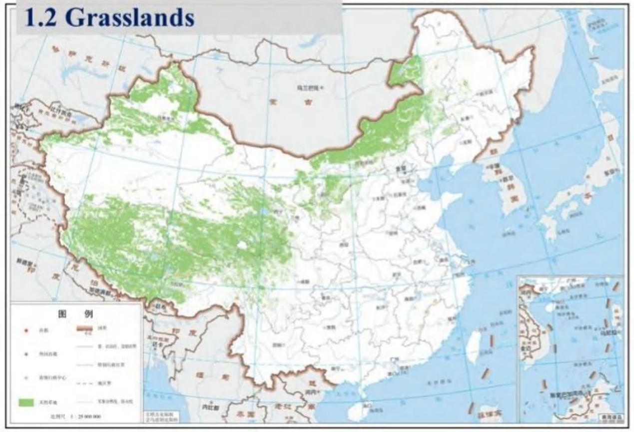
Global annual rate of forest expansion and deforestation, 1990-2025, FAO FRA

Top 10 countries for average annual net gain in forest area, 2015-2025

Ranking	Country	Annual net change	
		1 000 ha/year	%
1	China	1 686	0.77
2	Russian Federation	942	0.11
3	India	191	0.27
4	Türkiye	118	0.53
5	Australia	105	0.08
6	France	95.9	0.56
7	Indonesia	94.1	0.10
8	South Africa	87.6	0.39
9	Canada	82.5	0.02
10	Viet Nam	72.8	0.51

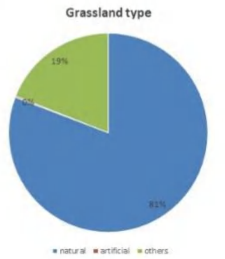
1. A glimpse of China's forest sector

1.2 Grasslands



Grassland 263m ha

Comprehensive vegetation cover 50%



1. A glimpse of China's forest sector/grasslands

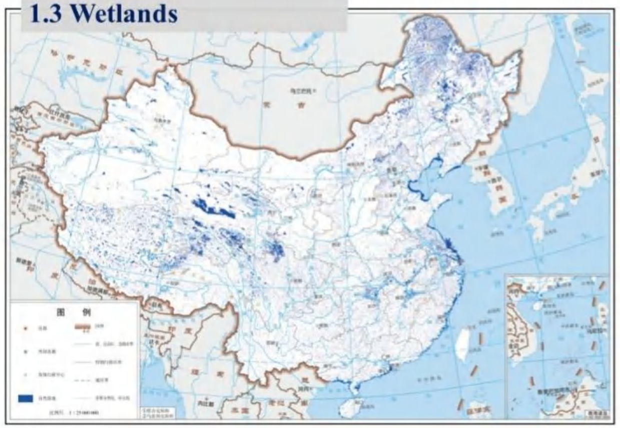
1.2.1 Legislation

***Grassland Law*, first introduced in 1985, latest revision in 2021**

Principle: science-based planning, overall protection, focused development and wise use, with a view to promote sustainable utilization of grassland, and coordinated ecological, economic and social development.

1. A glimpse of China's forest sector

1.3 Wetlands



Wetland area 56.35m ha/5.87%

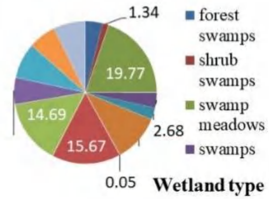
55% within ecological Redline

80 Wetland of National Importance

82 Wetland of International importance

22 International Wetland Cities

Carbon sink 77m t/y



1. A glimpse of China’s forest sector/wetland

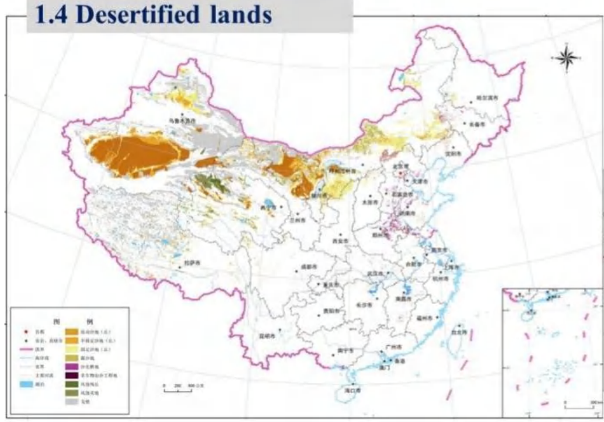
1.3.1 Legislation

Wetland Protection Law, released in 2021

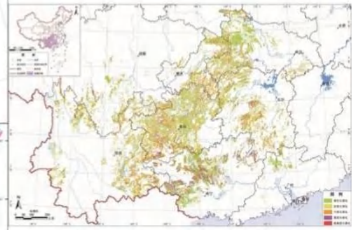
Principle: protection as priority, strict management, systematic control, science-based restoration and wise use in wetland protection, so as to play multiple ecological functions of wetland ecosystem in conserving water, regulating climate, improving environment and conserving biodiversity.

1. A glimpse of China’s forest sector

1.4 Desertified lands



Desertified land 257.37m ha/26.81%
Annual decrease 757,600 ha
Sandified land 168.78m ha/17.58%
Stony desertified land 7.22m ha/0.75%



Stony desertified land/Karst

1. A glimpse of China’s forest sector/desertification control

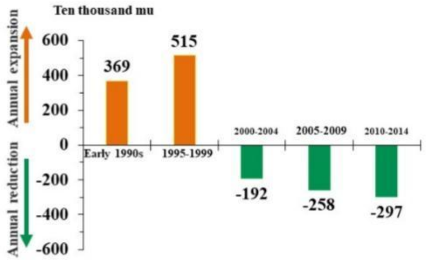
1.4.1 Legislation

Sand Prevention and Control Law, introduced in 2001, last revision in 2018

Principles:

- unified planning, site-specific, phased approach and combination of control in general and key regions;
- prevention first, combination of prevention and control, and integrated management;
- combination of protection and rehabilitation of vegetation and wise use of natural resources;
- follow rules of nature and rely on scientific innovation;
- combination of ecological improvement and poverty alleviation of rural herdsman;
- combination of central support and self-reliance of localities, government organization and participation of all walks of life, encourage contracting by units and individuals;
- all legal rights and benefits of participants in sand prevention and control shall be protected.

1. A glimpse of China’s forest sector/desertification control



Annual change in desertified land area (1990-2014)

1. A glimpse of China's forest sector

1.5 Wild fauna & flora

- Vertebrate species: 8600 (world No.4)
- Higher plants: 39330 (world No. 3)
- 85% wild population of national importance under effective protection
- Trees of historical & cultural values: 5.08m (10700 over 1,000 y)

1. A glimpse of China's forest sector/wild fauna & flora

1.5.1 Legislation

Wildlife Conservation Law, introduced in 1988, last revision 2022, come into force on May 1, 2023

Principles: protection as priority, regulated use and strict control, and encourages those activities of conducting scientific research of wildlife, raising awareness of the public in wildlife conservation, and promoting harmony between man and nature

1.5.2 National programs

- Endangered species rescue and protection (48 species, Giant Panda, Asian Elephant, Hainan Gibbon, etc.)
- Pilot for prevention of animal damage (wild boar, Asian Elephant, etc.)
- Protection and breeding of rare and endangered wild flora
- List of Key Protected Wild Animals of National Importance
- List of Key Protected Wild Plants of National Importance
- List of Terrestrial Wild Animals of Important Ecological, Scientific and Social Values
- Invasive alien species under priority management

1. A glimpse of China's forest sector

1.6 Protected Areas

- Proposal to designate natural forest protection areas at 1st session of the 1st National People's Congress, 1956
- Dinghushan Nature Reserve, Guangdong
- A system of natural protected areas:
  - National Park
  - Nature Reserve
  - Nature Park

1. A glimpse of China's forest sector/NP

1.7 National Park

National Park Law, approved in September 2025, will take effect on 1 Jan 2026

Spatial Layout of National Parks: identifies 49 National Park candidates, representing China's 39 natural ecological and geographic regions. Once completed, this National Park System, occupying 1.1million km²/10.3% of China's land territory, will be the largest NP system in the world.

Spatial Layout of China's National Park System

Five National Parks set up in 2021

	Name	Province	Size (km^2)	Features
1	Three-River-Source (Sanjiangyuan)	Qinghai, Tibet	190700	River source of YZ, Yellow River and Lancang-Mekong River
2	NE China Tiger and Leopard	Jilin, Heilongjiang	14100	NE Tiger and NE Leopard
3	Giant Panda	Sichuan, Shaanxi, Gansu	22000	Giant Panda
4	Hainan Tropical Rainforest	Hainan	4269	Tropical rainforest, wildlife
5	Wuyishan Mt.	Fujian, Jiangxi	1280	Primary forests, Danxia landform

1. A glimpse of China's forest sector

1.8 Forest industry & prataculture

- **Overall grass output value: RMB 10.496 trillion (2024)**

  Four pillar industry with annual output value over RMB 1 trillion
  - **Timber processing**
  - **Non-timber forest products**
  - **Eco-tourism**
  - **Understory economy**

2. Efforts in promoting a new type of international relations

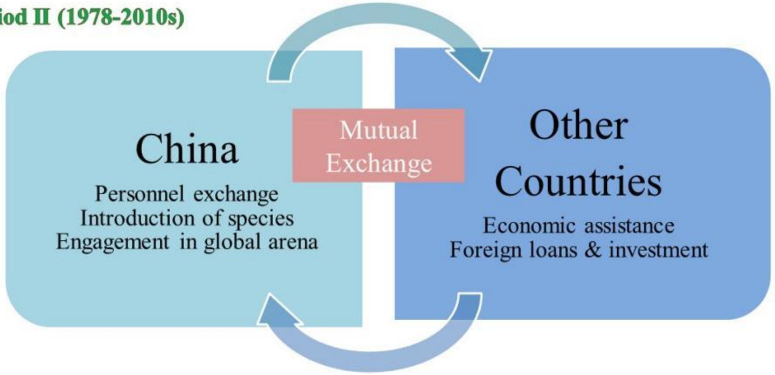
2.1 Three phases in international cooperation

Period I (1949-1978)

2. Efforts in promoting a new type of international relations

2.2 Three phases in international cooperation

Period II (1978-2010s)



2. Efforts in promoting a new type of international relations

2.2.1 Symbolic events after the reform

- **Joint Working Group on Forestry (JWG) est. under China-Finland Agreement in 1979, and STILL running**
- **Mar. 3, 1981, China-Japan Agreement on Migratory Species Conservation, and STILL effective**
- **NZ forest minister's visit to China 1980**
- **China's approval of accession to CITES on Dec., 25, 1980 and effective on Apr., 8, 1981**

2. Efforts in promoting a new type of international relations

2.2.2 Form of cooperation

- **High-level exchanges**
- **Introduction of tech. & equipment**
- **Engagement in international forest arena**
- **Foreign assisted national programs (grants + loans)**
- **Bilateral agreements on forests**
- **Sci. & tech. exchange**

2. Efforts in promoting a new type of international relations

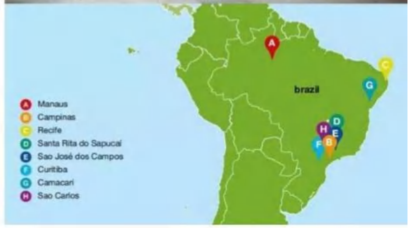
Economic cooperation

- **Australian International Development Assistance Bureau (AIDAB) 1981, Demonstration of Eucalyptus Forest in Guangxi, first EC project**
- **Multilateral/bilateral donors: WFP, UNDP, FAO, WWF/Canada, Australia, Japan, West Germany, Sweden (1981-86 value at $ 134m, $ 104m in grant)**
- **Loans from WB and other donors**

2. Efforts in promoting a new type of international relations

Procurement & Investment

- A 30,000 m³ single layer press particleboard production line from Bison, Germany to Bejing Timber Plant in 1979
- Jilin Linjiang Particleboard Plant, equipment also from Bison, Germany, 1982
- 1983, Brazil Huaxi Wood Industry Co. Ltd, first Chinese enterprise overseas, $ 4 m investment
- Other equipment includes nursery, seed processing, MDF, forestry chemicals, helicopter



2. Efforts in promoting a new type of international relations

Reintroduction of species

- David's Deer reintroduced from UK in 1986
- Przewalski's Horse (Equus ferus ssp. *Przewalskii*), reintroduced from UK and Germany in 1986, successful in breeding in the wild

Introduction of fast-g

- Eucalyptus from A
- *Populus euramevic*

2. Efforts in promoting a new

NGO cooperation

- MOU signed with WWF on Mar.


History is n

China signs with WWF

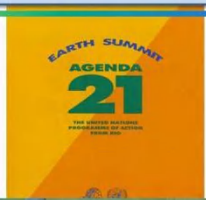
PEKIN

2. Efforts in promoting a new type of international relations

Extensive academic & tech. excha

- Scholar visits
- Foreign experts/teachers
- Overseas scholarships
- Technical training in other cou
- Study tours
- Seminars & workshops
- Joint research & investigation

2. Efforts in promoting a new type of international relations



Rio Earth Summit, 1992

NON-LEGALLY BINDING AUTHORITATIVE STATEMENT OF PRINCIPLES FOR A GLOBAL CONSENSUS ON THE MANAGEMENT, CONSERVATION AND SUSTAINABLE DEVELOPMENT OF ALL TYPES OF FORESTS

China's Agenda 21, Forestry Action Plan

China's sustainable forestry development is subject to or serve for the overall sustainable development of entire nation, and shall constantly satisfy the needs of national economic development and increasing livelihoods for material products and ecological services, so as to realize the integration of ecological, economic and social benefits in forestry.

- By early 2000, a foundation is laid for a relatively comprehensive ecological system and relatively developed industrial system in forestry;
- By 2050, a relatively comprehensive ecological system and relatively developed industrial system is put in place

2. Efforts in promoting a new type of international relations

Sino-German Cooperative Afforestation & Reforestation Program (KfW)

- first project launched in 1993
- involves 17 provinces, autonomous regions & municipalities in China
- total grant from Germany: € 186m
- loans: € 28.5m
- 607,880 ha forest planted (managed)
- 50 nurseries est. & 1,200,000 trained

2. Efforts in promoting a new type of international relations

Global Environment Fund (GEF)

- funded in 1991 by WB
- first project in the forest sector: Nature Reserves Management, 1995
- 19 projects (programs) in China, total grant $ 139.8m
- areas: biodiversity (wildlife, migratory birds), SFM, climate change, land degradation management, wetland & natural protected areas

2. Efforts in promoting a new type of international relations

2.2.3 Expanded Scope and form of Cooperation after 2000

- Forests, wetland, desertification control, wildlife
- Twinning
- Joint case study
- Collaborative research
- Academic workshop, seminars
- Exchange of specialists
- Information sharing (publications, journals, etc)
- Demonstration projects

2. Efforts in promoting a new type of international relations

Sustainable forest management overseas

- Guidelines on sustainable overseas silviculture, forest management & utilization, and trade & investment by Chinese enterprises issued by NFGA & Ministry of Commerce
- Forest resources development planning
- Alternative livelihood/trees for drugs
- Sustainable product trade

2. Efforts in promoting a new type of international relations

Increased cooperation with developing countries

- Training courses/seminars since 1993, 214 courses, 123 countries, 6400+ person/times
- Technical cooperation: Pest & disease Control in Maldives, Bamboo plantation in Rwanda
- Bilateral agreements with developing countries after 2000
- China Aid projects financed by Ministry of Commerce (MOC), and China's International Development Cooperation Agency (CIDCA)

2. Efforts in promoting a new type of international relations

2.3 Three phases in international cooperation

Period III—the New Era

Promote Harmony between Humanity and Nature

Build a Community with a Shared Future for Mankind

2. Efforts in promoting a new type of international relations

2.3.1 Forest features in Head-of-State Diplomacy

Panda diplomacy

H.E. President Xi & Mme. Peng
H.E. King Philippe & Queen Mathilde
Mar 30, 2014, Pairi Daiza, Belgium

2. Efforts in promoting a new type of international relations

The

2. Efforts in promoting a new type of international relations

Ramsar COP14

- Nov. 5-13, 2022, in Wuhan & Geneva
- Wetlands Actions for People and Nature
- 142 contracting parties, international organizations, 950 plus participants
- Ramsar Post-2025 Strategic Plan
- Wuhan Declaration
- Establishing International Mangrove Centre (IMC) in Shenzhen, China

Ramsar COP15

- July, 2025, Victoria Falls, Zimbabwe
- China handover to Zimbabwe

2. Efforts in promoting a new type of international relations

International Mangrove Center

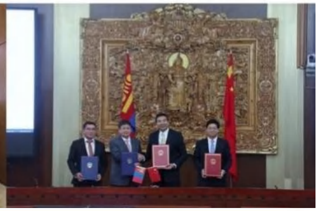
- Nov. 6, 2024, IMC Establishment Agreement signed in Shenzhen, China
- 18 founding members: Burkina Faso, Cambodia, China, Comoros, Cuba, Gabon, Guinea, Laos, Lesotho, Liberia, Libya, Madagascar, Mozambique, Nicaragua, Pakistan, Panama, Samoa, Sierra Leone
- 2 more: Zimbabwe, Sudan

IMC International Mangrove Center

2. Efforts in promoting a new type of international relations

China-Mongolia Cooperation Center for Combating Desertification

- Agreed in the meeting between Pres. XI and Pres. Khurelsukhb on Nov. 28, 2022 in Beijing
- MOU signed on Sept. 1, 2023
- Inaugurated in Ulan Bator



2. Efforts in promoting a new type of international relations

China-Arab International Research Center for Drought, Desertification and Land Degradation

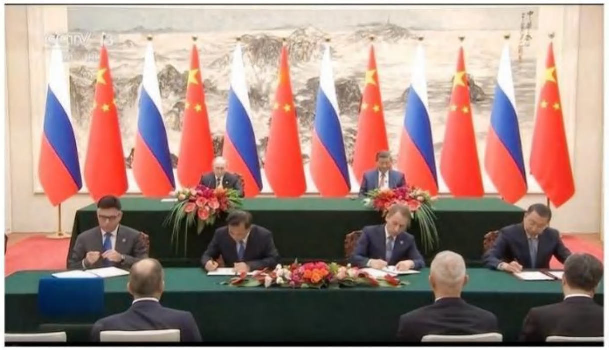
- An outcome among Eight Major Cooperation Initiatives at the First China-Arab States Summit on December 9, 2022
- A Collaborative program between NFGA and General Secretariat of League of Arab States
- Signed and inaugurated in Kubqi, Inner Mongolia, August 26, 2023
- On-the-ground projects invested by private sector

2. Efforts in promoting a new type of international relations

UNCCD COP13

- Sept. 6-17, 2017, Erdos, Inner Mongolia
- Combating Desertification for Human Well-being
- 190 contracting parties, 32 international organizations, 108 NGOs, 2000+ participants
- UNCCD Strategic Framework 2018-2030, + 35 resolutions
- 113 countries committed their national voluntary contributions to Land Degradation Neutrality (LDN) 2030

2. Efforts in promoting a new type of international relations



Bilateral MoUs

Chinese President Xi Jinping & Russian President Putin, witnessing Agreement signed between NFGA & Russian Ministry of Natural Resources, 16 May 2024, Beijing

Agreement between the Russian Federation and the People's Republic of China on the creation of the Land of Big Cats Reserve

2. Efforts in promoting a new type of international relations

17 governmental agreements with **10** countries
116 MOUs with forest-related agencies of **62** countries
6 MOUs with **4** regional organizations
3 International Conventions and the UNFI
2 International organizations with headquarters in China
11 NGOs operating in China

NFGA/NPA and the world, a greater picture

2. Efforts in promoting a new type of international relations

2.3.2 NFGA in major-country diplomacy with Chinese characteristics

2.3.2.1 Neighboring countries

- **5 governmental agreements** with 2 countries, **13 MOUs** with 9 countries out of 14 neighboring countries that share land boundaries with China
- **4 governmental agreements** with 3 countries, **15 MOUs** with 4 countries out of 8 neighboring countries that share maritime boundaries with China
- Sub-regional mechanisms: Lancang-Mekong Cooperation, Great Central Asia Forestry Cooperation, APFNet, China-Japan-Korea, DLDD-NEAN
- Featured collaborative areas: trans-boundary wildlife conservation, fire prevention & control in border areas, desertification control, integrated eco-system management, migratory birds

2. Efforts in promoting a new type of international relations

Mongolia Gobi Bear Conservation

- Technical assistance supported by China's International Development Cooperation Agency (IDCA), including technical know-how and equipment
- Mongolian counterpart: Ministry of Natural Environment and Tourism
- Implementing agency: Chinese Academy of Forestry, in collaboration with Mongolian Academy of Science
- Originally designed for 2018-2021, extended to 2024 due to pandemic
- First technical assistance project in wildlife conservation since 1978

2. Efforts in promoting a new type of international relations

Project components

- Geo-info system setup & habitat quality assessment
- Assessment of population number
- Population dynamics of main dietary plants
- Monitoring of habitat biodiversity
- Training of technical & and managerial staff
- Equipment supply: prefabricated houses, off-road vehicles, motorcycles, etc.

2. Efforts in promoting a new type of international relations

2.3.2.2 Developing countries

- Collaborative platforms: China-ASEAN, China-Africa Cooperation Forum, China-Arab State Cooperation Forum, China-CEECs
- 148 training courses/workshops for 5546 participants from 106 developing countries since 2013
- Technical cooperation: Pest & disease Control in Maldives, Bamboo development & utilization in Africa, High Value Tree Species Breeding in Cambodia, Sandal wood development/SPC
- Sustainable management and trade: Guidelines on sustainable overseas silviculture, forest management & utilization, and trade & investment by Chinese enterprises issued by NFGA & Ministry of Commerce
- China Aid projects/CIDCA: China-Africa Bamboo Center in Ethiopia

2. Efforts in promoting a new type of international relations

Bamboo establishment, processing and utilization in Rwanda (2009-2019)

- Total grant of RMB 25m financed by MOFCOM, jointly carried out by Rwanda Ministry of Natural Resources and China's National Bamboo Research Center (CBRC)
- CBRC offers technical know-how, equipment, machinery and experts
- Introduction of Chinese bamboo species, over 400 ha plantation, bamboo nurseries
- Bamboo curtain & furniture processing equipment
- Over 2000 trainees in bamboo planting & processing

2. Efforts in promoting a new type of international relations

2.3.2.3 Major countries

- High-level dialogue
- Global issues: forest & climate change, illegal logging & associated trade, etc.
- Various forms of collaboration: twinning, joint case study, collaborative research, academic workshop/seminars, exchange of specialists, demonstration projects
- Various levels of collaboration: government agencies, research institutes, people-to-people, NGOs

2. Efforts in promoting a new type of international relations

2.3.2.4 Global governance

Name	Enter into force	No. of Parties	Location of Secretariat	Date of accession	Sequence
UNCCD	1996.12.26	197	Bonn, Germany	1997.02.18	No.60
CITES	1975.07.01	184	Geneva, Switzerland	1981.04.08	No.63
Ramsar	1975.12.21	172	Gland, Switzerland	1992.03.31	No.68
UNFI	2007.04.28		New York, U.S.	——	——

International convention implementation and engagement by NFGA

Name	National implementation coordination	Legislation	China's share	No.	Posts by China
UNCCD	National Office, led by NFGA	Sand Prevention & Control Law	Swiss Franc 746,880	2	H.E. ZHANG Jianlong: COP 13 President and Bureau President (2017-2019) ZHONG Jing: Vice-president of COP 15 Bureau (2022-2024)
CITES	National Office, led by NFGA	Wildlife Conservation Law Regulations on Import & Export	€ 1,145,655	2	China: SC Vice-chair (2016-2022)
Ramsar	National Office, led by NFGA	Wetland Protection Law	$ 977,102	2	LI Chunliang: COP14 Chair Dr. XIA Jun: SC chair (2022-2025)
UNFI	National Focal Point-NFGA	Forest Law	voluntary con. $ 200,000	N.A.	WU Zhimin: Chair of UNFF 11 & 12 (2013-2017)

China & UNFF
National Pilots for SFM

- Demonstration of SFM and UNFI at ground level
- Started in 2012, 17 in total
- Chosen for their forest type, ownership, economic and social conditions, etc.
- National Park, state-owned forest farm, county forest bureau, state-owned forest company, nature reserve, etc.
- Guidelines and measures are provided by NFGA
- National expert group
- Co-financing between NFGA & executing bodies

2. Efforts in promoting a new type of international relations

International orgs est. in China

INBAR

- Nov.11, 1997, *International Network for Bamboo and Rattan* est. in Beijing
- 1st non-profit inter-governmental organization with headquarters in China
- Its mission is to improve the well-being of producers and users of bamboo & rattan within the context of a sustainable bamboo & rattan resource base by consolidating, coordinating and supporting strategic and adaptive research and development
- 9 founding members: China, Canada, Bangladesh, Indonesia, Myanmar, Nepal, Philippines, Peru and Tanzania

2. Efforts in promoting a new type of international relations

Ramboo & rattan in global trade

- Global bamboo & rattan industry is valued at $ 60b
- Global trade of bamboo & rattan is around $ 2.5b
- Most bamboo & rattan products are locally consumed
- China is one of the largest countries in bamboo & rattan production & consumption, the largest for bamboo products export

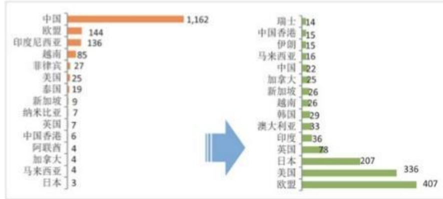


图3 2016年竹藤商品贸易主要进出口国家和地区

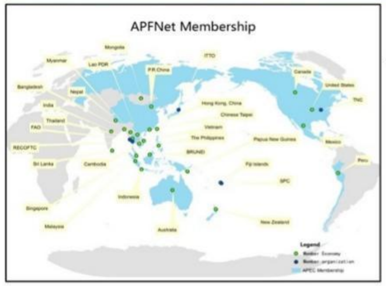
2. Efforts in promoting a new type of international relations

International orgs est. in China

APFNet

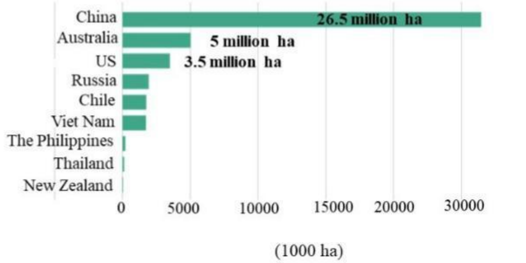
- Proposed by China, sponsored by Australia and the US 2007 in Sydney, "establish an *Asia Pacific Network for Sustainable Forest Management and Rehabilitation* to enhance capacity building and strengthen information sharing in the forest sector and work to achieve an APEC-wide aspirational goal of increasing forest cover in the region by at least 20 million hectares of all types of forest by 2020"
- Non-profit international organization with its headquarter in China
- Launched in Beijing 2008

2. Efforts in promoting a new type of international relations



Now 27 members economies and 5 member organizations, an American office in UBC, Canada

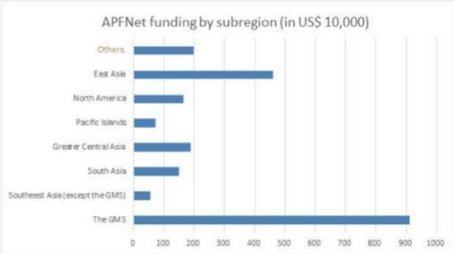
APFNet & FAO APEC forest cover change assessment 2021 found 27.9m ha of forests is gained in the APEC region 2007-2020



2. Efforts in promoting a new type of international relations

APFNet activities are focused on capacity building, demonstration projects, information sharing and policy dialogue

Year	No. of projects	APFNet funding (10,000US$)	Percentage
2010	4	158	7.2%
2011	6	459	20.9%
2012	2	60	2.7%
2013	3	106	4.8%
2014	3	356	16.2%
2015	8	412	18.7%
2016	4	325	14.7%
2017	7	326	14.8%
Sub-total	37	2201	100.0%



2. Efforts in promoting a new type of international relations

Global Development Initiative (GDI)

Bamboo as a Substitute for Plastic

An initiative co-launched by China and INBAR set to harness the potential of bamboo to alleviate plastic pollution while mitigating climate change

2. Efforts in promoting a new type of international relations

Global Development Initiative (GDI)

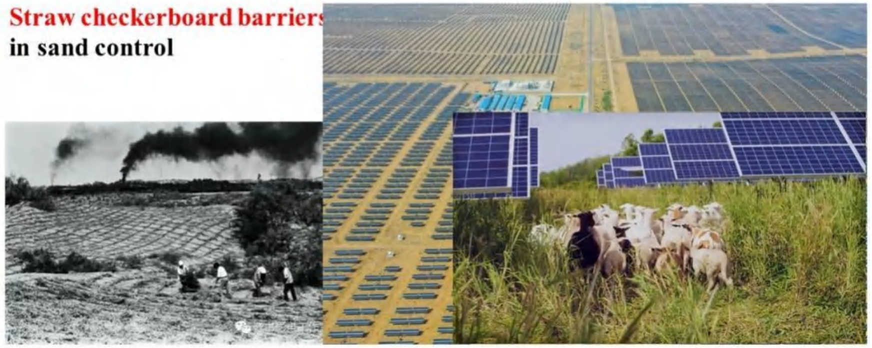
Global Network for Sustainable Forest Management

Officially launched Oct. 24, 2023, for SDG goals through enhancement of economic, social and ecological functions of forests and green, low-carbon development globally

2. Efforts in promoting a new type of international relations

Innovation in technologies

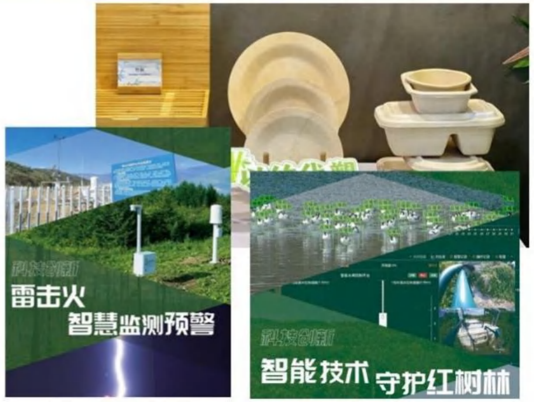
- **Straw checkerboard barriers in sand control**



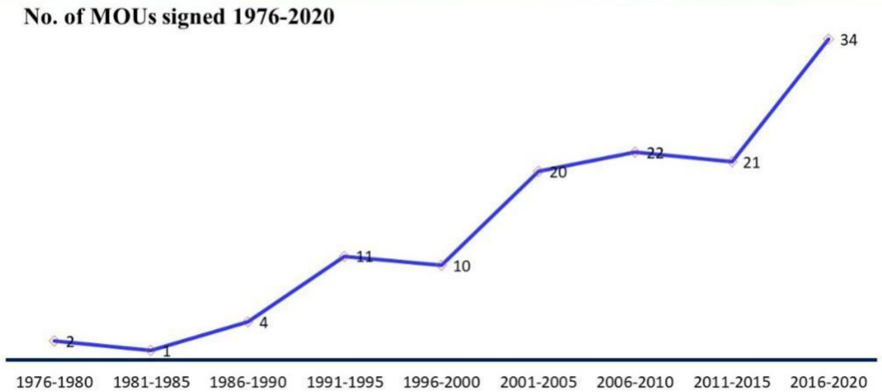
2. Efforts in promoting a new type of international relations

Innovation in technologies

- Bamboo as a substitute for plastics
- Thunder lightening early waring
- Mangrove monitoring



2. Efforts in promoting a new type of international relations



3. Foreign policies on major issue

3.1 A World at Crossroads

- International politics: regional conflicts, decoupling, de-globalization, North-South, South-South
- Almost all developing countries in the world are still facing the problem of economic growth vs. environment protection amid a sluggish post-pandemic recovery
- Major challenges to forest and ecosystems persist: fragmented global governance, climate change, biodiversity loss, deforestation & forest degradation, food security vs. forest protection, SDG2030

3. Foreign policies on major issue

3.2 China's position and stances

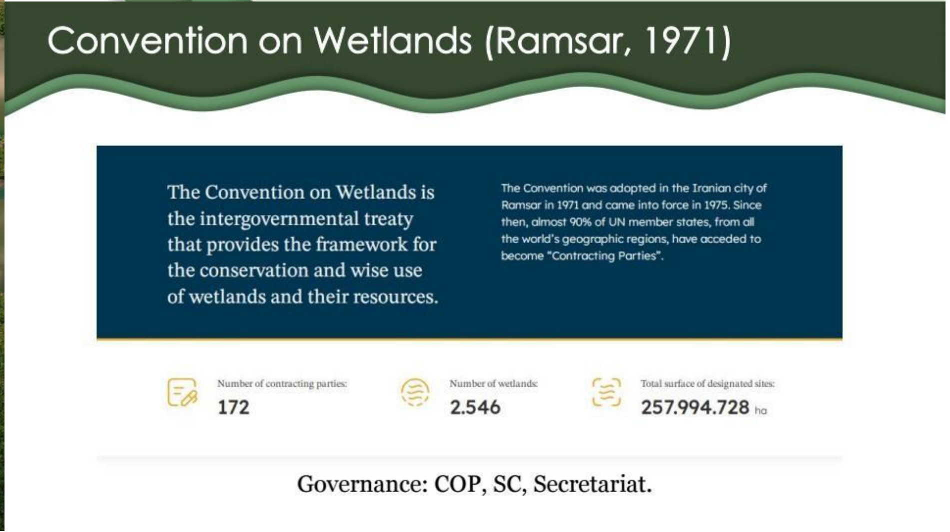
- The largest developing country, Global South
- National sovereign right & equity
- Right of development for developing countries
- Improve global governance & promote harmony between humanity and nature
- Sustainable forest management (GOs on Forests, SDGs)

A time to endeavor

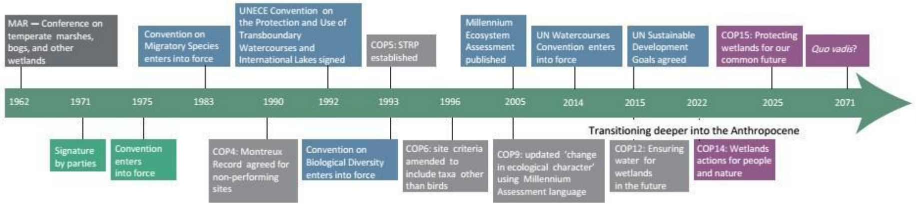
Where mountains stand in verdant row
With limpid streams that roll and flow
And fragrant flowers blossom and grow
While birdsongs echo in each hollow
Dressing landscapes in finest silk
Homeland turns to a masterpiece in every view

—Liang Xi, 'My Vision', 1951

Annex 3.3: China's Wetland Conservation and Ramsar Implementation



Convention on Wetlands (Ramsar, 1971)



Peter Bridgewater and Rakhyun E. Kim 2021

Convention on Wetlands (Ramsar, 1971)

Origin: large area of marshland and other wetlands in Europe were being "reclaimed" or otherwise destroyed, with decline in numbers of waterfowl.

Dr Luc Hoffmann
(1923–2016)

- Swiss ornithologist, conservationist, and philanthropist.
- Project MAR initiated in 1962
- "MARshes", "MARécages", "MARismas"
- Co-founder of WWF

Prof. Geoffrey Matthews
(1923–2013)

- British ornithologist
- Director of IWRB
- Contribute to convention text

Mr Eskander Firouz
(1926–2020)

- Director of Iran's Game and Fish Department
- Organizer of Ramsar meeting in 1971

Convention on Wetlands (Ramsar, 1971)

Ramsar Convention Brisbane Australia 1996

40 Ramsar 1971-2011

Convention on Wetlands 50 YEARS

COP14 2022

Convention on Wetlands COP15 Zimbabwe

2 February 1971, the Convention on Wetlands of International Importance especially as Waterfowl Habitat agreed by 18 nations

February 2011, the Convention celebrated its 40th anniversary.

On November 5, 2022, the COP14 of the Convention opened simultaneously in Wuhan and Geneva, which coincided with the 30th anniversary of China's accession to the Convention.

On July 23, 2025, the COP15 opened in Victoria Falls, Zimbabwe, and China successfully hosted an Exhibition and a Side Event on the Conservation.

Convention on Wetlands (Ramsar, 1971)

Mission

"The conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world."

A **broad** definition of Wetlands includes all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans.

Convention on Wetlands (Ramsar, 1971)

It has been 54 years since the adoption of the Convention, and the objectives of the Convention on Wetlands have shifted from the protection of waterfowls and their habitats at the beginning to the wetland ecosystem conservation and wise use of the wetlands.

Convention on Wetlands (Ramsar, 1971)

Three Pillars: Wise use

At the centre of the Convention on Wetlands philosophy is the "wise use" of wetlands.

1987 COP3 Regina, Canada

"The wise use of wetlands is their sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem".

Sustainable utilization was defined as "human use of a wetland so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations".

Natural properties of the ecosystem were defined as "those physical, biological or chemical components such as soil, water, plants, animals and nutrients, and the interactions between them".

1990 Guidelines for the implementation of the wise use concept.

"the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development".

Convention on Wetlands (Ramsar, 1971)

Three Pillars: Ramsar list

Each Contracting Party must designate at least one wetland site within their territory for inclusion in the List of Wetlands of International Importance (the "Ramsar List").

Convention on Wetlands (Ramsar, 1971)

Three Pillars: International Cooperation

The Convention on Wetlands provides the **single most global framework** for intergovernmental cooperation on wetland issues.

Article 5 of the Convention establishes that "the Contracting Parties shall consult with each other about implementing obligations arising from the Convention especially in the case of a wetland extending over the territories of more than one Contracting Party or where a water system is shared by Contracting Parties. They shall at the same time endeavour to coordinate and support present and future policies and regulations concerning the conservation of wetlands and their flora and fauna."

Transboundary Wetlands of International Importance
67 by 2024, 2.66%

Ramsar Regional Initiatives
22 RRIs by 2024

Convention on Wetlands (Ramsar, 1971)

Ramsar Regional Initiatives

Definition

Ramsar Regional Initiatives (RRIs) under the Convention on Wetlands are intended as Operational Means to provide effective **support** for improved **implementation** of the Convention and its **strategic plan** in specific geographic regions, through voluntary international cooperation on wetland-related issues of common concern. Regional Centers for training and capacity building, and Regional Networks to facilitate cooperation.

CWI	MedWet	EAAFP	Ramsar CREHO		RRC-EA		International Mangrove Center
2009 Europe 7 countries	1999(1991) **Europe** **Africa** **Asia** 27 Countries	2005 **North America** **Asia** **Oceania** 17+1 countries	1999(2004) Latin America & Caribbean North America 30 countries	2009 Latin America & Caribbean 14 countries	2009 East Asia 18 countries	2002 Central and West Asia 18+3 countries	2023 International Mangrove Center >18 countries

Regional Centres (4)	Regional Networks (18)				
1) CREHO	1) MedWet	5) BlackSeaWet	9) Mangroves & Coral Reefs	13) Amazon	17) IMC
2) RRC-CWA	2) WACoWet	6) Carpathian WI	10) River Plate Basin	14) IBRRI	18) Danube
3) RAMCEA	3) High Andean	7) NorBalWet	11) NigerWet	15) RRI-CA	
4) RRC-EA	4) EAAFP	8) CariWet	12) SenegalWet	16) SADC	

Convention on Wetlands (Ramsar, 1971)

Governance

The Conference of the Contracting Parties (COP)
The Standing Committee (SC)
The Scientific and Technical Review Panel (STRP)
The Communication, capacity building, education, participation and awareness (CEPA) Oversight Panel
International Partners(Birdlife International, IUCN , WI,WWF,International Water Management Institute ,WWT)
The Secretariat and the Secretary General

Strategic Plan

Convention on Wetlands (Ramsar, 1971)

Bodies of the Convention on Wetlands

COP
The Conference of Contracting Parties
The Standing Committee

Resolutions
Decisions

STRP
The science and technical review panel

CEPA
The oversight panel on Communication, Education and Public Awareness

Tools/methodologies

Management Subgroup

Finance Subgroup

Strategy Subgroup

Other Subgroups

Reports

The Secretariat
Secretary General

Operations

Convention on Wetlands (Ramsar, 1971)

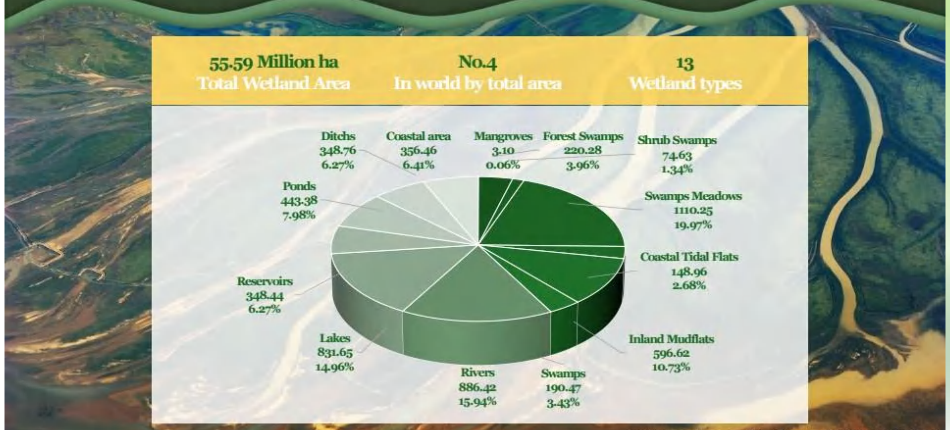
Convention on Wetlands (Ramsar, 1971)

Ramsar COPs

COP15	Zimbabwe Protecting Wetlands for Our Common Future	2025
COP14	China-Switzerland Wetland Actions for People and Nature	2022
COP13	UAE - Wetlands for a Sustainable Urban Future	2018
COP12	Uruguay - Wetlands for our Future	2015
COP11	Romania - Wetlands: Home and Destination	2012
COP10	Korea - Healthy Wetlands, Healthy People	2008
COP9	Uganda -Wetlands and water: supporting life, sustaining livelihoods	2005
COP8	Spain - Wetlands: Water, Life, and Culture	2002
COP7	Costa Rica - People and Wetlands -The Vital Link	1999
COP6	Australia	1996
COP5	Japan	1993
COP4	Switzerland	1990
COP3	Canada	1987
COP2	Netherlands	1984
COP1	Italy	1980

Wetlands in China

Wetlands in China-Resources



unit: ten thousand hectares, data based 2020

Shijiao Mangrove Nature Reserve in Guangxi Autonomous Region	Chishanhu National Wetland Park in Anhui Province	Weixi Shrub Swamp in Yunnan Province

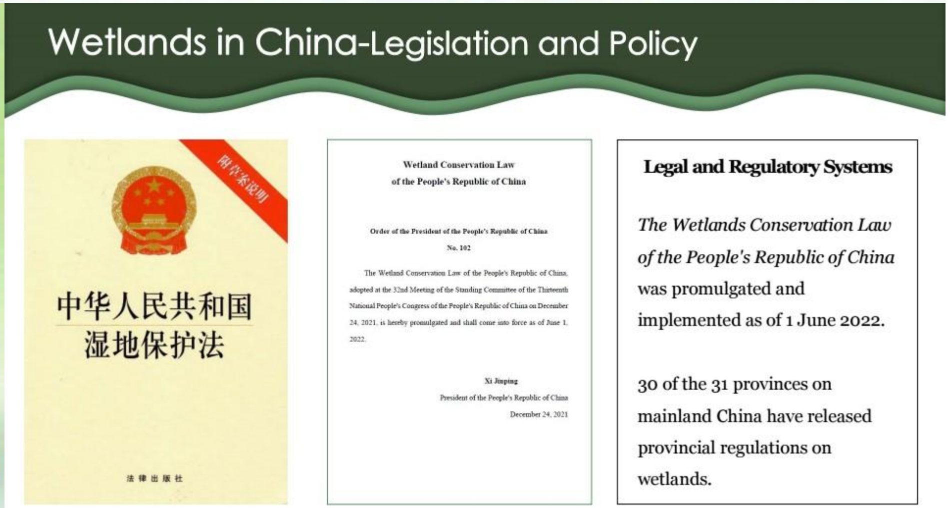
Mangrove

Forest swamp

Shrub swamp


Qilian Mountain National Park in Qinghai Province
Swamp meadow
Mordaga Wetland in Inner Mongolia
Swamp
Dafeng Milu National Nature Reserve in Jiangsu Province
Coastal wetland
Changde Huangshi Wetland in Hunan Province
Reservoir
Yellow River Delta Wetland in Shandong Province
Coastal
Yanqing District in Beijing
Pond
Southern China
Ditch


Yellow River Wetland
Inland mudflat
Poyang Lake
Lake
Sanjiang Plain Wetland
River


Wetlands in China-Legislation and Policy
中华人民共和国
湿地保护法
法律出版社
Wetland Conservation Law
of the People's Republic of China
Order of the President of the People's Republic of China
No. 102
The Wetland Conservation Law of the People's Republic of China, adopted at the 32nd Meeting of the Standing Committee of the Thirteenth National People's Congress of the People's Republic of China on December 24, 2021, is hereby promulgated and shall come into force as of June 1, 2022.
Xi Jinping
President of the People's Republic of China
December 24, 2021
Legal and Regulatory Systems
The Wetlands Conservation Law of the People's Republic of China was promulgated and implemented as of 1 June 2022.
30 of the 31 provinces on mainland China have released provincial regulations on wetlands.

Wetlands in China-Legislation and Policy

The Wetlands Conservation Law of the People's Republic of China

General Provisions

For purposes of this Law, wetlands refer to natural or artificial, perennial or seasonal waterlogged areas and waters with significant ecological functions, including areas of marine water the depth of which at low tide does not exceed six meters, with the exception of paddy fields as well as artificial waters and tidal flats used for aquaculture. The state adopts a system of hierarchical management and a system of lists for wetlands.

Wetlands in China-Legislation and Policy

The Wetlands Conservation Law of the People's Republic of China

Strictly control the occupation of wetlands

Article 19 The state shall strictly control the occupation of wetlands.

Occupation of wetlands of national importance is prohibited, except for major national projects, disaster prevention and mitigation projects, projects of important water conservancy and protection facilities, or wetland conservation projects, etc.

Article 20 If it is indeed necessary for a construction project to temporarily occupy wetlands, it shall be handled in accordance with the provisions of the Land Administration Law of the People's Republic of China, et al. The period of temporary occupation of the wetlands shall generally not exceed two years and no permanent structure shall be built on the wetlands temporarily occupied.

Within one year after the expiration of the temporary occupation of the wetlands, the land-using entities or individuals shall restore the size and ecological conditions of the wetlands.

Wetlands in China-Legislation and Policy

The Wetlands Conservation Law of the People's Republic of China

Strictly control the occupation of wetlands

Article 21 Except where flood control projects, navigation channels, ports or other water projects occupy wetlands in watercourse management areas and in flood detention and retention basins, the entity that has been approved to occupy important wetlands in accordance with the law shall, in light of local natural conditions, restore or rebuild the wetlands until they reach the original size and quality. If restoration or rebuilding is not feasible, a wetland restoration fee shall be paid. Those paying the wetland restoration fee may not be required to pay other fees of the same nature.

The management measures for the payment and use of wetland restoration fees shall be formulated by the financial department under the State Council, in conjunction with other relevant departments under the State Council such as the forestry and grassland department.

Wetlands in China-Legislation and Policy

The Wetlands Conservation Law of the People's Republic of China

Wetland Conservation and Utilization

Article 23 Adhering to the principles of ecology first and green development, the state strives to optimize the wetland conservation system, improve policy support and the scientific and technological support mechanism for wetland conservation, ensure the ecological functions and sustainable utilization of wetlands, and coordinate ecological, social and economic benefits.

Wetlands in China-Legislation and Policy

The Wetlands Conservation Law of the People's Republic of China

Wetland Conservation and Utilization

Article 28 The following acts that damage wetlands or their ecological functions are prohibited:

(1) reclaiming or draining natural wetlands, or permanently cutting off water sources of natural wetlands;

(2) filling in natural wetlands or conducting sand mining, ore mining, or soil extraction without authorization;

(3) discharging industrial wastewater or domestic sewage that does not meet the discharge standards for water pollutants, or other wastewater or sewage that pollutes wetlands, or dumping, stacking, discarding, or scattering solid wastes;

(4) overgrazing, indiscriminately exploiting wild flora, overfishing or fishing with damaging methods that might cause depletion of fish stocks, excessively using fertilizers or pesticides, overfeeding, or conducting other planting and breeding practices polluting wetlands; and

(5) other acts that destroy wetlands or their ecological functions.

Wetlands in China-Legislation and Policy

The Wetlands Conservation Law of the People's Republic of China

Wetland Conservation and Utilization

Article 26 The local people's governments at all levels shall give different guidance to the utilization of wetlands of provincial importance and general wetlands, encourage entities and individuals to carry out activities such as eco-tourism, eco-agriculture, eco-education and experiences in nature that meet the requirements for wetland conservation, and moderately control the scale of wetland utilization such as farming, animal husbandry and aquaculture.

The local people's governments at all levels shall encourage relevant entities to give priority to local residents' participation in wetland management and conservation.

Wetlands in China-Legislation and Policy

The Wetlands Conservation Law of the People's Republic of China

Mangrove

Article 34 The local people's governments at or above the county level of the places where mangrove wetlands are located shall organize the formulation of special planning for mangrove wetland conservation and take effective measures to protect such wetlands.

Mangrove wetlands shall be included in the lists of important wetlands. Those meeting the criteria for wetlands of national importance shall be included, with priority, in the List of Wetlands of National Importance.

It is prohibited to occupy mangrove wetlands.

Wetlands in China-Legislation and Policy

The Wetlands Conservation Law of the People's Republic of China

Mangrove

Digging ponds in mangrove wetlands is prohibited, so is logging, digging or transplanting mangroves, overharvesting mangrove seeds, or releasing or planting species that endanger the growth of mangroves. Where logging, digging, or transplanting mangroves, or collecting mangrove seeds is necessary for scientific research, medicinal purpose, or mangrove wetland conservation, the matter shall be handled in accordance with the provisions of the relevant laws and regulations.


Wetlands in China-Legislation and Policy
国家林业和草原局
财 政 部
国 家 林 草 局 文件
Regulations and Relegion on the Designation of Wetlands of National Importance (2022)
Interim Measures for the Payment, Use and Management of Wetland Restoration Fees (2024)


Wetlands in China-Hierarchical Management System
82
Ramsar Sites
22
Wetland Cities
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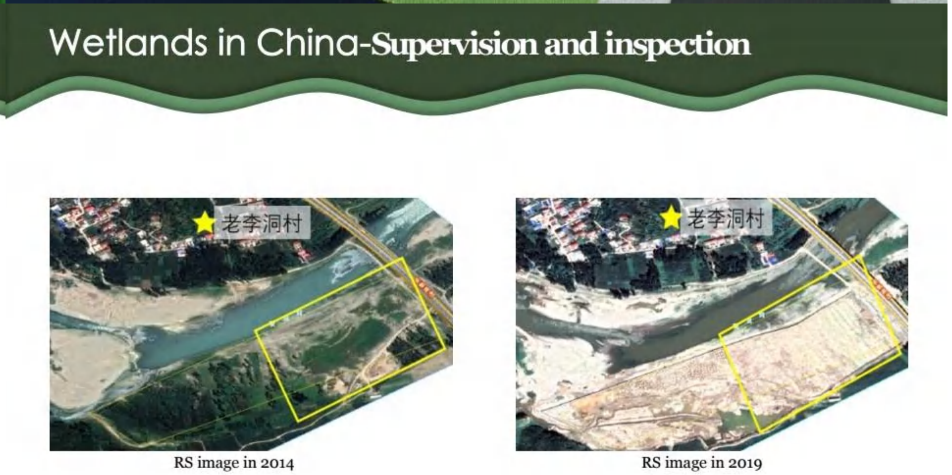
National Parks
80
Wetlands of National Importance
903
National Wetland Parks
1205
Wetlands of Provincial Importance

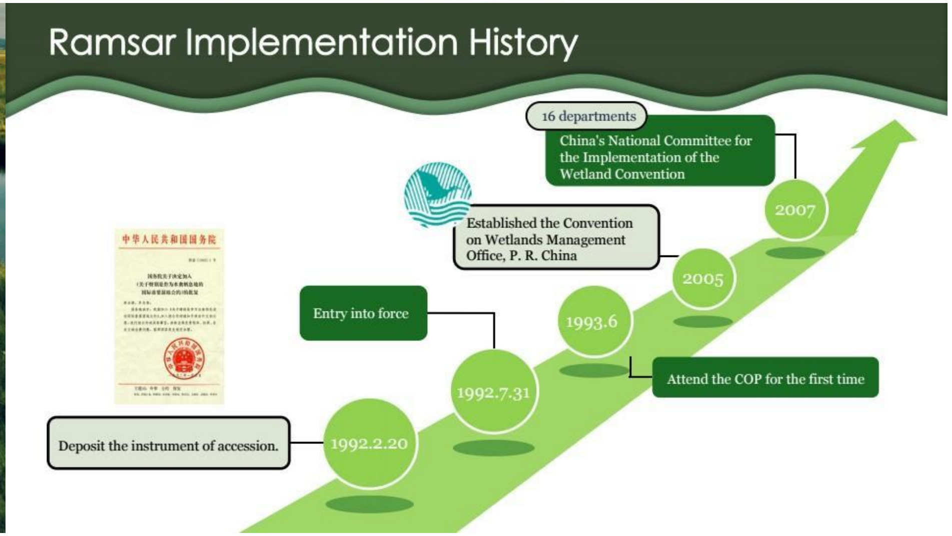

Wetlands in China-Supervision and inspection


Wetlands in China-Supervision and inspection
老李洞村
RS image in 2014
老李洞村
RS image in 2019


Wetlands in China-Supervision and inspection
Ecological Sensing Network System
林草生态网络感知系统
Application
Wetland database
Wetland conservation and restoration
Ramsar site management
Wetland supervision
Wetland dynamic monitoring
Convention implementation and publicity


Wetlands in China-Supervision and inspection
Inventory Resources of RS
• 1st national wetland inventory (1995-2003)
• 2nd national wetland inventory (2009-2013)
• 3rd national land inventory (including wetlands, 2017-2021)


3
China's Ramsar Implementation


Ramsar Implementation History
16 departments
China's National Committee for the Implementation of the Wetland Convention
2007
Established the Convention on Wetlands Management Office, P. R. China
2005
1993.6
Attend the COP for the first time
Entry into force
1992.7.31
Deposit the instrument of accession.
1992.2.20
中华人民共和国国务院

Ramsar Implementation

National Body

01

- Enhance integration of Ramsar implementation with domestic wetland conservation.

02

Conferences

- Host COP14
- Participate in COP and SC
- Organize exhibitions and side events.

Ramsar Sites

03

- Conduct the application, designation, and monitoring of Ramsar sites.

04

Wetland Cities

- Conduct the application and management of Wetland Cities.

International Cooperation

05

- Implement GEF fund project
- Combine with the "Belt and Road" initiative, deepen bilateral and multilateral wetland cooperation.

06

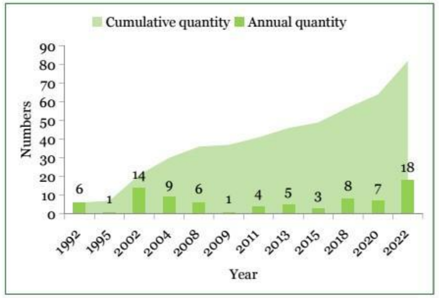
IMC

- Establish the International Mangrove Center in Shenzhen.

National Implementation Institution

01	Ramsar Administrative Authority of China, and Wetland Center under SFA established in 2005
02	National Committee to Implement Ramsar Convention established in 2007
03	Department of Wetlands Management under NFGA established in 2018

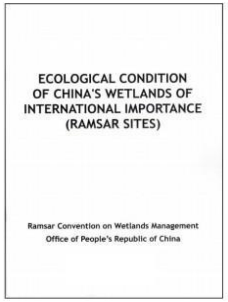
Ramsar sites in China



China has designated **82** Ramsar Sites since 1992, total **7.64 million ha.**

Ramsar sites in China

Monitoring the status of Ramsar sites



ECOLOGICAL CONDITION OF CHINA'S WETLANDS OF INTERNATIONAL IMPORTANCE (RAMSAR SITES)

Ramsar Convention on Wetlands Management Office of People's Republic of China

- Water Recharge
- Water Quality
- Eutrophication Status of Wetland Water
- Wetland Plants
- Wetlands Waterfowl
- Invasive Plants
- Wetlands Restoration and Utilization
- Major Threats to Wetlands
- Urgent Priorities

Wetland City in China

2018 6 Cities
China: Changde, Changshu, Dongying, Harbin, Haikou, Yinchuan

2022 7 Cities
Hefei,Jining, Liangping, Nanchang, Panjin,Wuhan and Yangcheng


国家林业和草原局办公室文件

Measures for the Administration of International Wetland City Accreditation and Indicators for International Wetland City Accreditation, NFGA

Wetland City in China

2025 9 Cities

- 74 Wetland Cities in total around the world, 31 newly accredited in COP15.
- 22 Wetland Cities in China, most in world.

Wetland City in China

Chinese Wetland Cities showed their cases in the China exhibition at COP15.

Haikou: Known as the "Water City," Haikou boasts the most important and distinctive wetland resources, including the Dongzhai Port mangroves and Yangshan volcanic lava wetlands.

Chongming: As the world's largest estuarine alluvial island, Chongming, a district of Shanghai, born from growing sediments at the Yangtze estuary, 70% of which is covered by wetlands.

Dali: Surrounded by mountains, Dali features a unique urban pattern where alpine lakes coexist with the city, setting a model for plateau lake wetland conservation and proper use.

Wetland City in China

Fuzhou

By innovating its wetland governance system, Fuzhou strives to build a poetic habitat spanning tidal mudflats to mangrove belts, and a paradise for birdwatching and intangible cultural heritage transmission.

Hangzhou

As a cradle of Chinese civilization and one of the Seven Ancient Capitals, Hangzhou has established a system that integrates satellite, aerial and ground-based monitoring, enabling smart management of Xixi and West Lake wetlands.

Jiujiang

As an important hotspot on the East Asian-Australasian Flyway and Asia's largest wintering ground for migratory birds, Jiujiang's Poyang Lake hosts 400,000–500,000 birds annually, as the most significant habitat in the flyway.

Wetland City in China

Lhasa

Located on the middle reaches of the Lhasa River (a tributary of the Brahmaputra) at an average altitude of 3,650 meters, Lhasa has implemented 238 wetland conservation projects.

Suzhou

As a 2,500 year old "Oriental Water City" with over 20,000 rivers and 400 lakes, Suzhou has developed a "Suzhou Path" balancing conservation and use, properly utilizing wetland resources and developing eco-economy

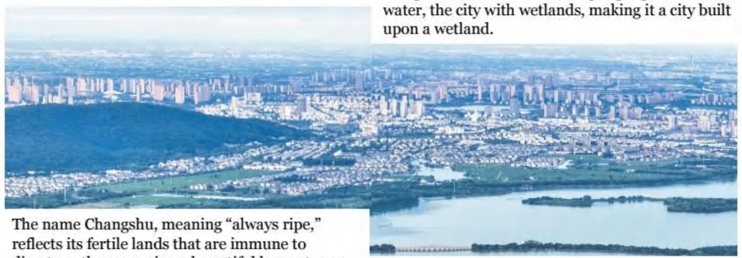
Wenzhou

At the junction of the subtropical and north subtropical zones, Wenzhou innovates "Wetland+" comprehensive governance, implementing coastal, island, and urban wetland restoration, promoting mangrove planting and blue carbon development.

Case on Wetland City

Changshu

For thousands of years, the lifestyle of the Jiangnan water town has merged people with water, the city with wetlands, making it a city built upon a wetland.



The name Changshu, meaning "always ripe," reflects its fertile lands that are immune to disasters, thus ensuring a bountiful harvest year after year.

Case on Wetland City

Changshu

Since 1985, Changshu has taken the lead in China to carry out the wetland restoration project, with a total investment of more than **8 billion yuan.**

Restored 10,000 ha of Shanghu Lake by relocating factories, afforesting, and diverting river water back to the lake.

Restored large wetlands ecologically, such as Kuncheng Lake, Shajiabang, Nanhu Dang and Qinhu Lake.

Comprehensively managed and protected a wide range of small wetlands.

Case on Wetland City

Changshu-Wetland Steward

In 2019, Changshu became the first city in China to establish a Wetland Steward Technical System. This addressed the lack of professionalism among personnel responsible for managing vegetation, food chains and bird habitats, by engaging a third party.

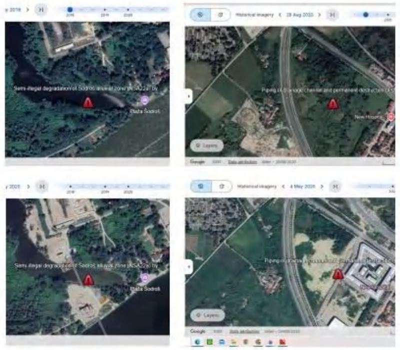
Negative Case on Wetland City

Novi Sad, Serbia

Novi Sad city was recognized as a Wetland City during COP 15.

Request for revocation from NGO because of systematic degradation of nearly all wetland ecosystems by aggressive urbanization, including:

- Procedural opacity
- Disregard for various environmental laws
- Ineffective (blocked) inspection system



Hosting COP14 (2022)

From 5^{th} to 13^{th} Nov, 2022
Wuhan and Geneva
142 parties and IOPs, more than 950 delegates

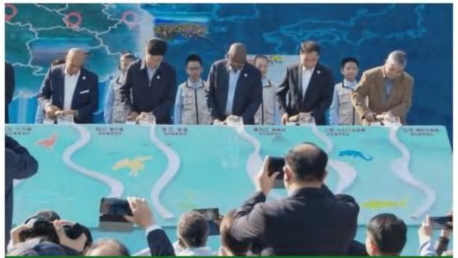
Hosting COP14 - overview

Hosting COP14 - close cooperation

- To establish Organizing Committee and the Executive Committee
- Composed by 22 government departments
- Made decisions on major issues
- Ensured the funding and security etc.

Hosting COP14 - rich activities

High-level Ministerial Segment



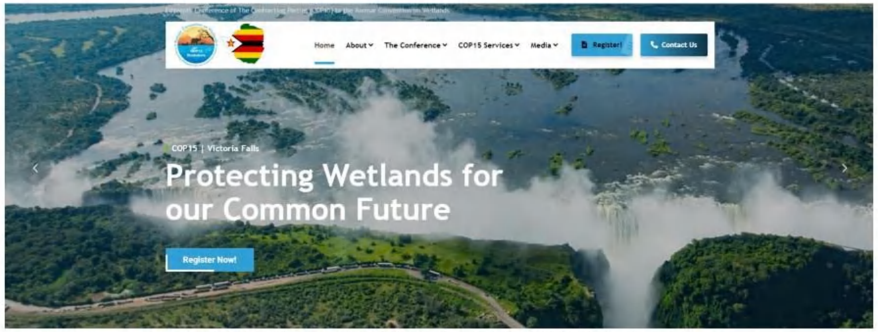
The exhibition of China's 30 years of implementing the Convention

Hosting COP14

Fruitful Outcomes

- The Wuhan Declaration
- The Global Strategic Framework for Wetland Conservation 2025-2030
- Establishment of the International Mangrove Center
- Adoption of 21 resolutions

Attending COP15



Fifteenth Conference of The Contracting Parties (COP15) to the Ramsar Convention on Wetlands
Victoria Falls | 23-31 July 2025

Attending COP15

Openning ceremony

Attending COP15

Hosting China's Exhibition

Attending COP15

Hosting China's Exhibition


H.G. E.D Mnangagwa.
President of the Republic of Zimbabwe.

Emmerson Mnangagwa, the President of Zimbabwe visited the China's Exhibition and leave note

Attending COP15

Hosting China's Exhibition

Musonda Mumba, the Secretary General of the Convention, visited the China's Exhibition and left a message highly praising China's achievements in wetland conservation.

Attending COP15

Hosting China's Exhibition

Cuba

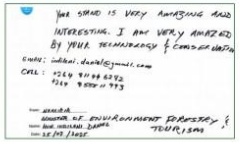
Adianez Taboada Zamora

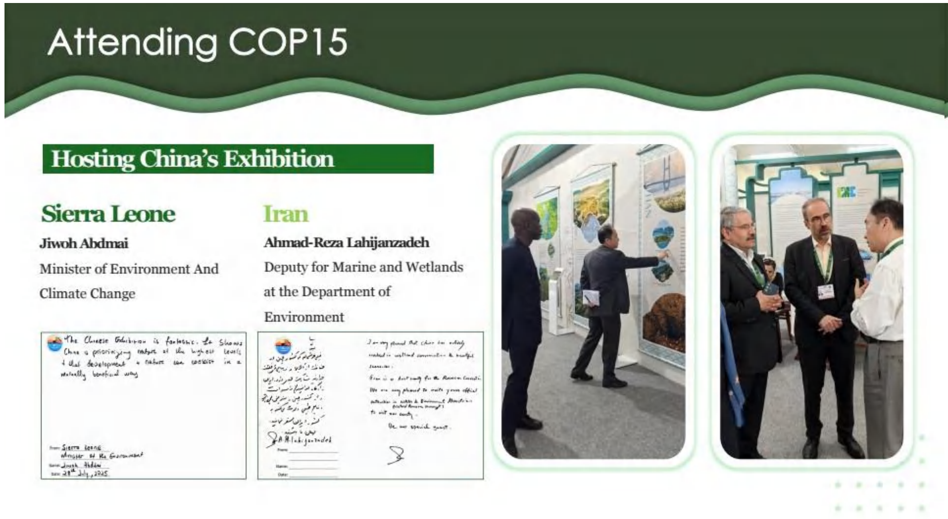
Vice Minister of Science, Technology and Environment

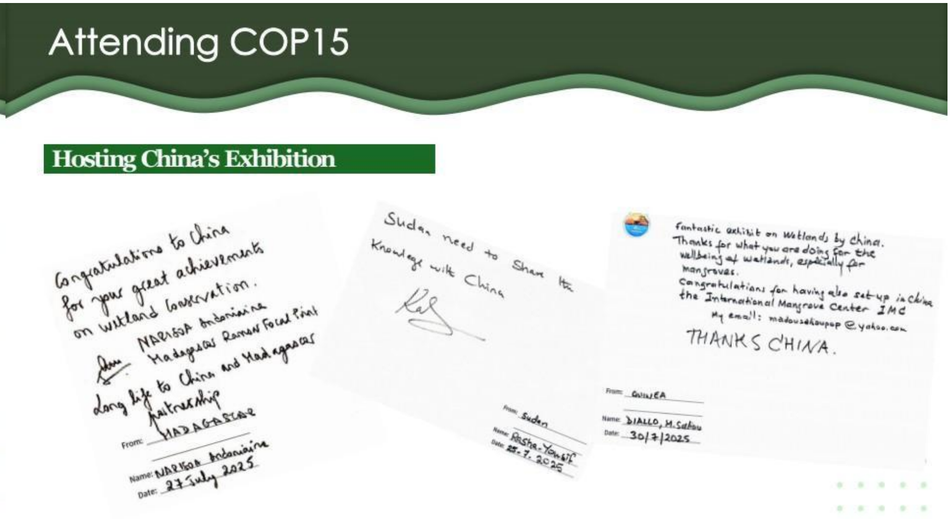
Namibia

Indileni.Daniel

Minister of Environment and Tourism


YOUR STAND IS VERY AMAZING AND INTERESTING. I AM VERY AMAZED BY YOUR TECHNOLOGY & CONSERVATION


Attending COP15
Hosting China's Exhibition
Sierra Leone
Jiwoh Abdmai
Minister of Environment And Climate Change
Iran
Ahmad-Reza Lahijanzadeh
Deputy for Marine and Wetlands at the Department of Environment


Attending COP15
Hosting China's Exhibition
Congratulations to China for your great achievements on wetland conservation.
NARISOA Andoniaina Madagascar Ramsar Focal Point
Long life to China and Madagascar partnership
From: MADAGASCAR
Name: NARISOA Andoniaina
Date: 27 July 2025
Sudan need to Share the Knowledge with China
From: Sudan
Fantastic exhibit on wetlands by china.
Thanks for what you are doing for the wellbeing of wetlands, especially for mangroves.
Congratulations for having also set up in China the International Mangrove Center IMC
THANKS CHINA.
From: GUINEA
Name: DIALLO, M.Saliou
Date: 30/7/2025


Attending COP15
Hosting China's Side Event
Yan Zhen, Vice Administrator of the NFGA , and Dr. Musonda Mumba, the SG of the Convention, attended the event and delivered speeches.


Attending COP15
Hosting China's Side Event
FAN Xibin
NFGA, China
Florent MERLE
France
NARISOA Andoniaina
Madagascar
LI Lifeng
FAO
Charles Karangwa
IUCN
CHANKin-fung
Hongkong, China
ZHU Weihua
Shenzhen, China
7 representatives delivered keynote speeches, sharing their experiences and achievements in wetland conservation

Attending COP15

Outcomes

Adoption of 25 resolutions, 2 submitted by China

5th Strategic plan 2025-2034

31 new wetland cities, 9 from China

The Victoria Falls Declaration

Attending COP15

Cultivate numerous friendly relationships

Draft resolution from China

COP15

Draft resolution on strengthening national actions for the conservation and restoration of waterbird flyways and critical sites

Submitted by China and Cambodia.

Draft resolution from China

COP15

Draft resolution on promoting incorporation of new technology and traditional knowledge in wetland conservation, restoration, management and wise use

Submitted by China, Burkina Faso, Cambodia, Gabon, Libya, Madagascar and Panama.

Draft resolution from China

COP14

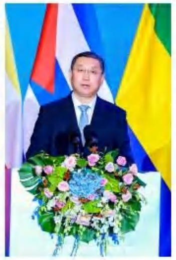
Proposal to establish an International Mangrove Center (a Ramsar Regional Initiative)

Submitted by China, Cambodia and Madagascar.

International Mangrove Center (IMC)

Signing Ceremony of the Establishment Agreement

Ceremony



China

Madagascar

Cambodia

Nov. 6, 2024, 18 founding member states signed the Establishment Agreement

International Mangrove Center (IMC)

Signing Ceremony of the Establishment Agreement

18 Founding Member States:

Asia

Cambodia China Laos Pakistan

North & Central America

Cuba Nicaragua Panama

Africa

Burkina Faso Comoros Guinea Gabon Lesotho Liberia Libya Madagascar Mozambique Samoa Sierra Leone

IMC membership is open to all Contracting Parties of the Convention and non-party states, with interests in mangroves.

International Mangrove Center (IMC)

More members

During COP15, Zimbabwe signed an establishment agreement with IMC, becoming the 19th intended member country.

International Mangrove Center (IMC)

Mangrove in the Republic of the Sudan

More members

The Republic of the Sudan became the 20th member.

On August 25th, the Republic of the Sudan contacted the Secretariat of the IMC via email, expressing its wish to join the IMC, and officially signed the Establishment Agreement on the same day.

International Mangrove Center (IMC)

More members

During the conference, a number of contracting parties including Iran, the United Arab Emirates (UAE), Oman, and Myanmar also expressed their willingness to join.

International Cooperation

GEF projects

May 2021, GEF flyway project launched.

International training

Training workshop on wetland conservation and management every year

International Cooperation

GEF project

Status of Liaohe River Estuary Wetland of International Importance

The wetlands are rich in species, with 497 types of wild animals, including 25 nationally first-level protected wild animals, 324 species of birds, and 275 types of wild plants.

Three typical wild plant communities: reed, winged saltbush, wild soybean

Three flagship wildlife species: Red-crowned Crane, Saunder's Gull, Northwest Pacific Spotted Seal

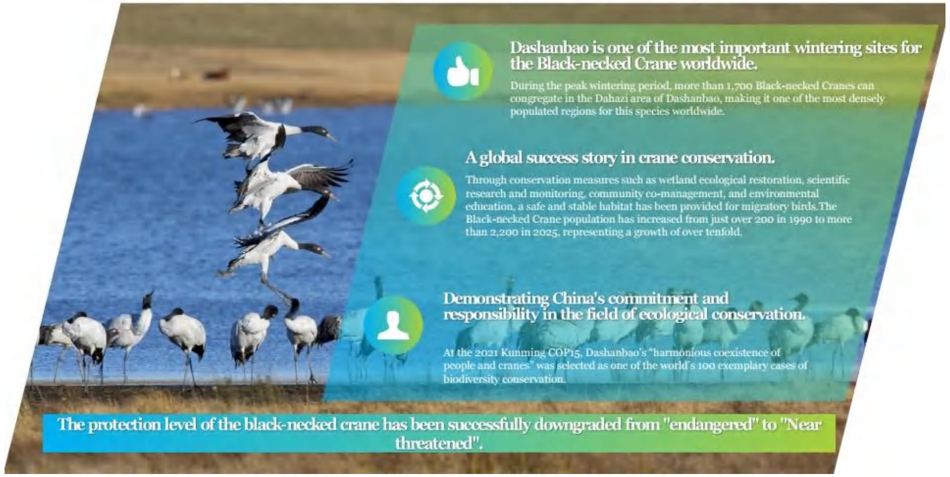
Important species habitats: The Saunder's Gull's largest breeding population in the world; the most concentrated stopover sites for the north-south migration of the continental population of the Red-crowned Crane and its third-largest natural wintering site; one of the eight major breeding sites for the Western Pacific Grey Seal in the world and the only pupping site in China.

Conservation Achievements of Liaohe River Estuary Wetland of International Importance

- *Liaohe River Estuary has implemented the largest single 'Return Grazing to Wetlands' project in the country, restoring 5,727 hm^2 and 15.77 km of natural coastline.*
- *Liaohe River Estuary is precisely implementing wetland protection, restoration, and ecological compensation projects, completing 350 m^3 of ecological water replenishment, 1,151 hm^2 of wetland restoration, and 168 km of water supply channel dredging.*
- *Establishing the Liaohe River Estuary National Park - 813 oil, gas, and water wells have been closed or withdrawn, and 599 well sites and stations have been ecologically restored.*
- *By 2025, the number of bird species increase to 324, with millions of migratory birds stopping here each year. Saunder's Gull: The breeding population increased from 1,200 in 1991 to over 10,000, making it one of the most successful cases of global endangered species protection.*
- *Red-crowned Crane: The migratory stopover population has reached up to 808 individuals; the wintering population increased to 187; a total of 531 cranes have been bred in captivity, with 255 successfully reintroduced into the wild, laying a solid foundation for the restoration of wild populations.*
- *Western Pacific Spotted Seal: On March 20, 2025, 364 individuals came ashore in a single day, breaking records set since the 1980s.*
- *Panjin is vibrant because of its wetlands and famous for its birds. It has been recognized as one of 'China's Six Most Beautiful Marsh Wetlands,' 'China's Top Ten Charming Wetlands,' 'The Hometown of Black-tailed Gulls in China,' and one of the first National Popular Science Bases for Forestry and Grasslands. In 2022, it was certified as an 'International Wetland City.'*

Status of Dashanbao Wetland of International Importance

Conservation Achievements of Dashanbao Wetland of International Importance



Status of Chongming Dongtan Wetland of International Importance

- East End of Chongming Island, 46km away from the city center, Total coverage: 241.55km^2, accounts for about 7.8% of the total area of wetlands in Shanghai.
- Established in 1998 as a provincial nature reserve, Admitted into the East Asia-Australasian shorebird site network in 1999, Designated as a Wetland of international Importance in 2002, Promoted to a national nature reserve in 2005, One of 51 National Demonstration Nature Reserve Since 2006
- Chongming Dongtan is situated at the center of the East Asian – Australasian Flyway, an essential stopover and wintering site for migratory birds and an essential migrating corridor and breeding ground for aquatic creatures of the Yangtze River system and the East China sea.
- 364 species of birds recorded :20 species under Grade One state protection, 62 species under Grade Two state protection

Conservation Achievements of Chongming Dongtan Wetland of International Importance

- **Empowering Management with Digital and Intelligent Systems**
  - ✓ A unified smart platform now integrates all elements and processes, including daily patrols, resource monitoring, facility maintenance, video surveillance, UAV (drone) self-service inspections, access gate management, and scientific research collaboration. This has not only greatly improved management efficiency but also standardized, refined, and intellectualized our operations, providing robust data support for scientific decision-making.
- **Strengthening Foundations Through Scientific Research and Long-term Monitoring**
  - ✓ Bird Monitoring: We have continuously conducted bird banding since 2002, consistently ranking among the top in China for shorebird banding numbers. Since 2005, annual synchronous waterbird surveys have been carried out, enabling us to accurately track dynamic changes in waterbird resources.
  - ✓ Interdisciplinary Collaboration: In collaboration with major Shanghai universities and institutions, we systematically monitor natural resources—such as vegetation, benthic animals, zooplankton, and fish—and environmental factors like hydrology and water quality. An Annual Resource Monitoring Report is compiled and publicly released each year.
  - ✓ Research Station Network: We have established high-level research stations, including the Global Carbon Flux Dongtan Observation Station and the Yangtze River Estuary Wetland Ecosystem Research Field Station, in partnership with various research institutes.
- **Innovating Public Education to Foster Collective Conservation Efforts**
  - ✓ Thematic Events: We organize diverse public activities aligned with key dates such as World Wetlands Day, Bird-Loving Week, and Shanghai International Nature Conservation Week.
  - ✓ Nature Education: "Nature Classroom" experiential activities are offered for school students, inspiring the younger generation's passion for nature and ecological protection.
  - ✓ Public Engagement: We actively involve NGOs, volunteers, and businesses in long-term initiatives like the "Clean Wetland" campaign and marine debris cleanup projects, transforming environmental awareness into collective action.
  - ✓ Community Outreach: Nature centers established in surrounding communities extend our educational reach, disseminating knowledge about laws and regulations, ecological civilization, and wildlife protection, thereby fostering a community spirit dedicated to joint conservation.
- **Implementing Major Ecological Projects to Revitalize the Environment**
  - ✓ Successful Invasive Species Control: We have effectively curbed the spread of the invasive smooth cordgrass (Spartina alterniflora), achieving an eradication rate of over 95%. This has created conditions for the recovery of native plants like common reed (Phragmites australis) and Scirpus mariqueter.
  - ✓ Habitat Recreation: A nearly 2,667-hectare, enclosed restoration area with water level management capabilities has been established, providing high-quality waterbird habitat.
  - ✓ Remarkable Results: Monitoring data shows a significant increase in bird populations both inside and outside the restoration area. The site has become an important habitat for over ten rare and endangered bird species, including the Oriental Stork, Tundra Swan, and Black-faced Spoonbill. Notably, the Tundra Swan population has rebounded from just over 60 individuals in 2012 to nearly 3,000 birds in the winter of 2023, serving as the most vivid testament to the project's success.
  - ✓ National Recognition: The Chongming Dongtan Ecological Restoration Project has received numerous prestigious national awards, including the Habitat Example Award for China, the China Environment Excellent Award, and the Dayu Award, earning high acclaim from all sectors of society.

Status of Yellow River Delta Wetland of International Importance

Geographical Location

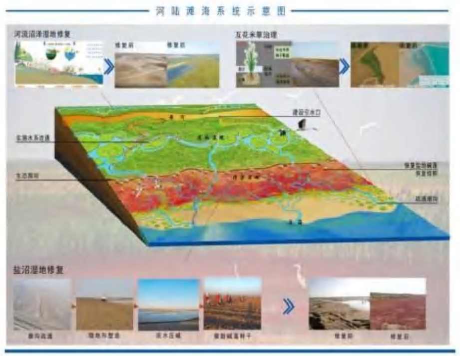
- Situated at the Yellow River estuary in Dongying City, Shandong Province, it is bordered by the Bohai Sea to the north and Laizhou Bay to the east.
- Founded in 1990 and elevated to national status in October 1992.
- The nascent wetland ecosystem and rare and endangered bird species.

Protected Area

- The reserve encompasses a total area of 153,000 hectares (1,530 km²). Its functional zoning.
- comprises a 59,400-hectare core zone, an 11,200-hectare buffer zone, and an 82,400-hectare experimental zone.

Conservation Achievements of Yellow River Delta Wetland of International Importance

The reserve has developed the "Yellow River Estuary Model," an integrated approach featuring land-sea coordination, systematic restoration, and comprehensive management.



Investment: Implementation of 17 dedicated projects with a total funding of 1.36 billion RMB.

- Reconnected 241 kilometers of waterways.
- Restored approximately 6,200 acres of native vegetation, including Suaeda salsa and seagrass beds.
- Controlled invasive Spartina alterniflora across approximately 13,100 acres.
- Cumulatively restored a total wetland area of about 28,200 acres.)

The ecological functions of the wetlands have significantly improved, leading to a healthier river ecosystem.

The proposal for the Yellow River Estuary National Park has been completed and is pending formal approval.

The Yellow River Estuary Waterbird Habitat has been inscribed on the World Heritage List.

International Cooperation

International Cooperation for Sustainable Management of Wetlands in the Lancang-Mekong Basin

2022.11

- Workshop on Lancang-Mekong Wetland Conservation Strategic Plan
- Training Workshop on Lancang-Mekong Wetland Conservation and Management

21 Representatives from Cambodia, Laos, Myanmar and Thailand attended the workshops online

International Cooperation

International Cooperation for Sustainable Management of Wetlands in the Lancang-Mekong Basin

2024.3

- Sustainable Utilization of Wetland Resources Sharing Session

27 Representatives from Cambodia, Laos, Myanmar and Thailand attended the session online

International Cooperation

International Cooperation for Sustainable Management of Wetlands in the Lancang-Mekong Basin

2024.6

- Training Seminar on the Formulation of Wetland Protected Area Management Plans at Shenzheng

Country	Name of Protected Area	Type of Protected Area
Cambodia	Strung Sen Ramsar site	Ramsar site
Laos	Xe Champhone Ramsar site	Ramsar site
Myanmar	Inlay Lake Biosphere Reserve	Biosphere Reserve, with an area covering a Ramsar
Thailand	Bang Pakong River Wetland	Planned to apply for being Ramsar, currently composed of four national - level important wetlands
Vietnam	Lang Sen Wetland Protected Area	Ramsar site, Nature Reserve

International Cooperation

International Cooperation for Sustainable Management of Wetlands in the Lancang-Mekong Basin

2024.6

- On-site tour and exchange activities were conducted in Guangzhou and Shenzhen respectively

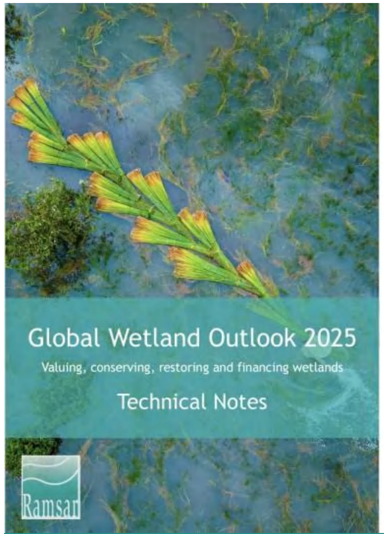
NO.1 Guangzhou Nansha Provincial Wetland

NO.2 Guangzhou Haizhu Ramsar Site

NO.3 OCT Natiiaol Wetland Park

NO.4 Shenzhen Bay Park Nature School

Annex 3.4: The Global Wetland Outlook 2025 – Technical Notes: Valuing, Conserving, Restoring and Financing



Global Wetland Outlook2025 – Technical Notes:

Valuing, conserving, restroring, and financing wetlands

Reporter: Anni Wang, Shenzhen University

Introduction

Purpose: To outline methodology for the Global Wetland Outlook 2025, a technical backbone.

HOW the numbers were calculated?

Table of Contents

Global Wetland Extent

Table 1. Global extent of wetland types used to assess the worth of wetland ecosystem services.

Wetland category	Area (million ha) estimate	Estimation method	Source
Seagrass	35.88	Compilation of existing spatial databases and satellite	UNEP-WCMC [13] (31.4 million ha) + newly found Bahamas seagrass extent (46.8 million ha) Blume et al [14].
Kelp Forests	1.71	Satellite	Mora-Soto et al [15].
Coral Reefs	34.84	Satellite	Allen Coral Atlas [16], Lyons et al [17].
Estuarine Waters	27.87	Compilation of existing spatial databases	Lehner et al [11].
Salt Marshes	5.29	Satellite	Worthington et al [18].
Mangroves	15.11	Satellite	Global Mangrove Watch v4. [19]
Tidal Flat	12.79	Satellite	Murray et al [20].
Lakes	271.53	Compilation of existing spatial databases	Lehner et al [11].
Rivers and Streams	58.93	Compilation of existing spatial databases	Lehner et al [11].
Inland marshes and swamps	461.65	Compilation of existing spatial databases	Lehner et al [11]. (Mid-point of range presented: 205.30 – 718.00)
Peatlands	500.00	Compilation of existing spatial databases	Global Peatland Assessment 2022 [21].
Total (million ha)	1,425.60		

Total Estimated Wetland Area: **1,425.60 million ha**

Limitation: data missing

Wetland Loss & Degradation

Table 2. Annual rates of wetland loss and estimated decline in natural wetland area since c. 1970.

Wetland Category	Average Change Rate (percentage per year)	Minimum past change rate (percentage per year)	Maximum past change rate (percentage per year)	Estimated change (million ha) since 1970	Estimated past area (million ha) circa 1970	Rate source
Seagrass	-0.39	-0.14	-0.63	-6.975	42.856	WET Index, Dunic et al. [23].
Kelp Forests	-1.85	-1.40	-2.30	-1.584	3.293	Krumhansl et al. [24].
Coral Reefs	-0.72	0.06	-1.50	-12.504	47.34	WET Index, Souter et al. [25].
Estuarine Waters	-0.01	0.00	-0.01	-0.084	27.954	WET Index, Jung et al. [26].
Tidal Flats	-0.60	-0.60	-0.60	-3.863	16.655	WET Index.
Salt Marshes	-0.33	-0.14	-0.52	-0.862	6.150	WET Index, Cambpell et al. [27].
Mangroves	-0.27	-0.20	-0.41	-2.019	17.131	WET Index, Richards et al. [28], Bunting et al. [29].
Rivers and Streams	-0.13	-0.13	-0.13	-3.726	62.656	WET Index.
Lakes	-0.90	-0.90	-0.90	-122.847	394.377	WET Index.
Inland Marshes and Swamp	-0.77	-0.61	-0.92	-177.001	638.651	WET Index, Davidson et al. [30].
Peatlands	-0.32	-0.05	-0.59	-80.037	580.037	WET Index, Joosten et al. [31].
Total				**-411.502**	**1,837.1**	

Degradation Trend:

Method: Ecological Character State Index (ECSI)

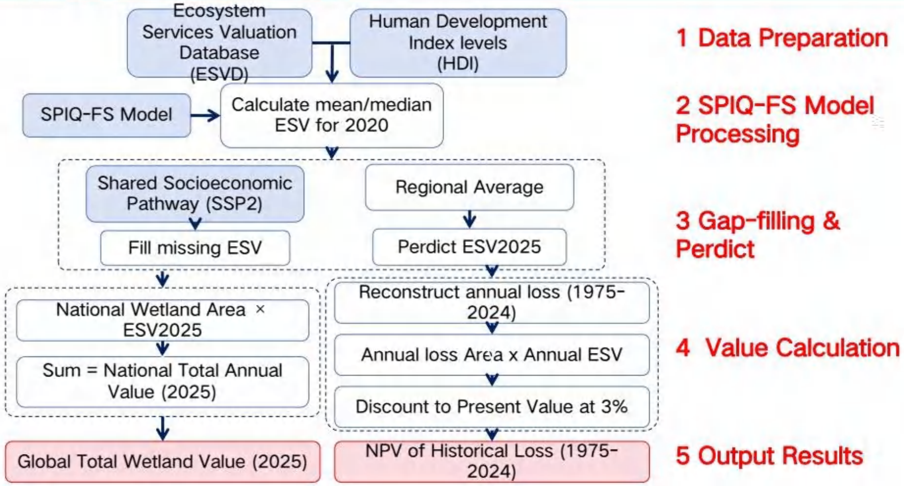
Formula:

$$(n_{+1} - n_{-1})/n_{total}$$

Total loss: **411.5 million ha**

Limitation: data missing

Valuing Wetland Ecosystem Services



Conservation & Restoration: Scale & Cost

KM-GBF Targets:
- Target 2 (Restoration): 30% of lost area → 123.45 Mha
- Target 3 (Conservation): 30% of remaining area → 427.68 Mha

Table 7. The scale of conservation and restoration required to meet Target 2 and Target 3 of the KM-GBF.

	Target 2		Target 3	
Wetland category	*Wetland area lost since c.1970 (million ha)*	*30% restoration target (area, million ha)*	*Remaining wetland area (million ha)*	*30% conservation target (area, million ha)*
Seagrass	6.98	2.09	35.88	10.76
Kelp forests	1.58	0.48	1.71	0.51
Coral reefs	12.50	3.75	34.84	10.45
Estuaries	0.08	0.03	27.87	8.36
Salt marshes	0.86	0.26	5.29	1.59
Mangroves	2.02	0.61	15.11	4.53
Tidal Flats	3.86	1.16	12.79	3.84
Lakes	122.85	36.85	271.53	81.46
Rivers and streams	3.73	1.12	58.93	17.68
Inland marshes and swamps	177.00	53.10	461.65	138.50
Peatlands	80.04	24.01	500.00	150.00
Total (ha)	**411.50**	**123.45***	**1,425.60**	**427.68**

Table 8. Average restoration and conservation costs for different wetland types (2023 Int$/ha/yr)

Wetland type	**Average restoration cost (2023 Int$/ha/yr)**	**Average conservation cost (2023 Int$/ha/yr)**	**Ratio (Rest:Cons)**
Seagrass	18,402	*	*
Kelp forests	27,198	*	*
Coral reefs	37,343	304	123:1
Estuaries	*	*	*
Salt marshes	28,952	3,880	7.5:1
Mangroves	2,322	*	*
Tidal Flats	5,069	*	*
Lakes	*	*	*
Rivers and streams	71,346	*	*
Inland marshes and swamps	24,308	64	379:1
Peatlands	1,094	610	1.8:1

* Insufficient data estimates for wetland type.

Data sourced from 42 studies;
Limitation: Gaps exist, especially conservation costs

Challenges & Limitations

Data Gaps : Incomplete extent maps, limited cost data for conservation

Methodological Limits:
- Opportunit transfer limitations,
- exclusion of opportunity costs,
- Non-linear marginal values not captured

Regional Bias: Few studies from low-income regions

Conclusion & Implications

Wetlands are vast, valuable, and vulnerable, but critically undervalued and underprotected

Urgent Need:
- Enhanced mapping and monitoring
- More localized and contextual valuation studies
- Integration of opportunity costs in planning

Wetland conservation and restoration is **Global Relevance**, should
CALL TO ACTION

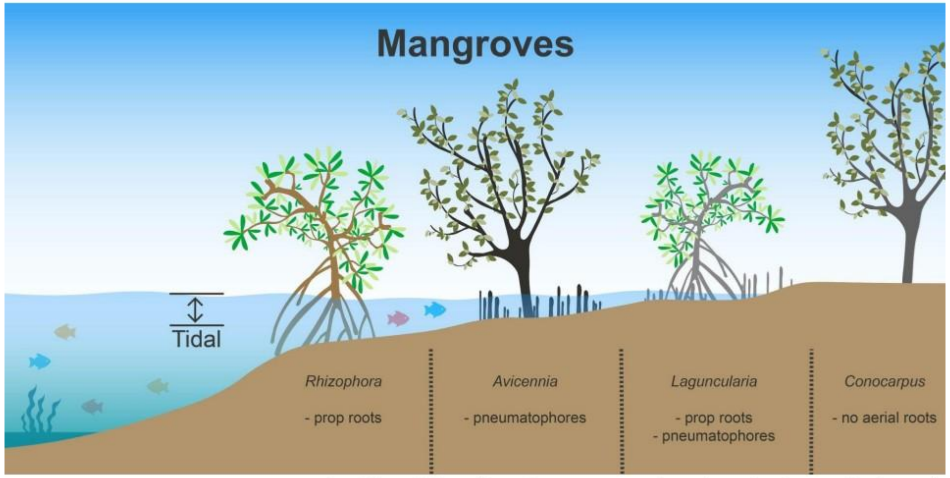
Annex 3.5: Mangrove Ecological Character Maintenance

Outline

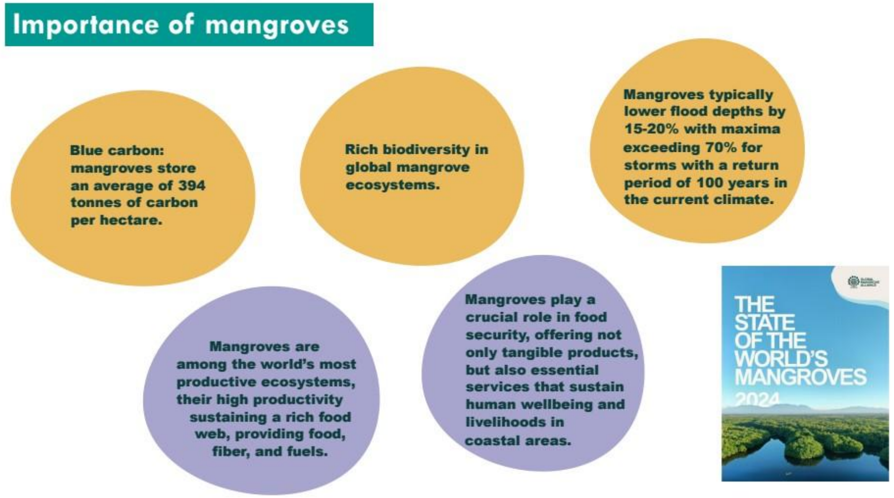
1. Wetland Definition and Categories
2. Ecosystem Services
3. Status, Trends and Drivers
4. Concept of Ecological Characters
5. Ecological Character Description
6. Monitoring and maintenance
7. Group discussion

Ramsar
CONVENTION ON WETLANDS
VENTION SUR LES ZONES HUMI
VENCIÓN SOBRE LOS HUMEDA
(Ramsar, Iran, 1971)

Brief on mangroves

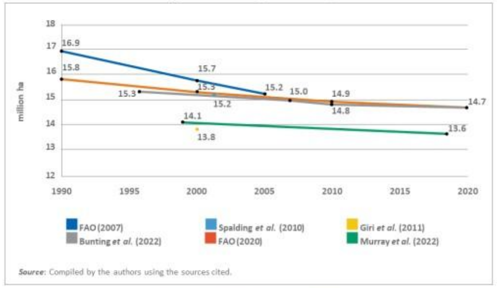


https://kingwildlife.com/the-mighty-mangroves-guardians-of-coastal-resilience-and-biodiversity/



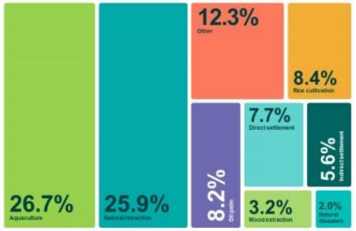
Trends and divers of change

Estimates of global mangrove area, 1990–2020



The world's mangroves 2000–2020. (FAO, 2023)

The conversion of mangroves for aquaculture, oil palm plantations and rice cultivation accounted for 43.3% of global mangrove loss between 2000 and 2020. Nature itself contributes to 25.9%.



Global drivers of mangrove loss, 2000–2020 (Source: FAO (2023) The world's mangroves 2000–2020. Rome) Re-generated by the State of World's Mangroves 2024

Urgency of action

PRESS RELEASE 21 MAY, 2024

More than half of all mangrove ecosystems at risk of collapse by 2050, first global assessment finds

Gland, Switzerland, 22 May 2024 (IUCN) – More than half of the world's mangrove ecosystems are at risk of collapse, according to the first global mangrove assessment for the International Union for Conservation of Nature (IUCN) Red List of Ecosystems.

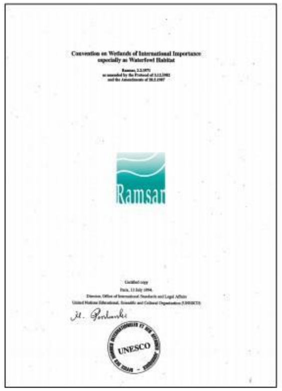
Without significant changes by **2050**, climate change and sea level rise will result in the loss of

- **1.8 billion tonnes** of carbon stored (**17%** of the total current carbon stored in mangroves), currently valued at a minimum of **$13 billion** at market prices in voluntary carbon markets and representing a cost to society equal to **$336 billion** based on the social cost of carbon.
- protection for **2.1 million lives** exposed to coastal flooding (**14.5%** of current lives exposed) and **$36 billion** worth in protection to properties (**35.7%** of current property values protected)
- **17 million days** of fishing effort per year (**14%** of current fishing effort is supported by mangroves).

https://iucn.org/press-release/202405/more-half-all-mangrove-ecosystems-risk-collapse-2050-first-global-assessment

1. Wetland Definition and Categories

CONVENTION ON WETLANDS
CONVENTION SUR LES ZONES HUMIDES
CONVENCIÓN SOBRE LOS HUMEDALES
(Ramsar, Iran, 1971)



Convention on Wetlands
1971

Wetlands Conservation Law
of the People's Republic of China
2022

What are wetlands?

Convention Definition of Wetlands

Ramsar
CONVENTION ON WETLANDS
CONVENTION SUR LES ZONES HUMIDES
CONVENCIÓN SOBRE LOS HUMEDALES
(Ramsar, Iran, 1971)

Article 1 Definition

1. For the purpose of this Convention wetlands are **areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres**.

The wetlands include **surrounding areas** of the shores, riverbanks, and entire watercourses.

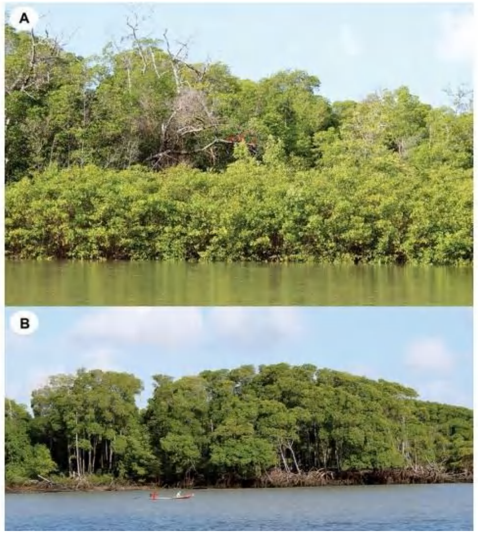

Convention on Wetlands of International Importance especially as Waterfowl Habitat

UNESCO

NASA/Joshua Stevens

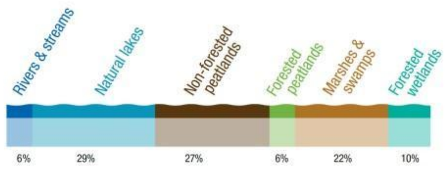
https://earthobservatory.nasa.gov/images/92130/dramatic-flooding-in-eastern-africa

Ottoni et al. 2021
DOI: 10.1590/1676-0611-BN-2020-1172

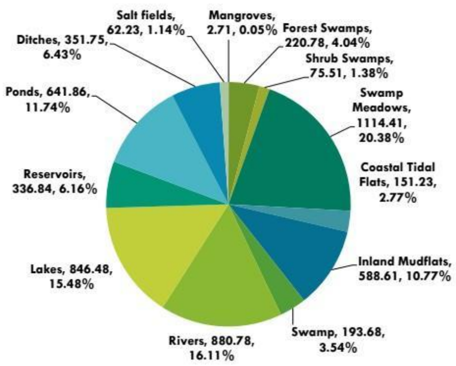


Categories of Wetlands

Ramsar	China
3 classes 42 types • marine wetlands • artificial wetlands • inland wetlands. These groups can be classified further according to the type of water such as the fresh, alkaline, saline, and brackish water.	5 classes 42 types GB/T 24708-2009 • coastal wetlands • riverine wetlands • lake wetlands • marsh/swamp wetlands • artificial wetlands Statics by Ramsar Category is different by China's Category



Areas (%) of world natural inland wetland classes

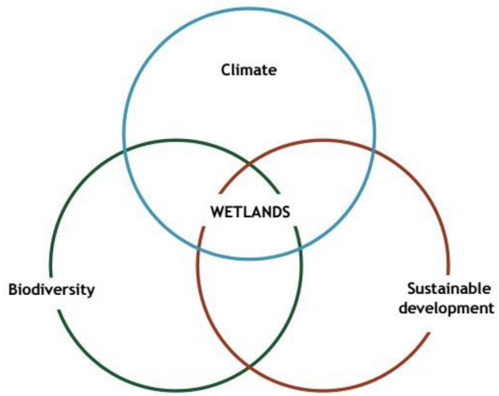


Areas (%) of wetland classes in China

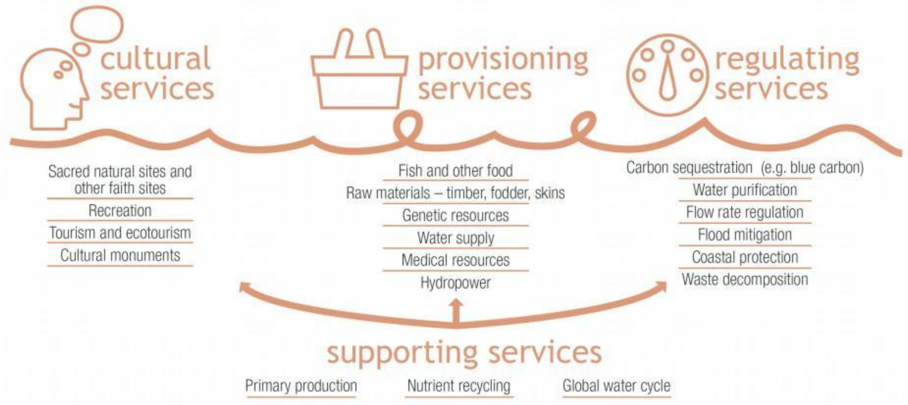
2. Ecosystem Services

Ramsar
CONVENTION ON WETLANDS
CONVENTION SUR LES ZONES HUMIDES
CONVENCIÓN SOBRE LOS HUMEDALES
(Ramsar, Iran, 1971)

- Wetland ecosystem services **far exceed** those of terrestrial ecosystems
  - **critical food supplies** including rice and freshwater and coastal fish, **and fresh water, fibre and fuel**.
  - **regulating** services influence **climate and hydrological regimes**, and **reduce** both **pollution and disaster risk.**
  - natural features of wetlands often have **cultural and spiritual importance.**
- Wetlands offer **recreational possibilities and tourism benefits.**
- Storage and sequestration of **carbon** by wetlands play an important role in regulating the global climate.
  - **Peatlands and vegetated coastal wetlands** are large carbon sinks. Salt marshes sequester millions of tonnes of carbon annually.
  - Despite occupying only 3% of the land surface, peatlands store twice as much carbon as the world's forests
  - **Mangroves store 3-4 more times of Carbon than Rainforest**



Water
Food
Water regulation
Climate regulation
Salinization of soils
Culture heritage
Recreation and tourism



Carbon cycle in/through Wetlands

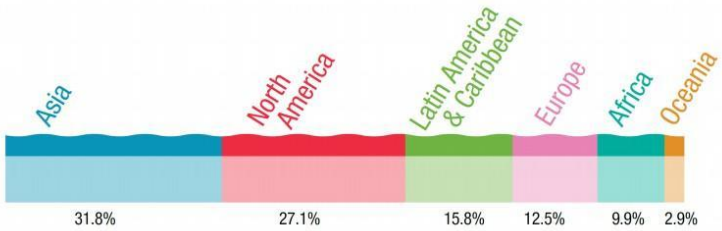
3. Status ,Trends & Drivers

GWO 2018 & 2021

Ramsar
CONVENTION ON WETLANDS
CONVENTION SUR LES ZONES HUMIDES
CONVENCIÓN SOBRE LOS HUMEDALES
(Ramsar, Iran, 1971)

Area of global inland and coastal wetlands

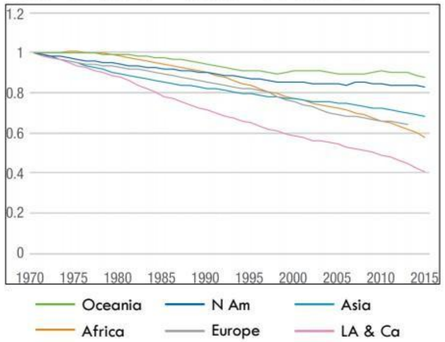
15-16 million km² GWO 2021
12.1 million km² GWO 2018



Loss of Wetlands

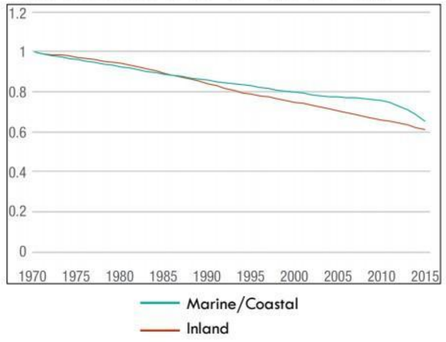
GWO 2018

Up to **87%** of the global wetland resource has been lost since **1700 CE** in places where data exist



Natural WET Index by Region

About **35%** in both marine/coastal and inland natural wetland areas studied between **1970 and 2015**



Inland and Marine/Coastal WET Index

Trends of Wetlands

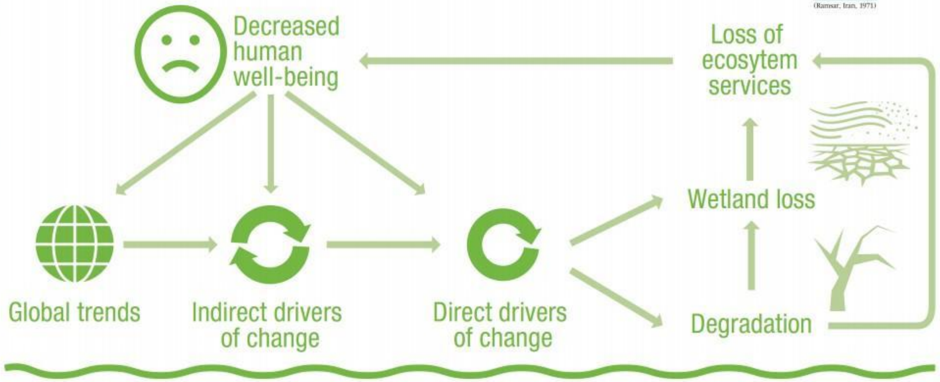
GWO 2018

Inland natural wetlands	Global area (million km²)			
	Wetland classes	Wetland sub-classes[a]	Global area change (% change)[b]	Global area change (qualitative)[c]
Rivers & streams	0.624-0.662			↓
Natural lakes	3.232-4.200			↓
Natural lakes (>10 ha)		2.670		↓
Natural pools (1-10 ha)		0.562		
Peatlands	4.232		-0.97	→
Non-forested peatlands (bogs, mires & fens)		3.118	+6.80	↑
Forested peatlands		0.698	-25.32	↓
Tropical peatlands		1.505	-28	↓
Temperate & boreal peatlands		3.380		
Marshes and swamps (on alluvial soils), including floodplains	2.530			↓
Tropical freshwater swamps (alluvial soils)		1.460		↓
Forested wetlands (on alluvial soils)	1.170			
Groundwater-dependent wetlands				
Karst & cave systems				
Springs & oases				
Other groundwater-dependent wetlands				

	Global area (million km²)			
	Wetland classes	Wetland sub-classes[a]	Global area change (%)[b]	Global area change (qualitative)[c]
Estuaries	0.660			↓-↓↓
Unvegetated tidal flats		0.458		↓-↓↓
Saltmarshes		0.550		↓
Coastal deltas		>0.030	-52.4	↓↓
Mangroves	0.143		-4.3%	→
Seagrass beds	0.177		-29	↓
Coral reefs (warm water systems)	0.284		-19	↓
Shellfish reefs			-85	↓↓
Coastal lagoons				↓
Kelp forests			–0.018	→
Shallow subtidal marine systems				↓
Sand dunes/beaches/rocky shores				
Coastal karst & caves				

3. Status ,Trends & Drivers

CONVENTION ON WETLANDS
CONVENTION SUR LES ZONES HUMIDES
CONVENCIÓN SOBRE LOS HUMEDALES
(Ramsar, Iran, 1971)



Type of Drivers

GWO 2018

Direct drivers
Drainage and conversion, introduction of pollution and invasive species, extraction activities, and other actions affecting the water quantity and frequency of flooding and drying

Indirect drivers
Supply of energy, food, fibre, infrastructure, tourism and recreation

Direct and indirect drivers
Climate change: abnormal precipitation and evaporation, extreme weathers, phenology shift, warmer temperature
Global megatrends: demography, globalization, consumption and urbanization, with climate change creating uncertainty
Governance: awareness, inventory, monitoring, research, management

Alteration-Physical regime change
- Flow regime (quantity and frequency)
- Sediment
- Salinization
- Temperature

Extraction-Over use
- Water
- Fishing
- Wood harvesting
- Sand and gravel mining

Introduction-Over load
- Nutrients
- Chemicals
- Solid wastes
- Invasive Species

Conversion-Structure Change
- Drainage
- Reclamation/Construction/urbanization
- Activities/noise
- Buring/ploughing
- Community composition/horticulture

Hot Issues and Priorities of the Ramsar Convention

Themes
- **Climate & Carbon**-Impacts and responses, Blue Carbon, mitigation
- **Agriculture**-Maintaining and restoring the ecological character in agricultural wetlands
- **Biodiversity**-KM Global Biodiversity Framework, OECMs, Working coastal habitats
- **Sustainable Development**-SDGs

Tools
- **Application** of criteria for designating RS
- **Tools** for wetland assessment, mapping and monitoring: Carbon and Small Wetlands

Solutions
- **Financial** cost of wetland loss and degradation and investment required for restoration
- **Policy** and **legal** framework for conservation and wise use

4. Concept of Ecological Characters

Ramsar
CONVENTION ON WETLANDS
CONVENTION SUR LES ZONES HUMIDES
CONVENCIÓN SOBRE LOS HUMEDALES
(Ramsar, Iran, 1971)

Article 3.2 Ecological Character

Each Contracting Party shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List **has changed, is changing or is likely to change** as the result of technological developments, pollution or other human interference. Information on such changes shall be passed without delay to the organization or government responsible for the continuing bureau duties specified in Article 8.

COP14 2022

14th Meeting of the Conference of the Contracting Parties to the Ramsar Convention on Wetlands

"Wetlands Action for People and Nature"
Wuhan, China, and Geneva, Switzerland 5-13 November 2022

Resolution XIV.13

The status of Sites in the List of Wetlands of International Importance

75% of the 2,439 Sites that had been designated by 30 June 2022, either the Ramsar Information Sheets (RISs) or adequate maps had not been submitted, or relevant RISs or maps had not been updated for over six years, so that recent information on the status of these Sites was not available

Convention on Wetlands (Ramsar, Iran, 1971)
5th Meeting of the Conference of the Contracting Parties
Kushiro, Japan
9-16 June 1993

Resolution 5.4: The Record of Ramsar sites where changes in ecological character have occurred, are occurring, or are likely to occur (Montreux Record)

DETERMINES that the purpose of the Montreux Record **is to identify priority sites for positive national and international conservation attention**, to guide implementation of the Monitoring Procedure, and to guide allocation of resources available under financial mechanisms;

CONVENTION ON WETLANDS (Ramsar, Iran, 1971)

Proceedings of the 6TH Meeting of the Conference of the Contracting Parties (Brisbane, Australia, 19-27 March 1996)

RESOLUTION VI.1: WORKING DEFINITIONS OF ECOLOGICAL CHARACTER, GUIDELINES FOR DESCRIBING AND MAINTAINING THE ECOLOGICAL CHARACTER OF LISTED SITES, AND GUIDELINES FOR OPERATION OF THE MONTREUX RECORD

3.2 The Montreux Record is the principal tool of the Convention for highlighting those sites where **an adverse change in ecological character has occurred**, is occurring, or is likely to occur, and which are therefore in need of priority conservation attention. It shall be maintained as part of the Ramsar Database and shall be subject to continuous review.

When we look at people, there are... then we describe...


Common


Style


Wierdo...

When we look at wetlands, there are... then we describe...


typical


unique


degraded

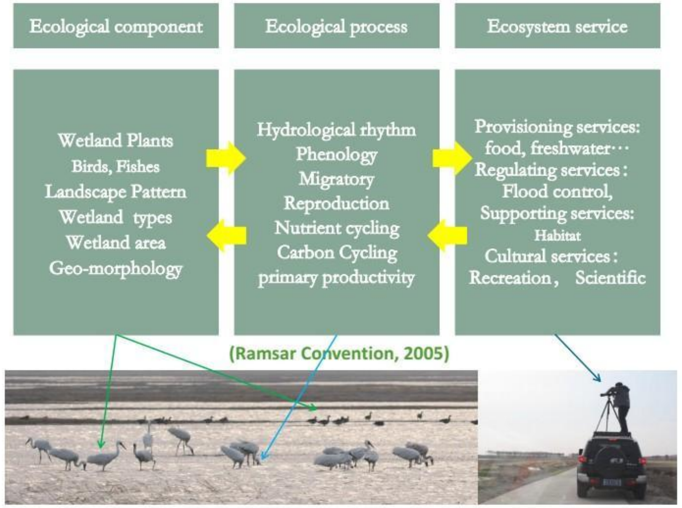
Wetlands also have characters: ecological characters

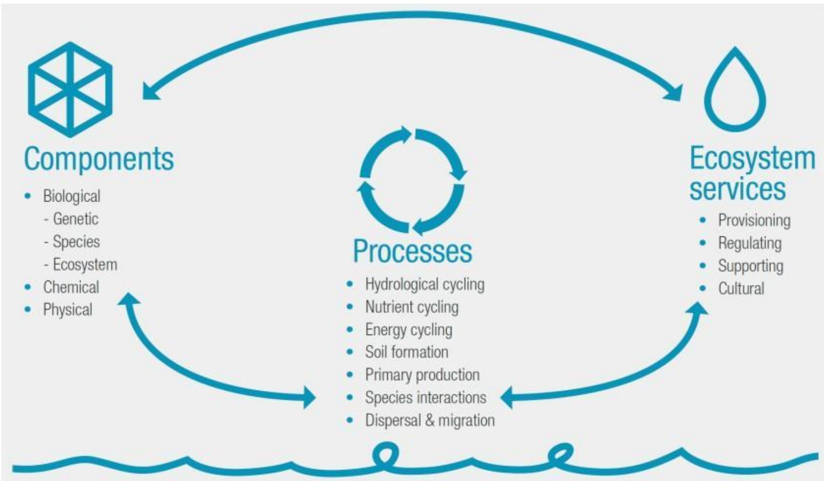
Ecological Characters:
Why a Wetland is THE WETLAND

The Concept of Ecological Character

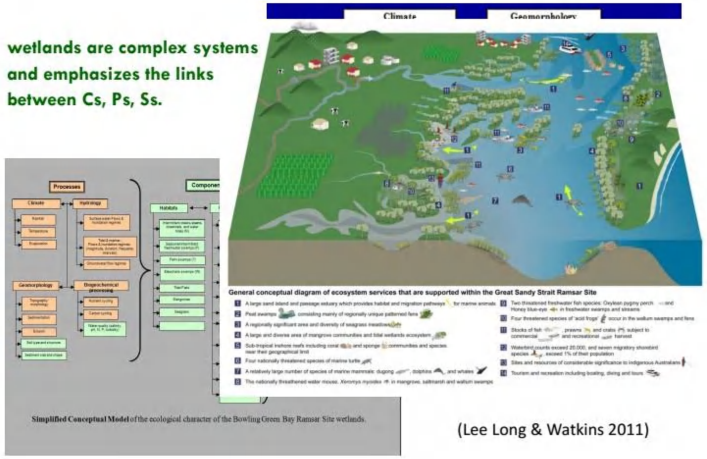
=Ecological component
+Ecological process
+Ecosystem service

Momoge: World largest stopover site for Siberian Cranes





Conceptual Model for EC



5. Ecological Character Description

Ramsar
CONVENTION ON WETLANDS
CONVENTION SUR LES ZONES HUMIDES
CONVENCIÓN SOBRE LOS HUMEDALES
(Ramsar, Iran, 1971)

- Describes the **ecosystem services** of a wetland, and the critical **ecological components** and **ecological processes** that underpin those services - **at a given point in time**
- Via ECD
  - ➢ provides a benchmark description at the time of listing, natural variability and **limits of acceptable change (LAC)** of the ecosystem
  - ➢ better dynamic monitoring on biodiversity
  - ➢ provides support for management plans, decisions and actions

Rogers K et al 2017
DOI:10.1007/s10750-017-3257-5.

1605 Earth Quake at Dongzhaigang, Hainan

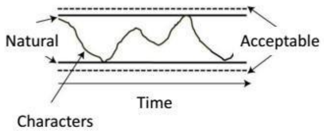
Identifying Critical Characters

Principle of identifying critical character

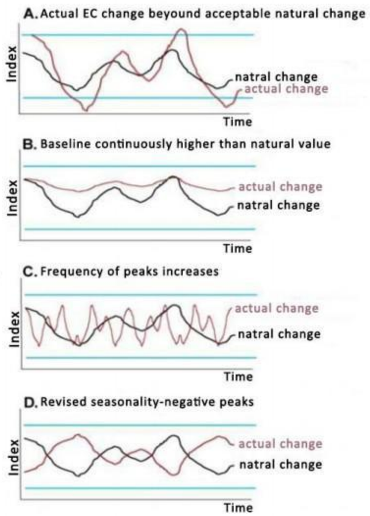
—are key determinants of a sites' character and/or degree of importance and/or unique status;
—if they change beyond their natural range, are likely to cause significant negative consequences to the ecosystem(s) of this site;
—have important ecological links in space or time to other ecosystems or populations

Thus, a critical C,P must meet 1, as well as 2 and/or 3

Setting LAC



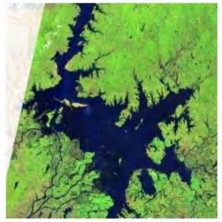
(after Phillips 2006).



NASA/Joshua Stevens

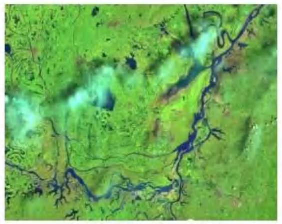
https://earthobservatory.nasa.gov/images/92130/dramatic-flooding-in-eastern-africa

Dongting Lake, 11 July 2022



Poyang Lake, 11 July 2022

2022

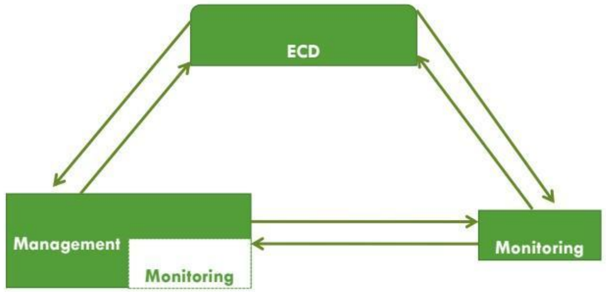


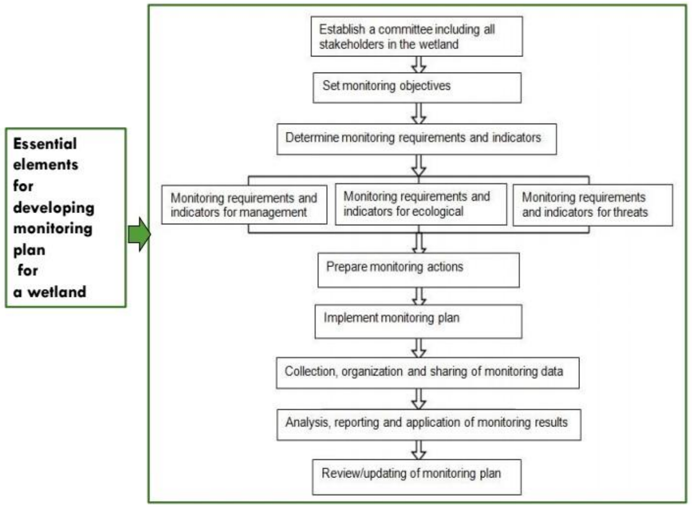
Dongting Lake, 15 August 2022

Poyang Lake, 15 August 2022

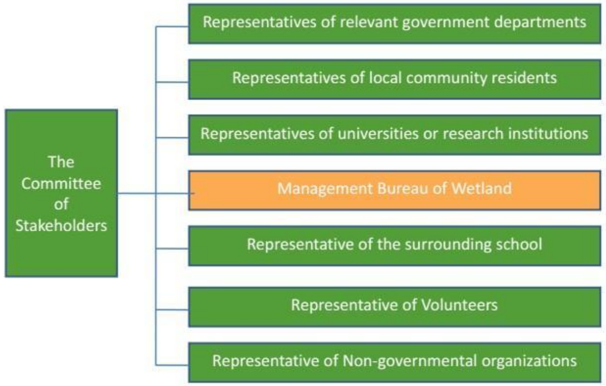
6. Ecological character monitoring and maintenance

Understanding the relationship between the ECD, Management and Monitoring

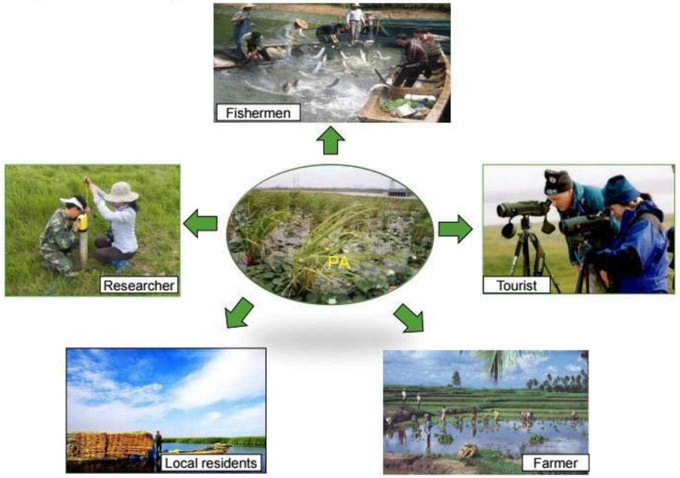




Step 1 Establishing Monitoring Committee of Stakeholders



Step 1 Establishing Monitoring Committee of Stakeholders



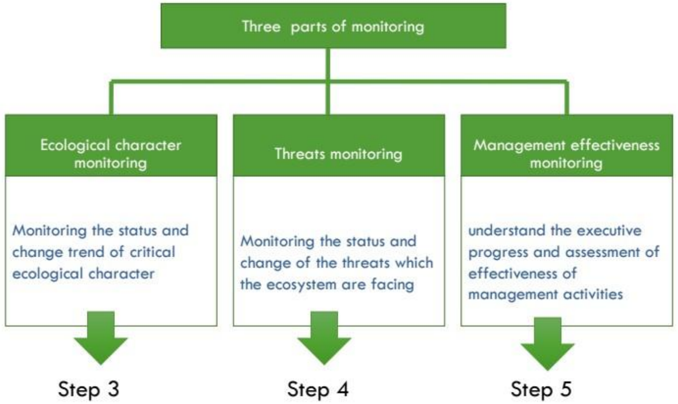
Step 1 Establishing Monitoring Committee of Stakeholders

In order to ensure that

- integrates well with the development plans of all stakeholders,
- secures more supporting resources,
- facilitates implementation,

a committee of stakeholders in monitoring should be established at the outset.

Step 2 Identifying Monitoring Objectives

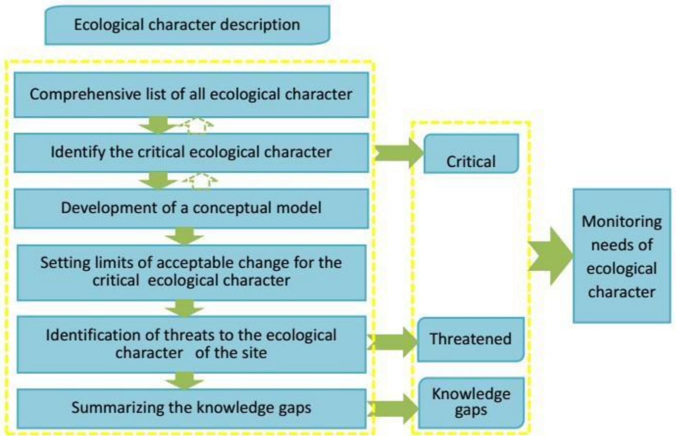


Step 2 Identifying Monitoring Objectives

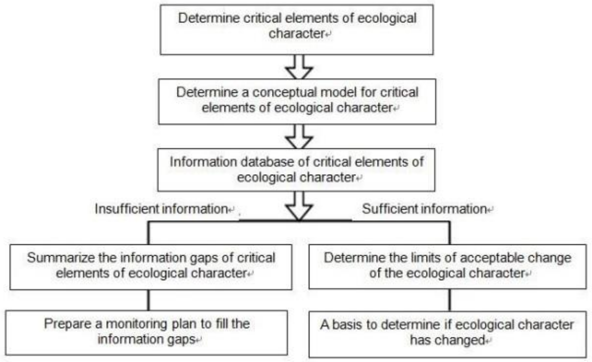
General "Guiding Principles"

- Answer the questions raised in the management process
- Iinvestigate the status and trends of change of ecological character;
- Investigate the threats that may influence ecological character;
- Monitor implementation progress and the effectiveness of management activities;
- Promote public participation and balance the interests of all parties.

Step 3 Identify Monitoring Needs and Indicators for Ecological Character



Step 3 Identify Wetland Monitoring Needs and Indicators for Ecological Character

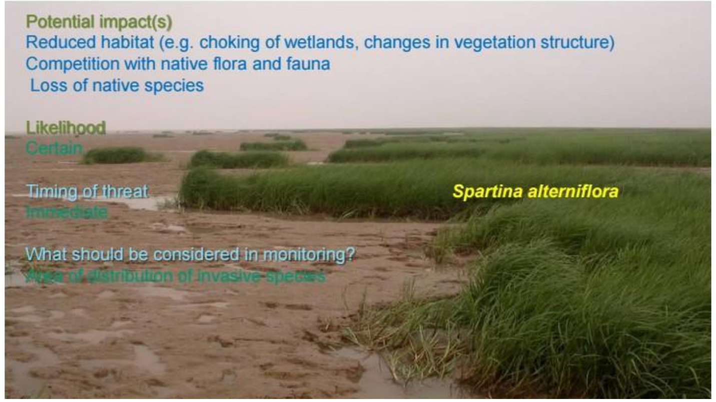


Step 4 Identify Monitoring Needs and Indicators for Threats

Eexisting or potential threats to the ecological character of PAs

Actual or likely threat or threatening activities	Impacted ecological character	Potential impact(s) to ecosystem components, processes and/or services	Likelihood	Timing of threat

e.g., threats: Introduction and/or poor control of invasive species



Step 5 Identify Monitoring Needs and Indicators for Management Effectiveness

Through monitoring of executive progress and effectiveness of wetland management activities, managers can assess the impacts of management actions on wetland ecosystem, review and update management plan.

Management activities	Excepted objectives	Implementation	Whether objectives has been achieved	Reason

A list of threats developed by the **International Union for the Conservation of Nature (IUCN)** and the **Conservation Measures Partnership (CMP)**

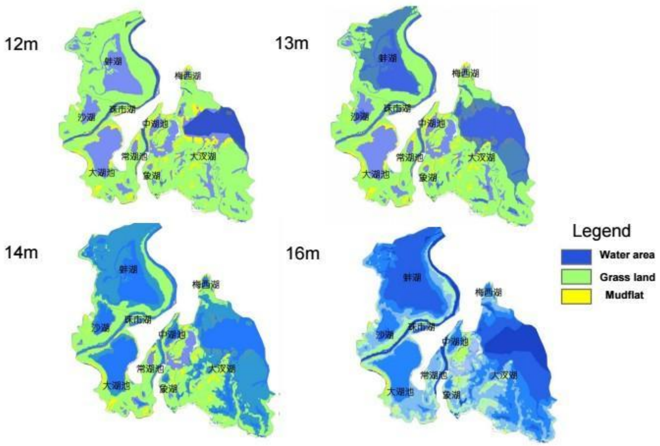
http://www.iucn.org/about/work/programmes/species/red_list/resources/technical_documents/new_classification_schemes/

These categories may be a useful starting point for identifying threats to ecological character of a Protected Area.

Wetland restoration

review of the extent of expected scenarios realized…………

Monitor Change of wetland landscape by remote sensing technology

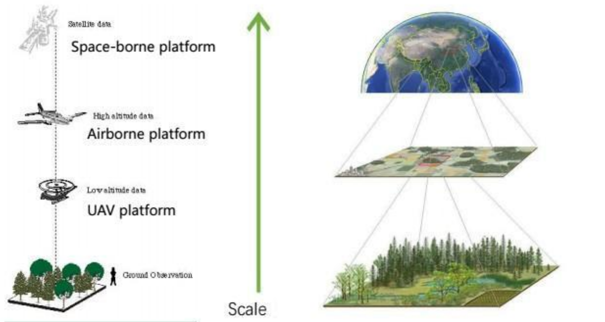


Step 6 Develop Action Plan for Monitoring Indicators

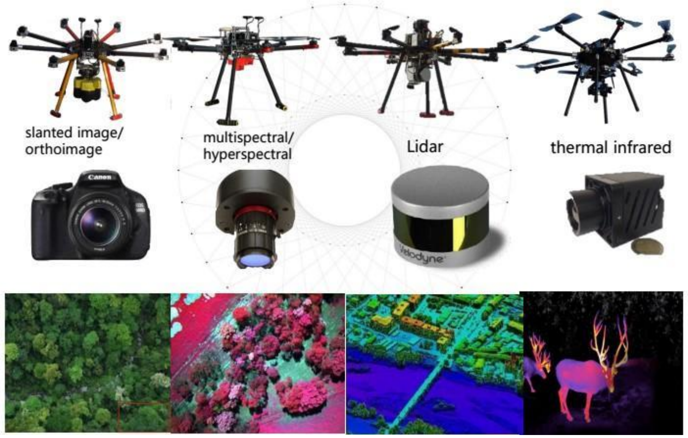
In this section, we should select monitoring methods, indentify monitoring frequency, and priority of monitoring activities as showing in the following table:

Indicators	Methods	Monitoring frequency	Source of funding	Priority

RS can provide biodiversity information of multiple spatial scale and time scale

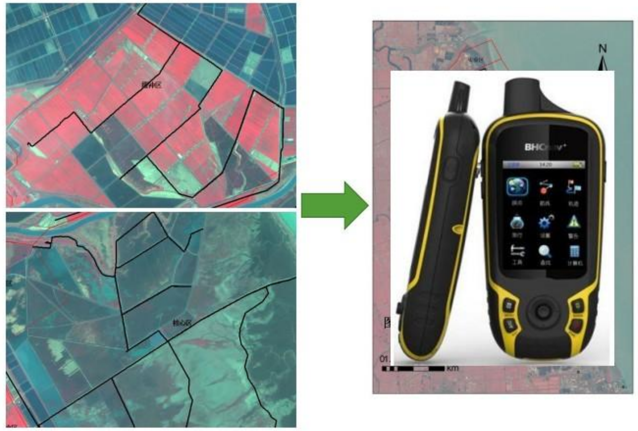


(global-region-landscape-sample area)



Plant survey

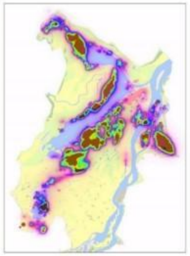
Sampling of benthos



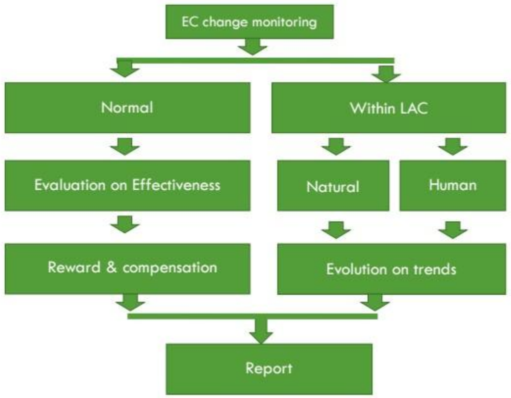
Acoustic recorder





Step 9 Analysis, Reports and Applications of Monitoring Data



Step 7 Implementation of Monitoring Action Plan

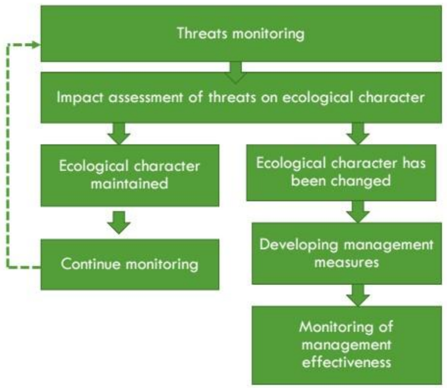
Monitoring action plan should be implemented with contracting parties; the task arrangement should be recorded by management bureau.

Monitoring activities	Executor	Reporting frequency	Contact

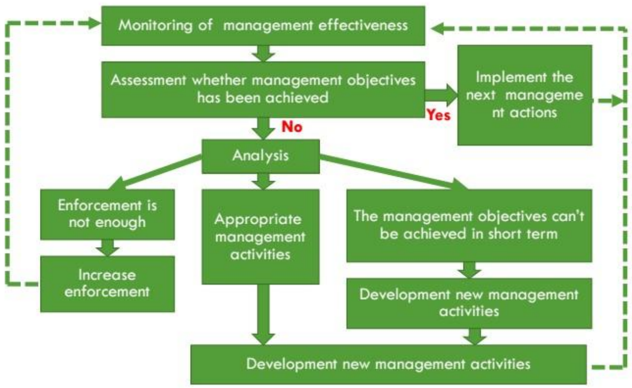
Step 8 Collection and Submission of Monitoring Data

The executors of monitoring activities should submission data to the Bureau.

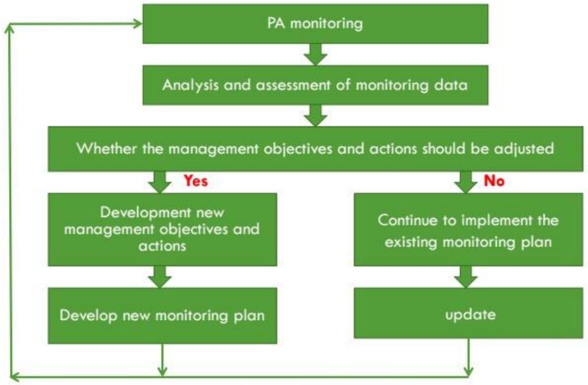
Step 9 Analysis, Reports and Applications of Monitoring Data

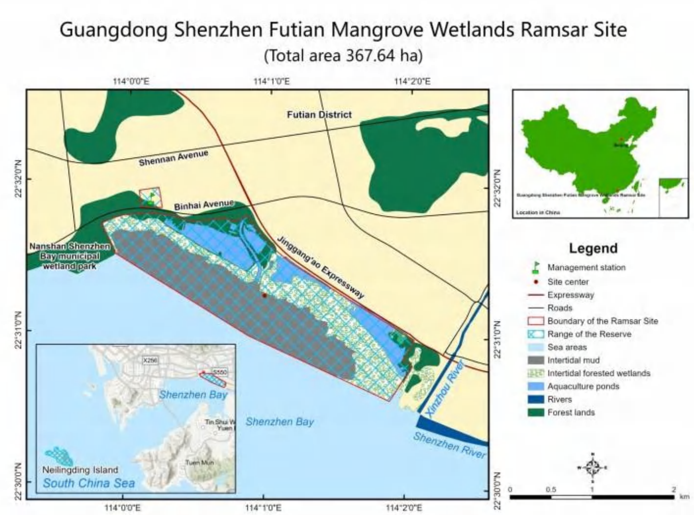


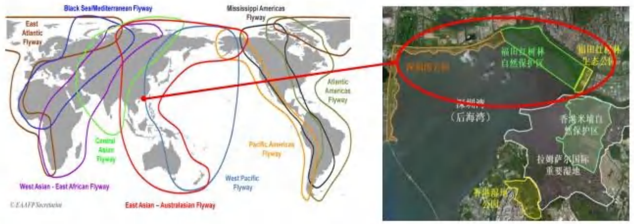
Step 9 Analysis, Reports and Applications of Monitoring Data



Step 10 Update of monitoring plan

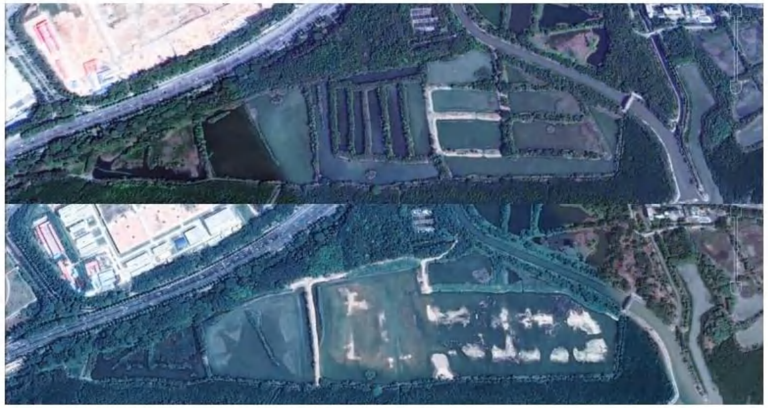






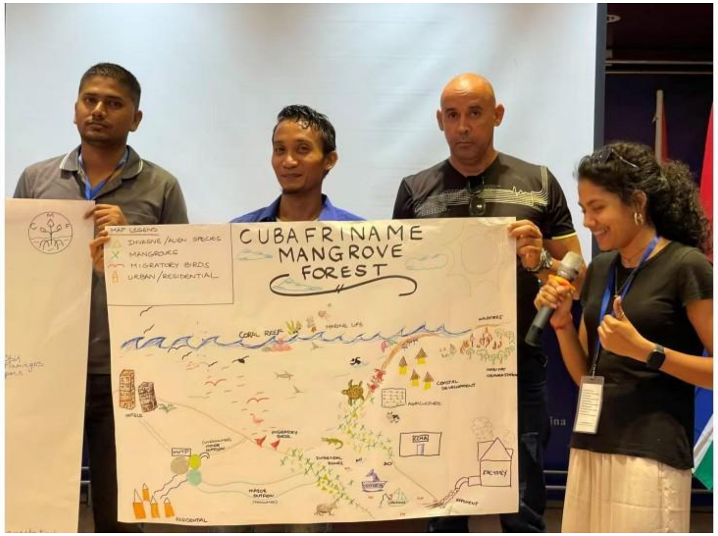
Before

After



Group discussion on challenges and priorities

1. Select a shared challenge in your region 5min
2. Describe the issue + list 3 major Components, Processes and ESs 15min
3. Draw a map of conceptual model + optional box conceptual model 20min
4. Identify/Think of 1 Critical Ec 10min
5. Think one priority solution 10min
6. 5 Group reports 5 min each:
   - challenge
   - map
   - 1-3 critical ECs
   - 1-3 Priorities



Annex 3.6: Mangrove Habitat Dynamics, Connectivity and Complexity

Mangrove Habitat Dynamics, Connectivity and Complexity

Dr. A. Aldrie Amir
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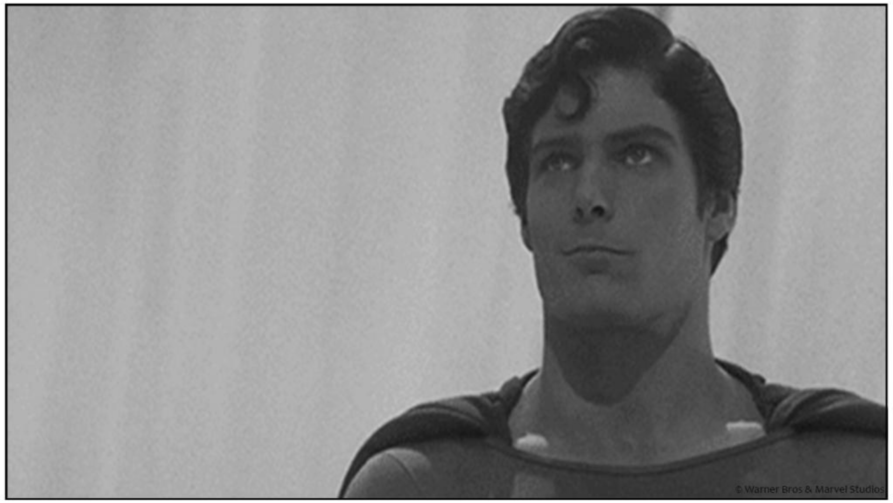
Commission Member, International Union for the Conservation of Nature, Species Survival Commission, Mangrove Specialist Group
Coordinator, The Malaysian Mangrove Research Alliance and Network (MyMangrove)

1

2



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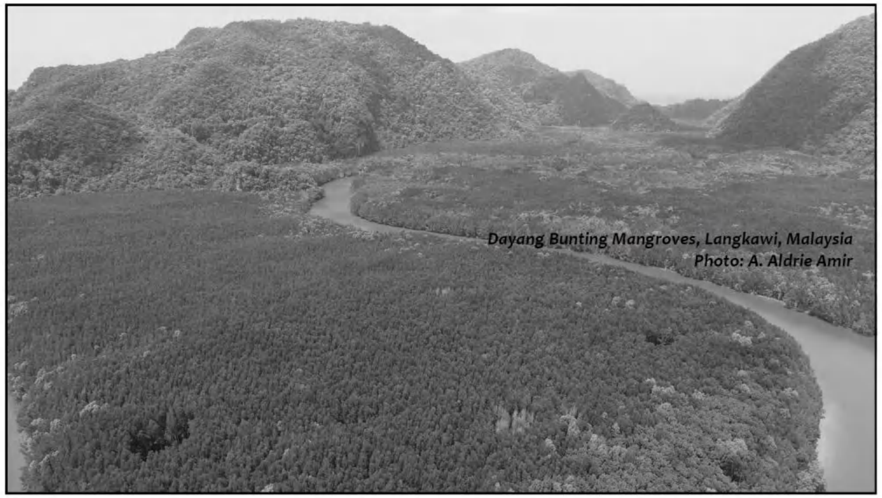

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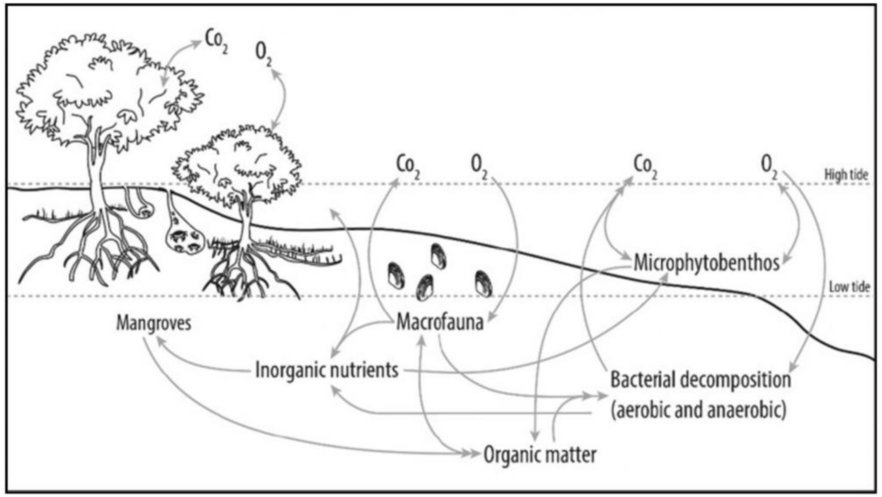

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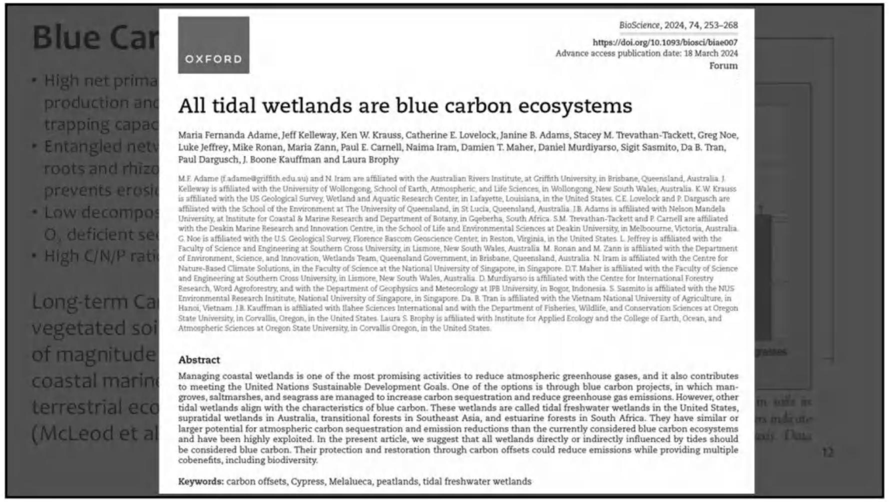

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Forum

All tidal wetlands are blue carbon ecosystems

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Abstract

Managing coastal wetlands is one of the most promising activities to reduce atmospheric greenhouse gases, and it also contributes to meeting the United Nations Sustainable Development Goals. One of the options is through blue carbon projects, in which mangroves, saltmarshes, and seagrass are managed to increase carbon sequestration and reduce greenhouse gas emissions. However, other tidal wetlands align with the characteristics of blue carbon. These wetlands are called tidal freshwater wetlands in the United States, supratidal wetlands in Australia, transitional forests in Southeast Asia, and estuarine forests in South Africa. They have similar or larger potential for atmospheric carbon sequestration and emission reductions than the currently considered blue carbon ecosystems and have been highly exploited. In the present article, we suggest that all wetlands directly or indirectly influenced by tides should be considered blue carbon. Their protection and restoration through carbon offsets could reduce emissions while providing multiple cobenefits, including biodiversity.

Keywords: carbon offsets, Cypress, Melalueca, peatlands, tidal freshwater wetlands

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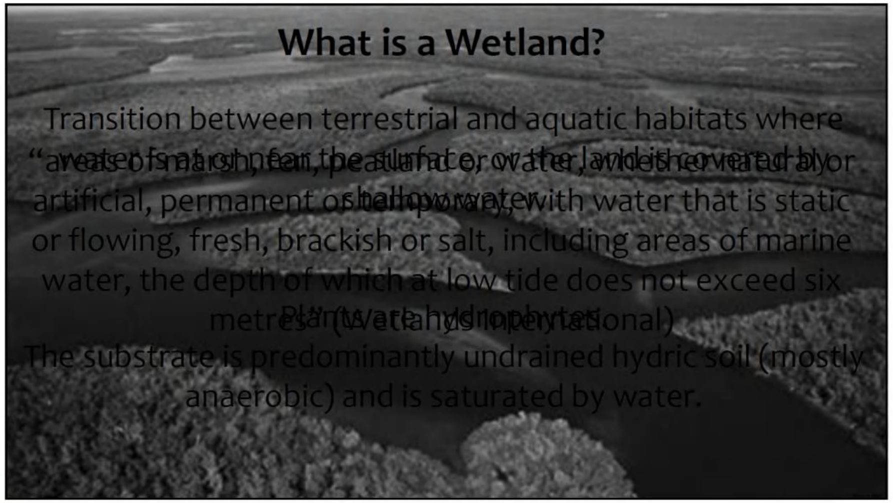

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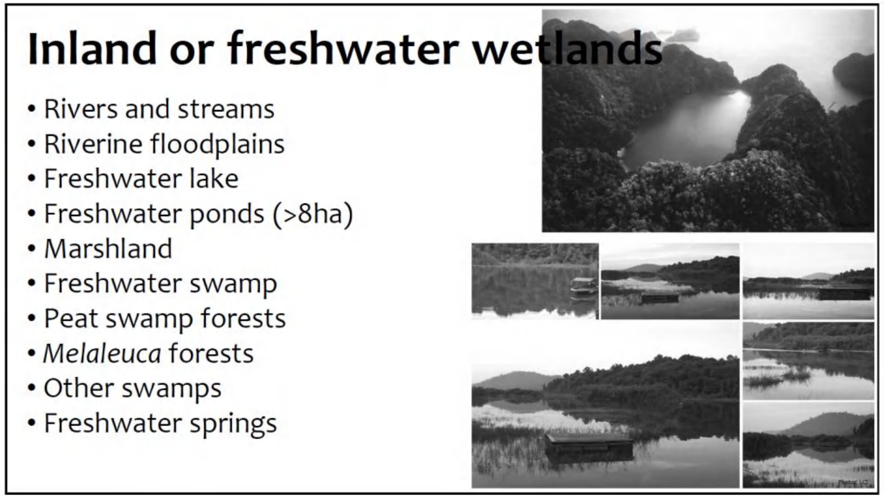


8

Coastal and Marine Wetlands

- Marine waters
- Subtidal aquatic beds
- Seagrass beds
- Seaweed beds
- Coral reefs
- Rocky shores
- Sandy beaches
- Mangrove forests
- Salt marshes
- Lagoons and bays
- Intertidal mud and sand flats

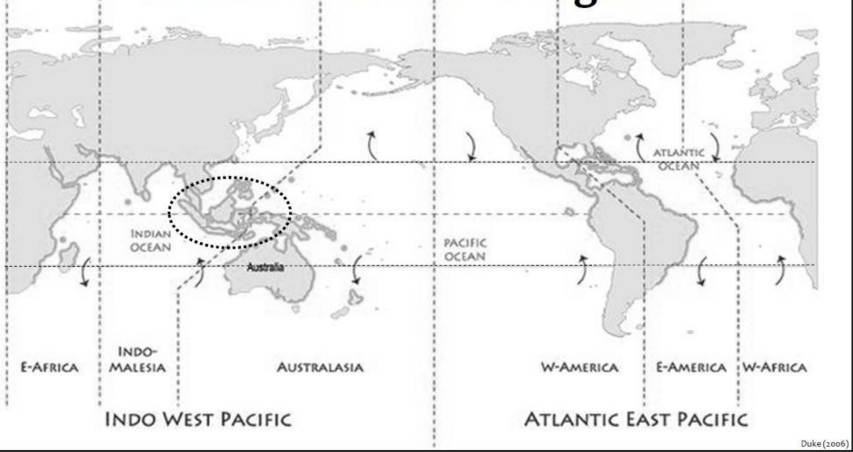
9

Man-made or Constructed Wetlands

- Water storage areas;
  - reservoirs
  - barrages
  - hydroelectric dams
- Aquaculture;
  - fish ponds
  - shrimp ponds
- Excavations;
  - mining pools
- Wastewater treatment;
  - sewage farms
  - settling ponds
  - oxidation ponds
- Irrigated land (incl. channels);
  - rice field
  - canals
  - ditches
- Other ponds (>8 ha);
  - farm ponds
  - ash ponds
  - stock ponds
- Constructed wetlands;
  - marsh
  - ponds
  - lakes
  - saltwater lakes

10

The Distribution of Mangroves



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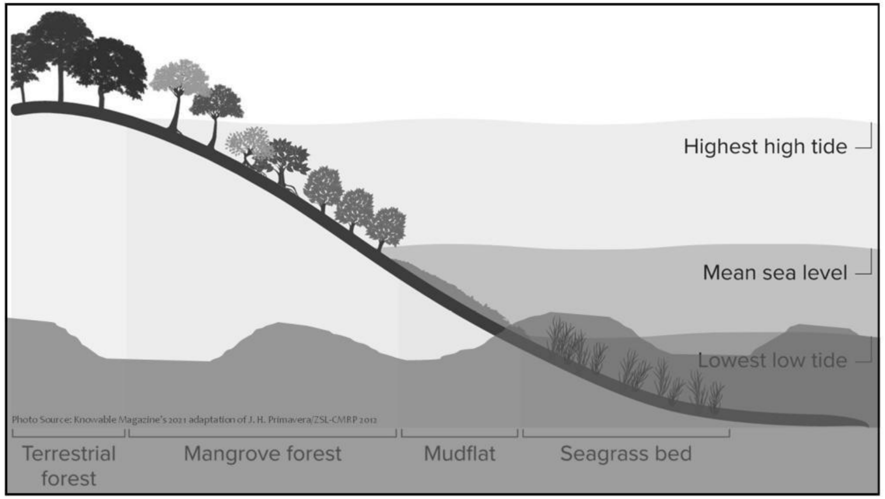

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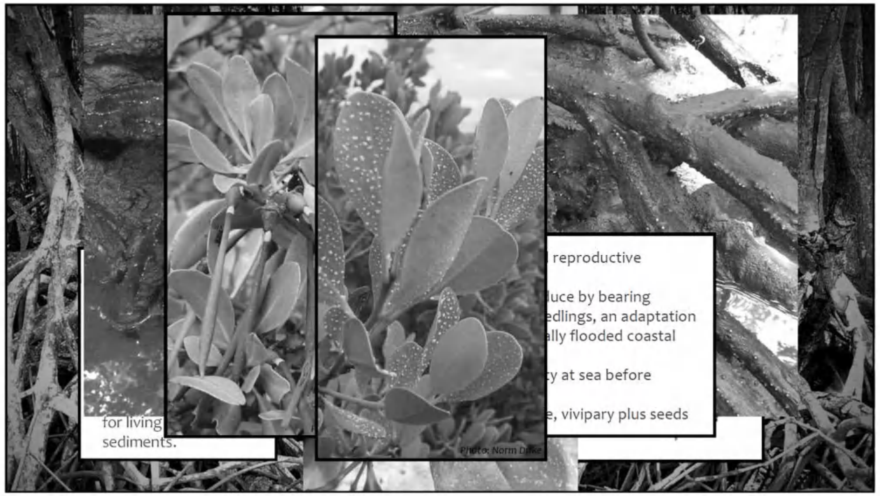
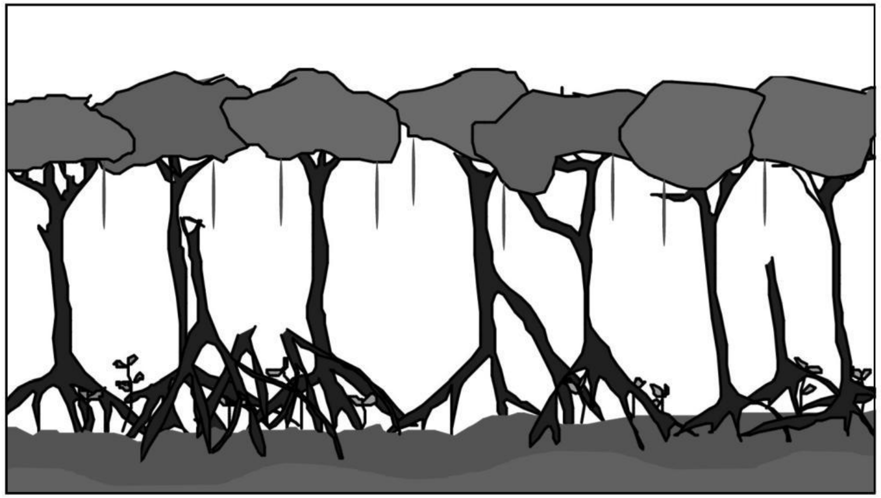


reproductive
luce by bearing
edlings, an adaptation
ally flooded coastal
y at sea before
e, vivipary plus seeds
for living
sediments.
Photo: Norm Duke

13



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XYZ Mangrove Island, Malaysia
Photo: A. Aldrie Amir

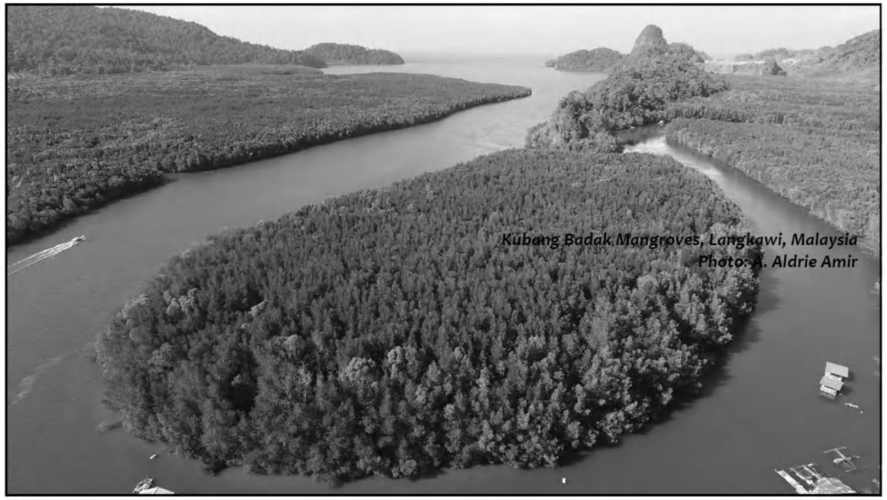
15

XYZ Mangrove Island, Malaysia
Photo: A. Aldrie Amir

16


XYZ Mangrove Island, Malaysia
Photo: A. Aldrie Amir

17


Kubang Badak Mangroves, Langkawi, Malaysia
Photo: A. Aldrie Amir

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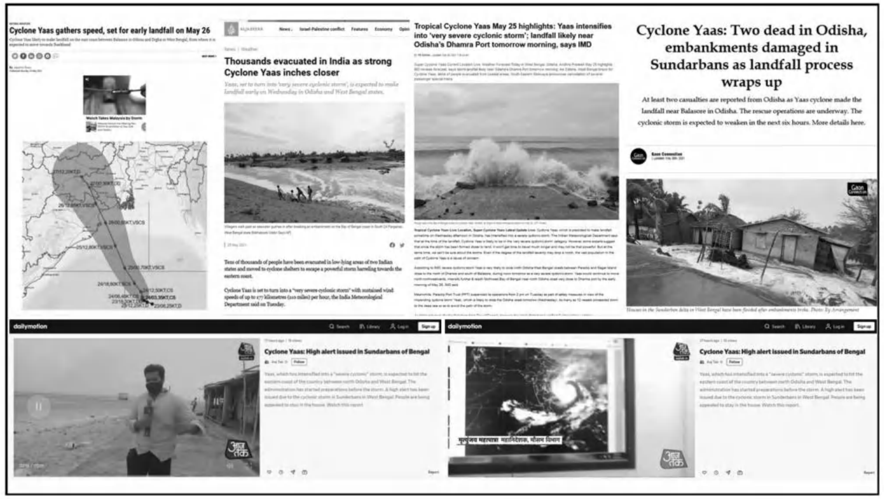
Cyclone Yaas gathers speed, set for early landfall on May 26
Thousands evacuated in India as strong Cyclone Yaas inches closer
Tropical Cyclone Yaas May 25 highlights: Yaas intensifies into 'very severe cyclonic storm'; landfall likely near Odisha's Dhamra Port tomorrow morning, says IMD
Cyclone Yaas: Two dead in Odisha, embankments damaged in Sundarbans as landfall process wraps up
At least two casualties are reported from Odisha as Yaas cyclone made the landfall near Balasore in Odisha. The rescue operations are underway. The cyclonic storm is expected to weaken in the next six hours. More details here.
dailymotion
Cyclone Yaas: High alert issued in Sundarbans of Bengal
dailymotion
Cyclone Yaas: High alert issued in Sundarbans of Bengal

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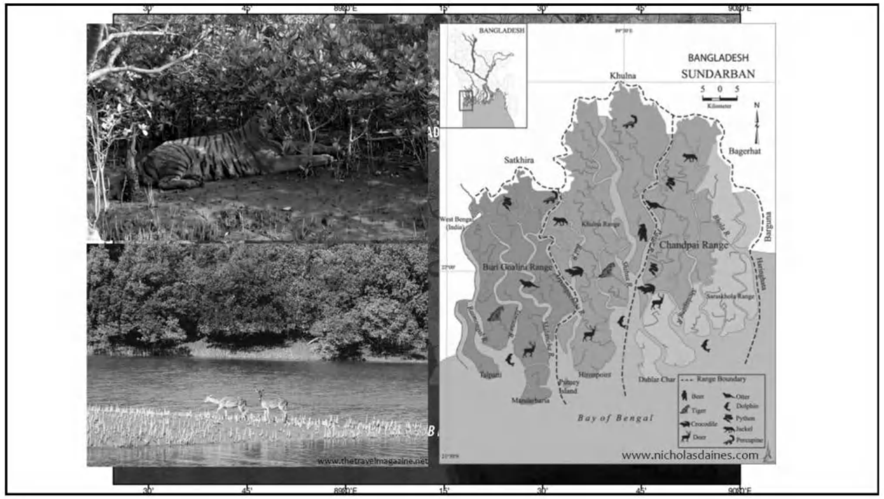
BANGLADESH
BANGLADESH
SUNDARBAN
Khulna
Satkhira
Bagerhat
West Bengal (India)
Buri Goalini Range
Khulna Range
Chandpai Range
Sarankhola Range
Bargana
Dublar Char
Bay of Bengal
Range Boundary
Bear
Tiger
Crocodile
Deer
Otter
Dolphin
Python
Jackal
Porcupine
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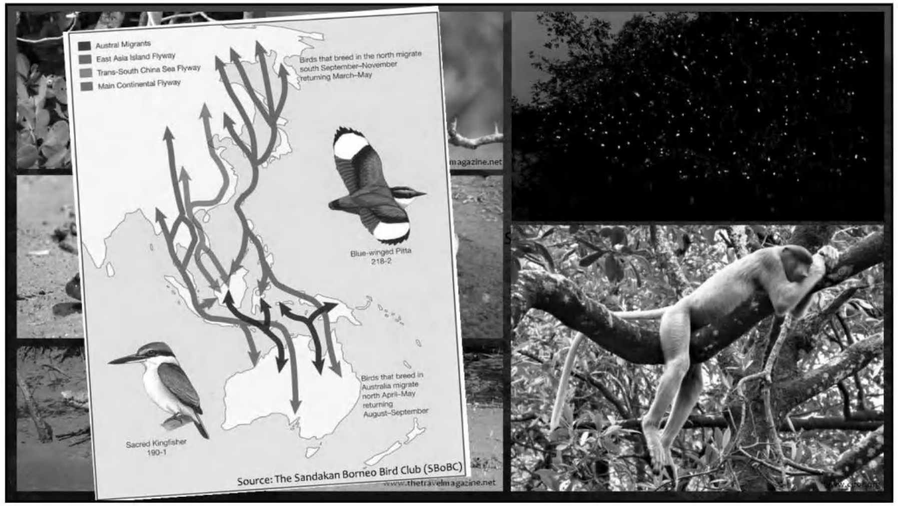
Austral Migrants
East Asia Island Flyway
Trans-South China Sea Flyway
Main Continental Flyway
Birds that breed in the north migrate south September–November returning March–May
Blue-winged Pitta 218-2
Sacred Kingfisher 190-1
Birds that breed in Australia migrate north April–May returning August–September
Source: The Sandakan Borneo Bird Club (SBoBC)
www.thetravelmagazine.net

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Muar Mangroves, Johor, Malaysia
Photo: A. Aldrie Amir

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Seri Buat Mangroves, Pahang, Malaysia
Photo: A. Aldrie Amir

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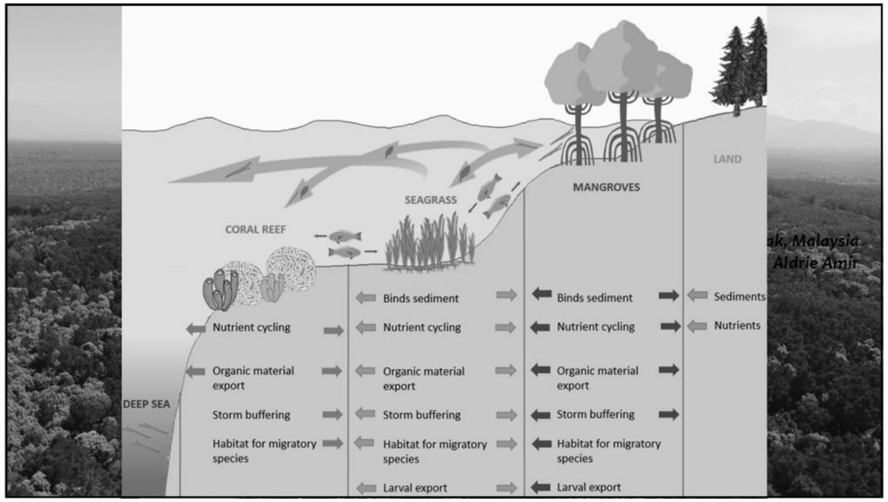
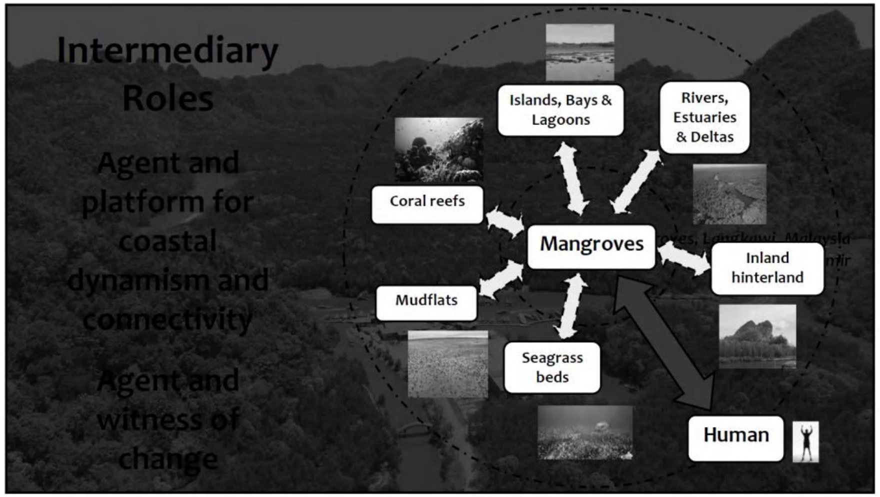
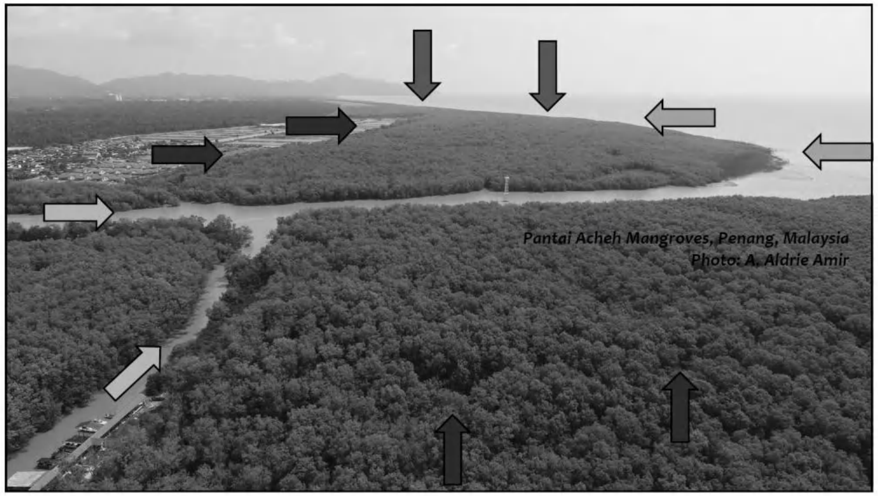

CORAL REEF
SEAGRASS
MANGROVES
LAND
DEEP SEA
Binds sediment
Binds sediment
Sediments
Nutrient cycling
Nutrient cycling
Nutrient cycling
Nutrients
Organic material export
Organic material export
Organic material export
Storm buffering
Storm buffering
Storm buffering
Habitat for migratory species
Habitat for migratory species
Habitat for migratory species
Larval export
Larval export

27


Intermediary Roles
Agent and platform for coastal dynamism and connectivity
Agent and witness of change
Islands, Bays & Lagoons
Rivers, Estuaries & Deltas
Coral reefs
Mangroves
Inland hinterland
Mudflats
Seagrass beds
Human

28



Pantai Acheh Mangroves, Penang, Malaysia
Photo: A. Aldrie Amir

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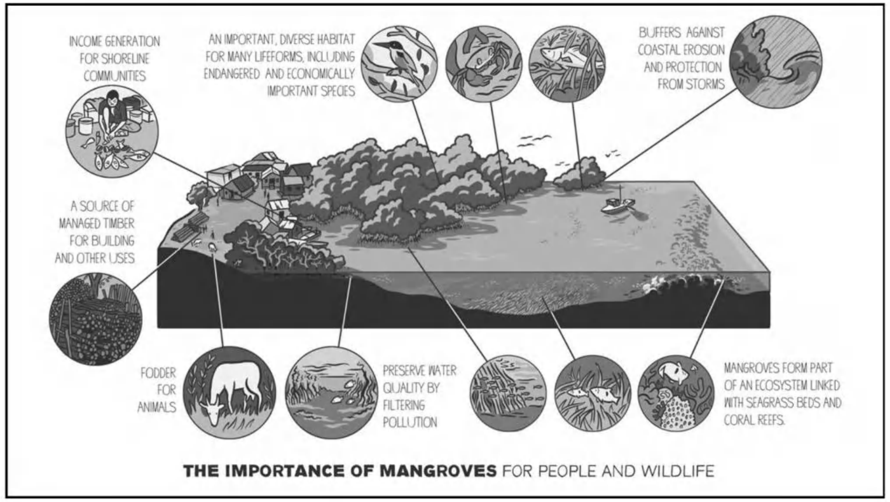

INCOME GENERATION FOR SHORELINE COMMUNITIES
AN IMPORTANT, DIVERSE HABITAT FOR MANY LIFEFORMS, INCLUDING ENDANGERED AND ECONOMICALLY IMPORTANT SPECIES
BUFFERS AGAINST COASTAL EROSION AND PROTECTION FROM STORMS
A SOURCE OF MANAGED TIMBER FOR BUILDING AND OTHER USES
FODDER FOR ANIMALS
PRESERVE WATER QUALITY BY FILTERING POLLUTION
MANGROVES FORM PART OF AN ECOSYSTEM LINKED WITH SEAGRASS BEDS AND CORAL REEFS.
THE IMPORTANCE OF MANGROVES FOR PEOPLE AND WILDLIFE

30

PORT WELD
KTM
1885
KTM
ala Sepetang, Perak, Malaysia
Photo: A. Aldrie Amir

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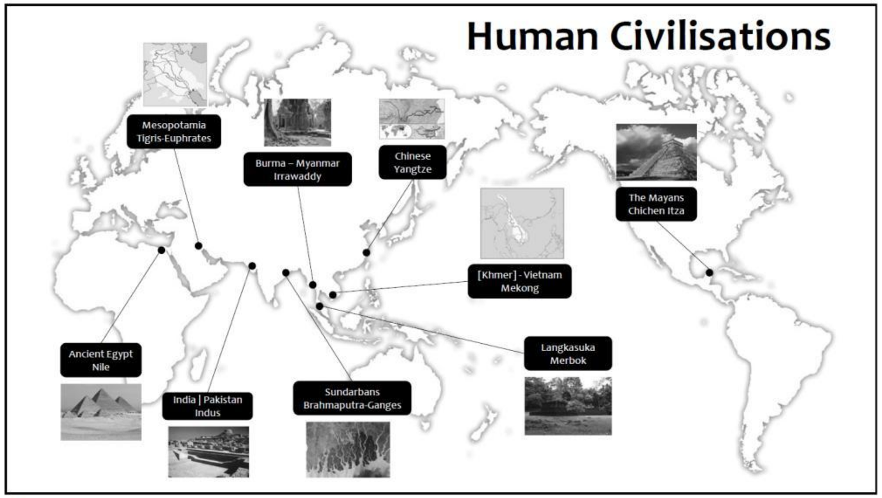
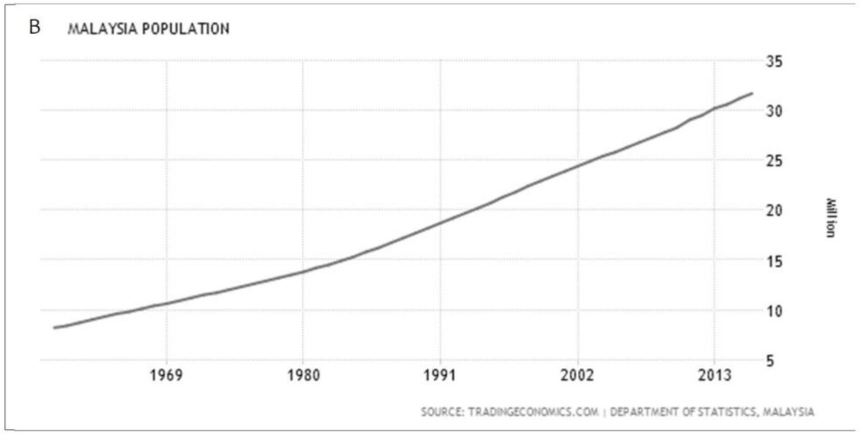


Human Civilisations
Mesopotamia
Tigris-Euphrates
Burma – Myanmar
Irrawaddy
Chinese
Yangtze
The Mayans
Chichen Itza
[Khmer] - Vietnam
Mekong
Langkasuka
Merbok
Ancient Egypt
Nile
India | Pakistan
Indus
Sundarbans
Brahmaputra-Ganges

32

Malaysia's major cities, towns and districts are on the coast

33



34

Table 2. Percentage of the total deforested mangrove (2000–2012) converted to different land uses

Country	Aquaculture	Rice	Oil palm	Mangrove forest	Urban	Other category
Indonesia	48.6	0.1	15.7	22.6	1.9	11.2
Myanmar	1.6	87.6	1.1	0.5	1.6	7.6
Malaysia	14.7	0.1	38.2	17.6	12.8	16.7
Thailand	10.8	5.6	40.0	5.1	14.4	24.1
Philippines	36.7	0.9	11.1	7.3	2.7	41.3
Cambodia	27.7	1.5	8.9	9.8	4.6	47.6
Vietnam	21.0	10.4	0.5	0.6	62.5	4.9
Brunei	29.2	0	27.7	12.5	15.9	14.8
Timor-Leste	0	26.1	0	0	0	73.9*
Singapore	0	0	0	0	0	0
Total	29.9	21.7	16.3	15.4	4.2	12.3

Countries are ordered by total mangrove lost. Percentages might not sum to 100 owing to rounding.
*The small amount of mangrove deforestation in Timor-Leste is due mainly to shoreline erosion.

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Anthropogenic Disturbances

- Excessive logging
- Toxic chemicals runoff
- Reclamation (agriculture, aquaculture)
- Mining for peat, coal, sand, gravel, etc.
- Excessive siltation and deposition
- Impoundment
- Wash and erosion
- Long-term flooding
- Oil spills

36


Balik Pulau Mangroves, Penang, Malaysia
Photo: A. Aldrie Amir

37


Bukit Malut Mangroves, Langkawi, Malaysia
Photo: A. Aldrie Amir

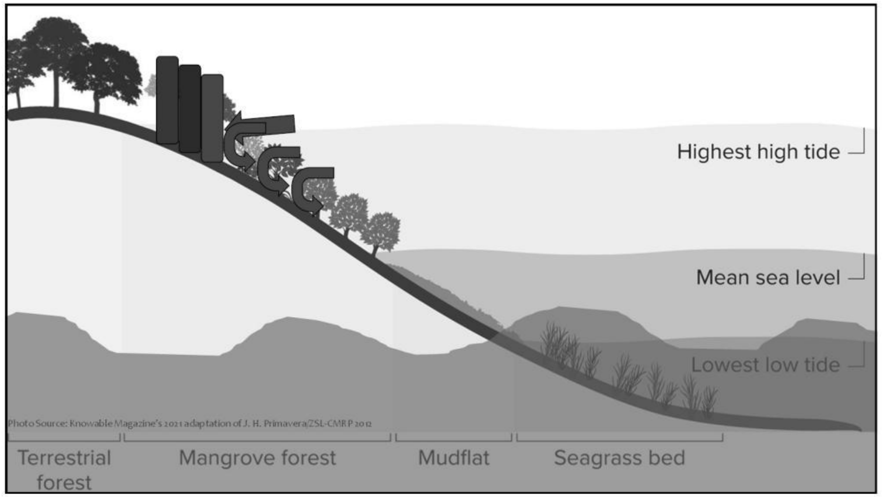
38


Merbok Mangroves, Kedah, Malaysia
Photo: A. Aldrie Amir

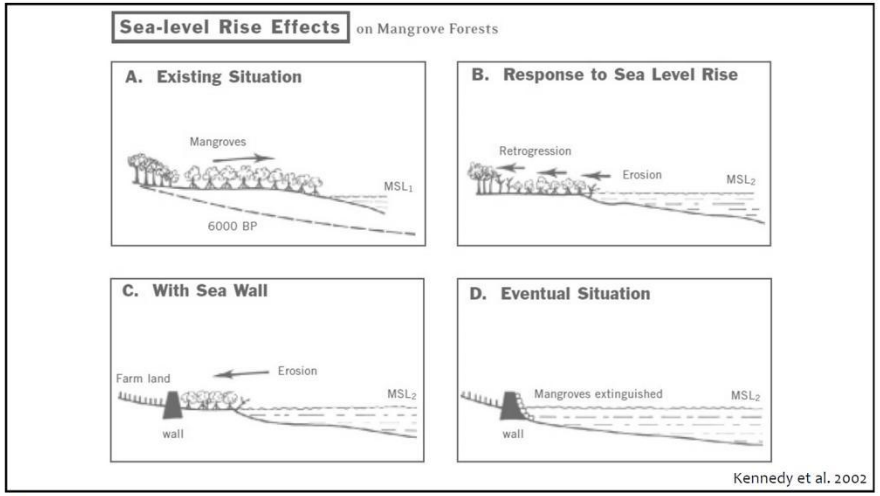
39


Sungai Pulai Mangroves, Johor, Malaysia
Photo: A. Aldrie Amir

40


Highest high tide
Mean sea level
Lowest low tide
Photo Source: Knowable Magazine's 2021 adaptation of J. H. Primavera/ZSL-CMRP 2012
Terrestrial forest
Mangrove forest
Mudflat
Seagrass bed

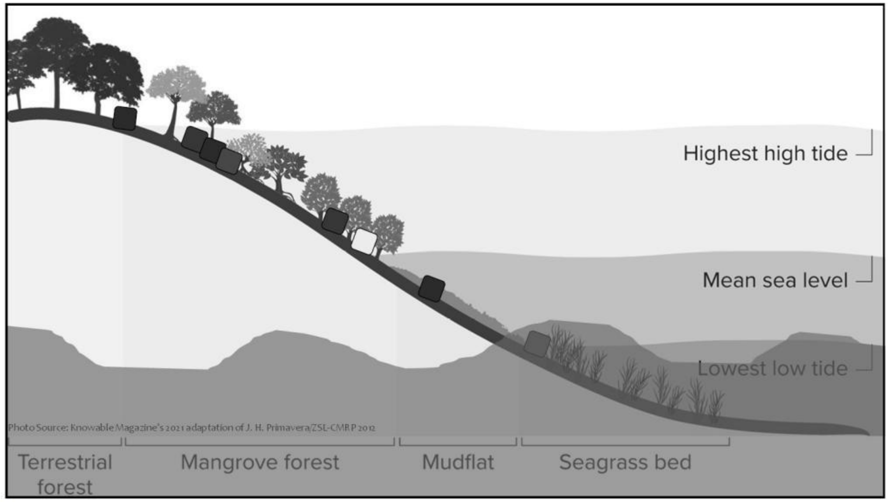
41


Sea-level Rise Effects on Mangrove Forests
A. Existing Situation
Mangroves
MSL_1
6000 BP
B. Response to Sea Level Rise
Retrogression
Erosion
MSL_2
C. With Sea Wall
Farm land
Erosion
MSL_2
wall
D. Eventual Situation
Mangroves extinguished
MSL_2
wall
Kennedy et al. 2002

42


Sungai Kertih Mangroves, Terengganu, Malaysia
Photo: A. Aldrie Amir

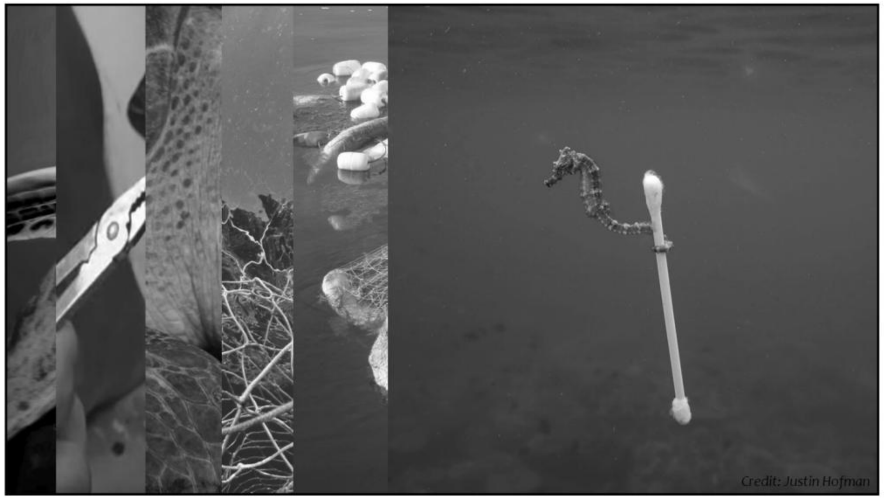
43


Highest high tide
Mean sea level
Lowest low tide
Photo Source: Knowable Magazine's 2021 adaptation of J. H. Primavera/ZSL-CMRP 2012
Terrestrial forest
Mangrove forest
Mudflat
Seagrass bed

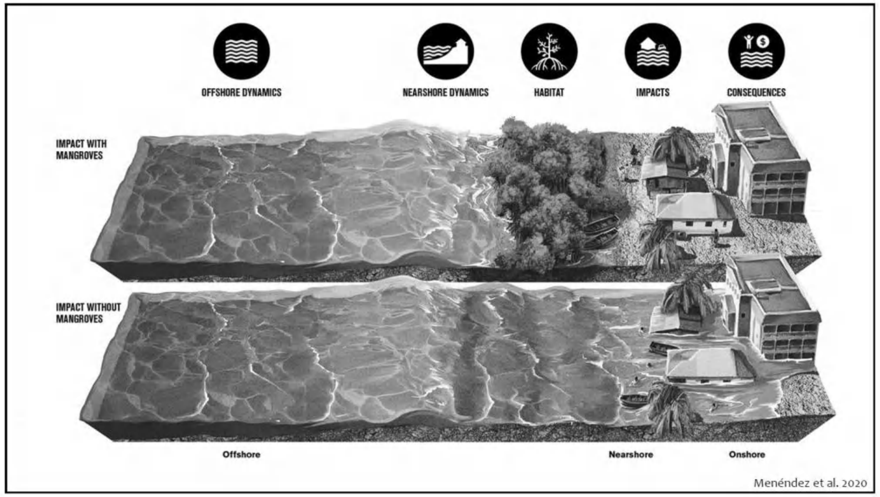
44


Mangroves, Selangor, Malaysia
Photos: A. Aldrie Amir

45


Credit: Justin Hofman

46


OFFSHORE DYNAMICS
NEARSHORE DYNAMICS
HABITAT
IMPACTS
CONSEQUENCES
IMPACT WITH MANGROVES
IMPACT WITHOUT MANGROVES
Offshore
Nearshore
Onshore
Menéndez et al. 2020

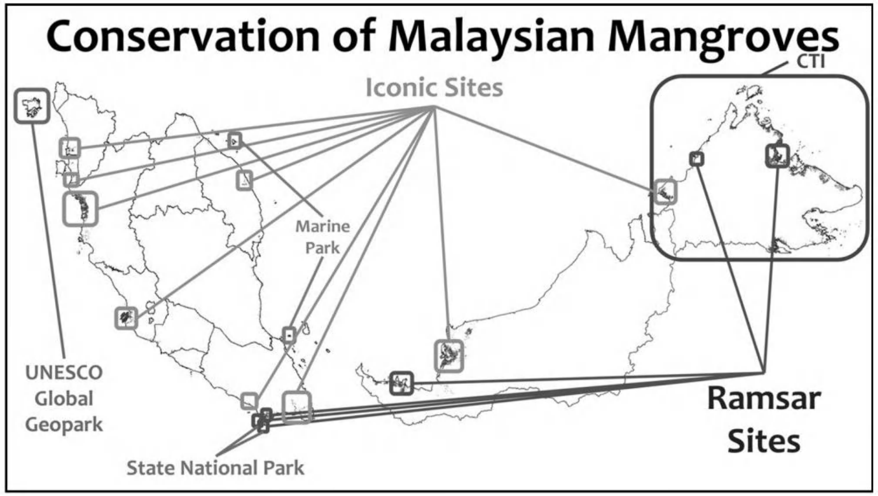
47


Matang Mangroves, Perak, Malaysia
Photo: A. Aldrie Amir

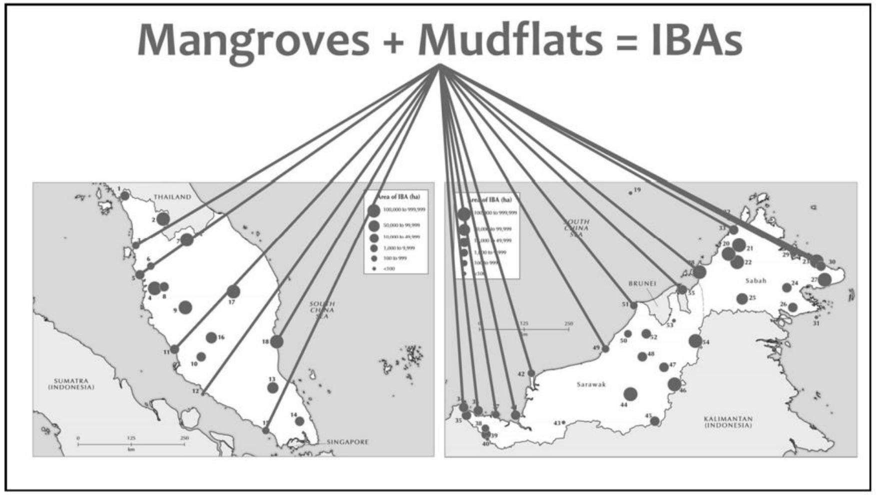
48

1. Continental Shelf Act (1966) (Revised 1972)
2. Economic Exclusive Zone Act (1984)
3. Environmental Quality Act (1974) (Amended 2012)
4. Fisheries Act (1985)
5. Five-Fuel Policy (2001)
6. Four-Fuel Diversification Policy (1981)
7. Green Technology and Climate Change Council (2010)
8. Land Conservation Act 1960 (revised 1989)
9. Local Government Act 1976
10. Low Carbon Cities Framework (2011)
11. National Agricultural Policies (NAP 1-3)
12. National Agro-food Policy (2011)
13. National Automotive Policy (2014)
14. National Biofuel Policy (2006)
15. National Coastal Zone Physical Plan (2012)
16. National Depletion Policy (1980)
17. National Energy Policy (1979) (Revised 2008)
18. National Forestry Act (1984) (Amended 1993)
19. National Forestry Policy (1978) (Revised 1992)
20. National Green Technology Policy (2009)
21. National Integrity Plan (2004)
22. National Parks Act 1980 (Updated 2013)
23. National Petroleum Policy (1975)
24. National Physical Plans
25. National Policy on Biological Diversity (2016)
26. National Policy on Climate Change (2009)
27. National Policy on the Environment (2002)
28. National Strategic Plan for Solid Waste Management (2005)
29. National Water Resources Policy (2012)
30. National Wetlands Policy (Draft)
31. New Economic Model, Government Transformation Program and Economic Transformation Program (2010)
32. Protection of Wild Life Act 1972
33. Renewable Energy Policy and Action Plan (2010)
34. Sabah Biodiversity Enactment (2000)
35. Sabah Parks Enactment (1984) (2008)
36. Sabah Wildlife Conservation Enactment (1997)
37. Sarawak Forests Ordinance (1958) (Amended 2015)
38. Sarawak Wildlife Protection Ordinance (1998)
39. Street, Drainage and Building Act 1974 (Amended 2006)
40. Territorial Sea Act (2012)
41. Town and Country Planning Act 1976 (Amended 2006)
42. Waters Act (1920) (Revised 1989)

49

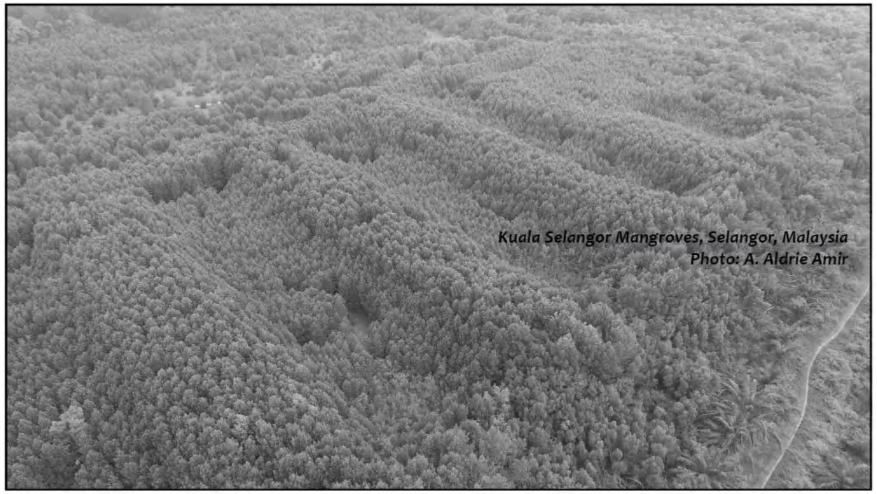


50



51

52



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55

Natural Disturbances

- Severe winds and gusts
- Hurricane, storm
- Hail
- Lightning strikes
- Tidal surges, tsunami
- Severe herbivory
- Drought

56

Disturbance	Causes	Impact	Location	Mean Gap Size	Reference
Natural	Lightning strike	Small to large gaps	Everglades, Florida	332 m²	Whelan and Smith, 2004
			Everglades, Florida	289 m²	Whelan, 2005
			Moreton Bay, Queensland	84.2 m²	Amir, 2011
			Pulau Kecil, Matang, Malaysia	1783.1 m²	Amir, 2012
			Kosrae, Micronesia	[a]700 m²	Allen et al., 2001
			Los Haitises, Dominican Republic	724 m²	Sherman et al., 2000
			Punta Galeta, Panama	601.6 m²	Sousa and Mitchell, 1999
			Punta Galeta, Panama	329 m²	Sousa et al., 2003
			Everglades, Florida	59 m²	Zhang, 2008 Zhang et al., 2008
			Galley Reach, Papua New Guinea	[b]1900 m²	Johns, 1986
			Galley Reach, Papua New Guinea	[c]300-700 m²	Paijmans and Rollet, 1977
	Insect	Small gaps	Central Belize	12 m² (Ag) 72 m² (Rma)	Feller and McKee, 1999
			Matang, Malaysia	-	Putz and Chan, 1986
	Hurricane	Major dieback	Everglades, Florida	-	Smith et al., 1994
		Major dieback	Isla Del Venado, Nicaragua	-	Roth, 1992
		Patches of gaps	Los Haitises, Dominican Republic	[d]~700 m²	Sherman et al., 2001
	Hail	Major dieback	Port Curtis, Queensland	169.9 ha	Houston, 1999
	Tree-fall / Branch-fall	Small gaps	Ranong, Thailand	144.2 m²	Imai et al., 2006
		Small gaps	Kosrae, Micronesia	64.4 m²	Pinzon et al., 2003
	Severe drought	Major dieback	Gulf of Carpentaria, Australia	7400 ha	Duke et al., 2017
	Crown shyness	Channel-like gaps between canopy crowns	Parque Nacional de Santa Rosa, Guanacaste, Costa Rica	0-9.5 m width	Putz et al., 1984
Anthropogenic	Small-scale Cutting	Patches	Kosrae, Micronesia	-	Allen et al., 2001
		Small gaps	Kosrae, Micronesia	158 m²	Ewel et al., 1998
		Patches	Kosrae, Micronesia	-	Hauff et al., 2006
		Small to large patches	Metinaro, Timor Leste	-	Alongi and de Carvalho, 2008
		Small gaps	Bais Bay, The Philippines	2.6 m²	Walters, 2005
		Large gap	Somone, Senegal	1.4 km²	Sakho et al., 2011
	Logging	Small to large gaps	Kosrae, Micronesia	114 m²	Pinzon et al., 2003
		Large gaps	Matang, Malaysia	41.4 ha	Muda and Mustafa, 2003
	Oil Spill	Major dieback	Bahia Las Minas, Panama	307 ha	Duke et al., 1997
	Experiment	Small gaps	North Queensland	50 m² & 225 m²	Clarke, 2004

Amir & Duke 2019 ECSS

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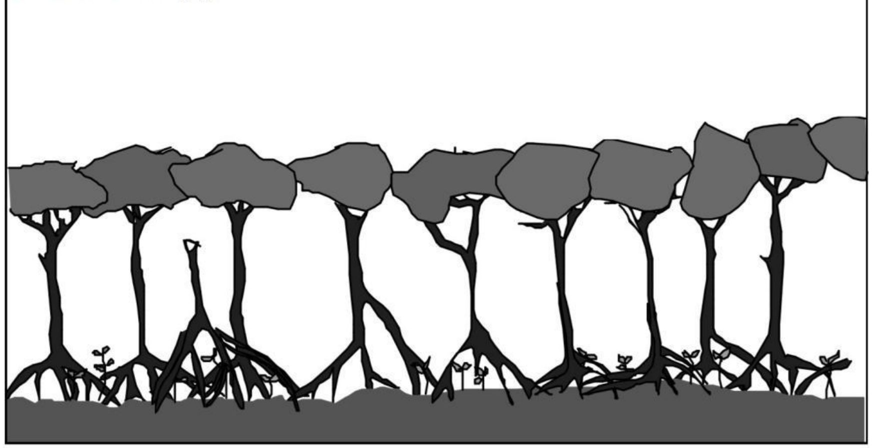
Closed Canopy



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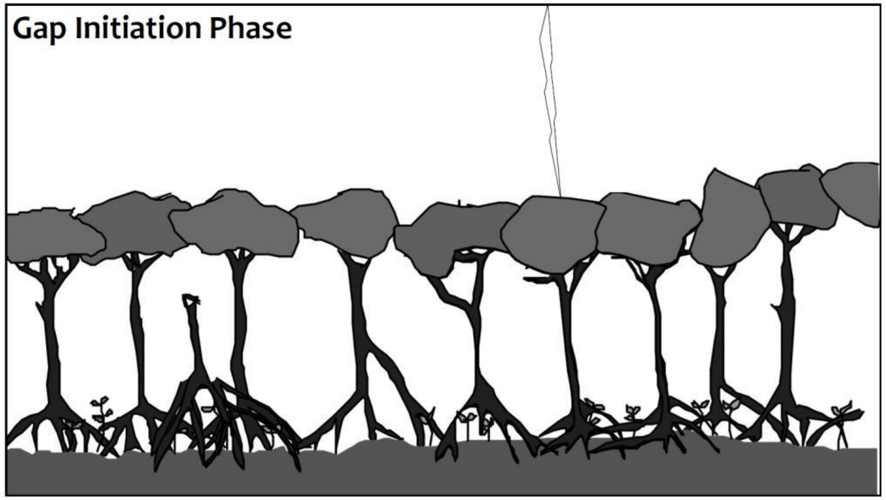
Gap Initiation Phase



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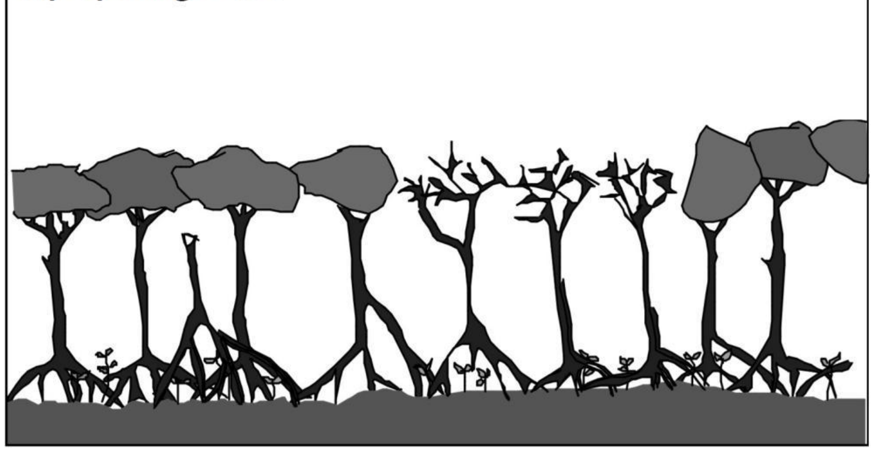
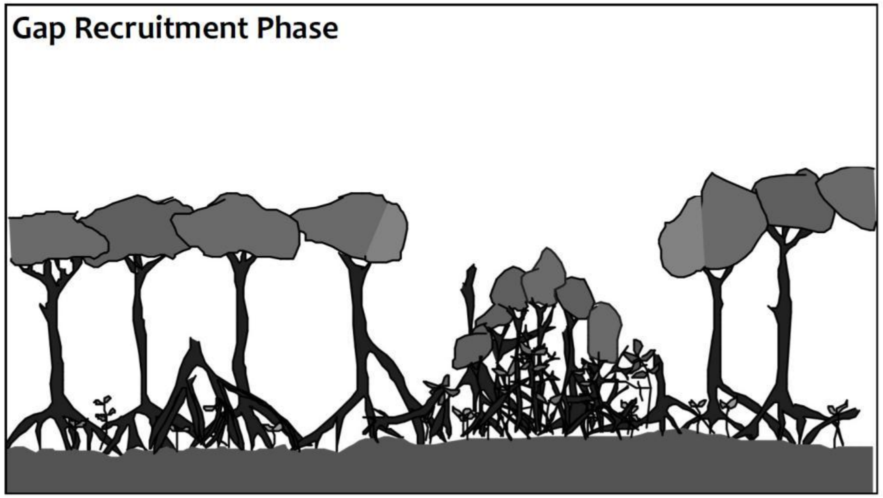
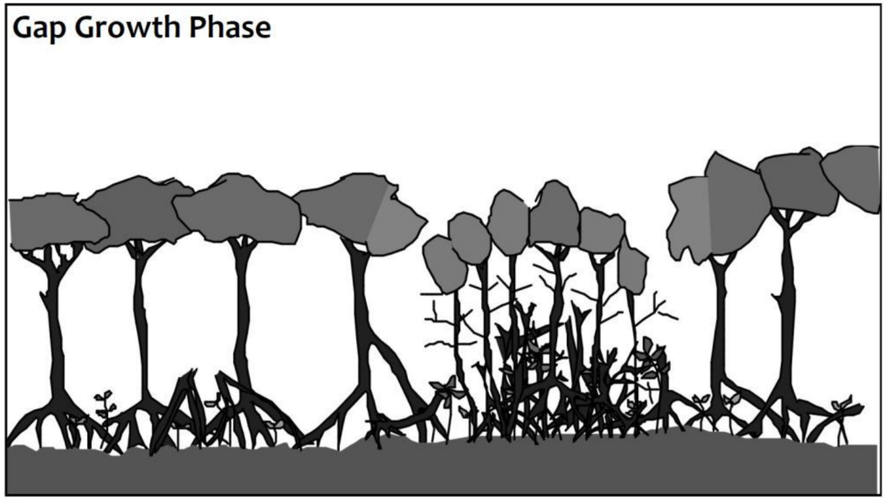
Gap Opening Phase



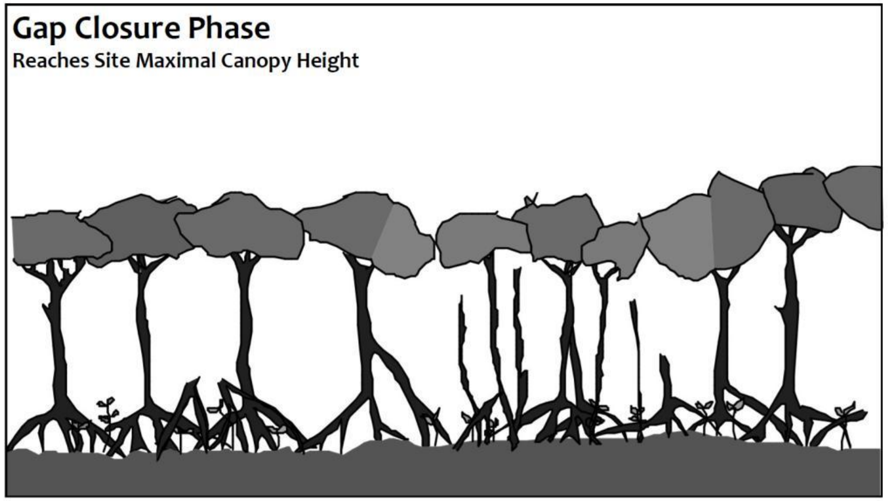
60


Gap Recruitment Phase

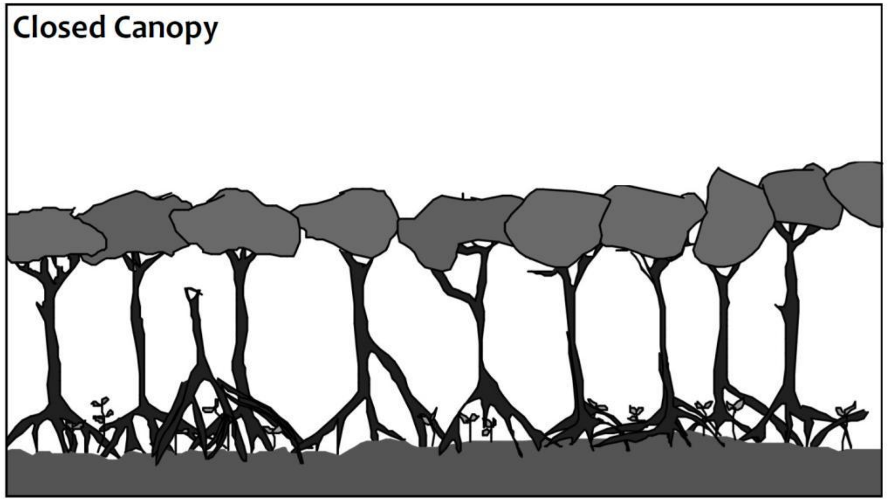
61


Gap Growth Phase

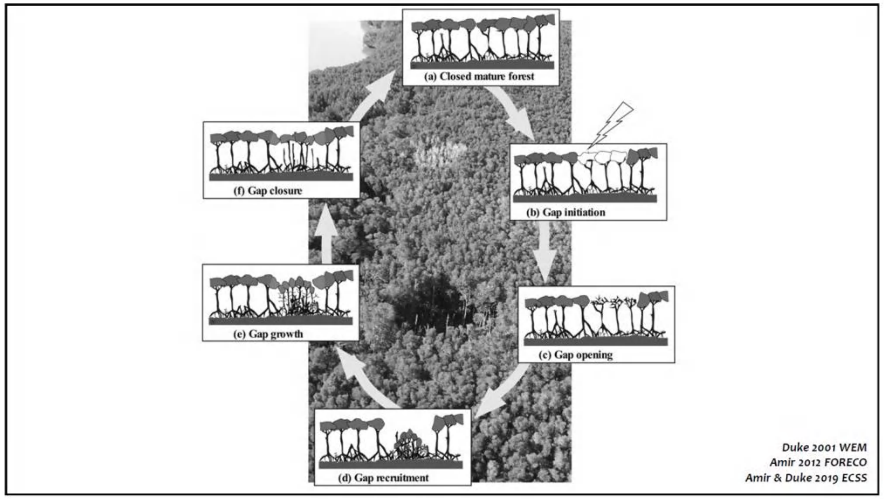
62


Gap Closure Phase
Reaches Site Maximal Canopy Height

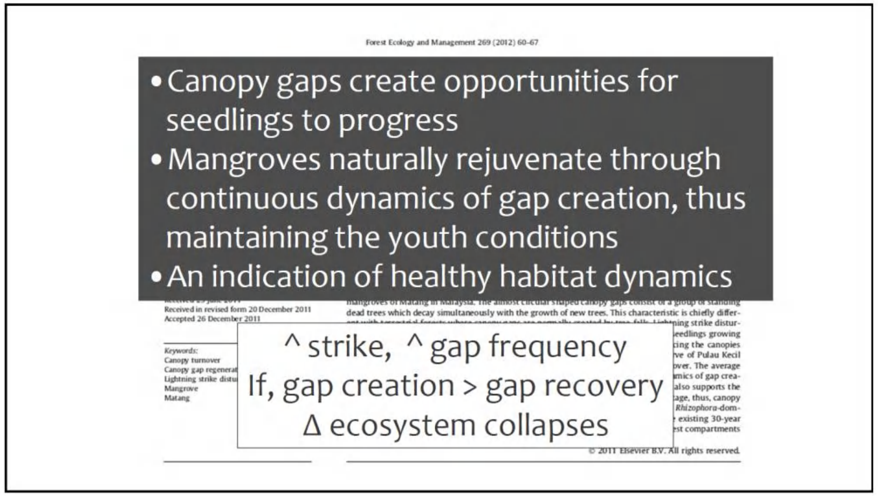
63


Closed Canopy

64


(a) Closed mature forest
(b) Gap initiation
(c) Gap opening
(d) Gap recruitment
(e) Gap growth
(f) Gap closure
Duke 2001 WEM
Amir 2012 FORECO
Amir & Duke 2019 ECSS

65


Forest Ecology and Management 269 (2012) 60-67
• Canopy gaps create opportunities for seedlings to progress
• Mangroves naturally rejuvenate through continuous dynamics of gap creation, thus maintaining the youth conditions
• An indication of healthy habitat dynamics
^ strike, ^ gap frequency
If, gap creation > gap recovery
Δ ecosystem collapses
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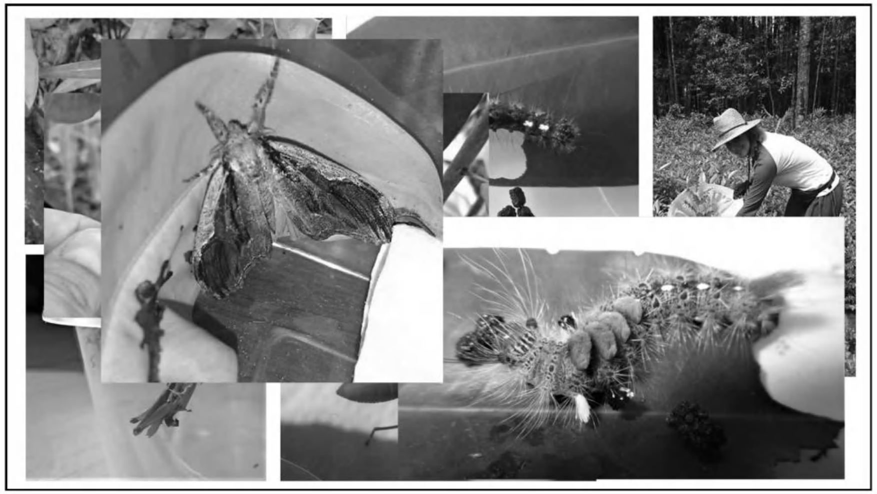
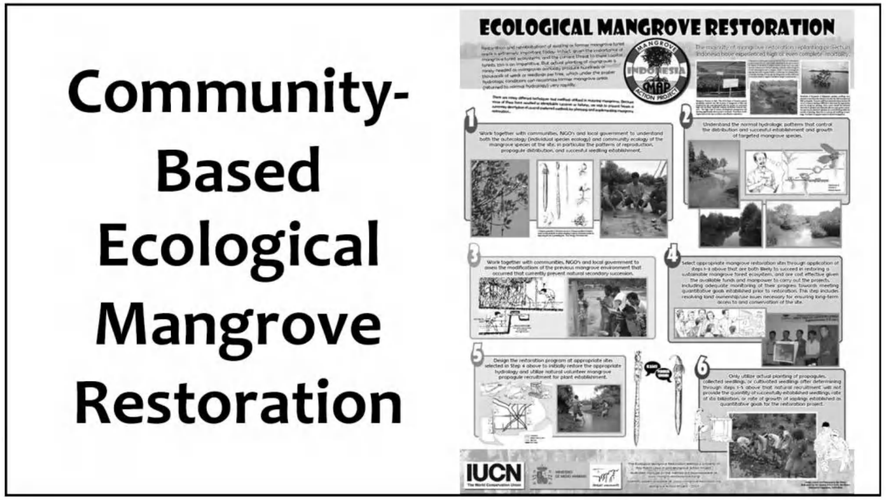
66



67


Community-Based Ecological Mangrove Restoration
ECOLOGICAL MANGROVE RESTORATION
IUCN

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Provisioning:
Goods and Products
Regulating:
Natural Processes
Cultural:
Non-material
Benefits
Food
Fresh water
Medicines
Raw materials
Carbon sequestration & storage
Moderate extreme weather events
Climate & environment
Hydrological & atmospheric cycles
Soil stabilization and fertility
Pollination & biological control
Waste-water treatment
Nutrient cycle and primary productivity
Coastal protection & erosion control
Bioremediation
Supporting:
Provision of habitat to sustain genetic and species diversity and connectivity
Providing avenue for the maintenance of all other ecosystem services
© A. Aldrie Amir
Education
Strict Enforcement
Payment for Ecosystem Services
Public-Private Partnership in Conservation
and more!

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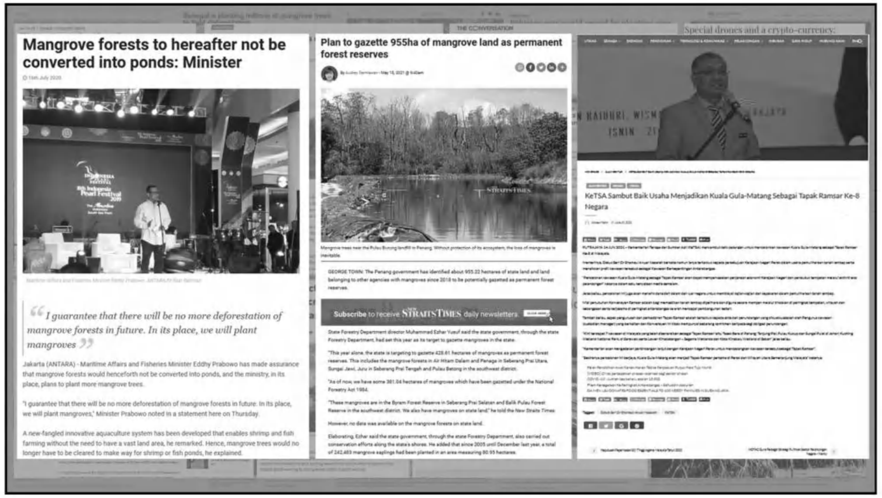

Mangrove forests to hereafter not be converted into ponds: Minister
I guarantee that there will be no more deforestation of mangrove forests in future. In its place, we will plant mangroves
Plan to gazette 955ha of mangrove land as permanent forest reserves
Subscribe to receive STRAITS TIMES daily newsletters
KeTSA Sambut Baik Usaha Menjadikan Kuala Gula-Matang Sebagai Tapak Ramsar Ke-8 Negara

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frontiers in Marine Science
Public Perceptions of Mangrove Forests Matter for Their Conservation
OPEN ACCESS

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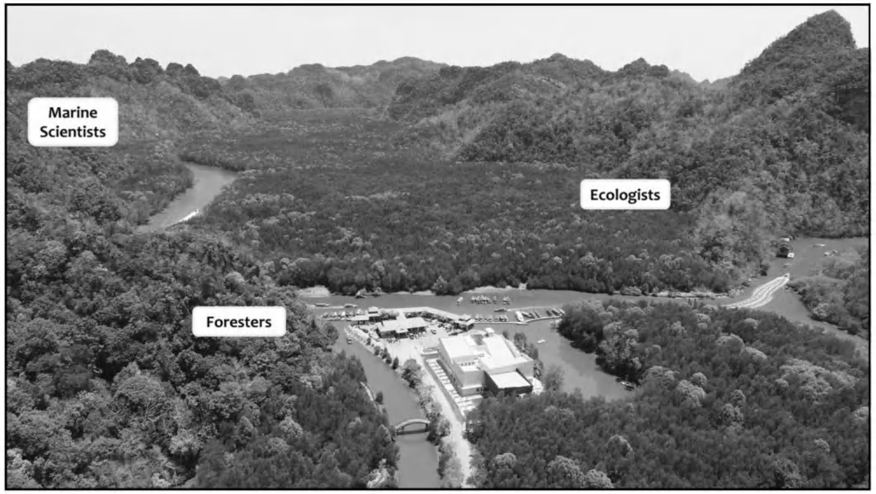


Marine Scientists
Ecologists
Foresters

72

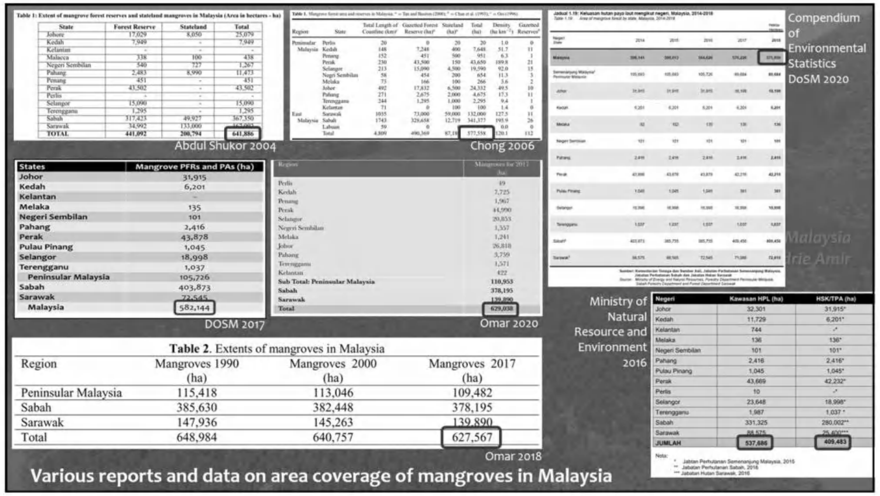
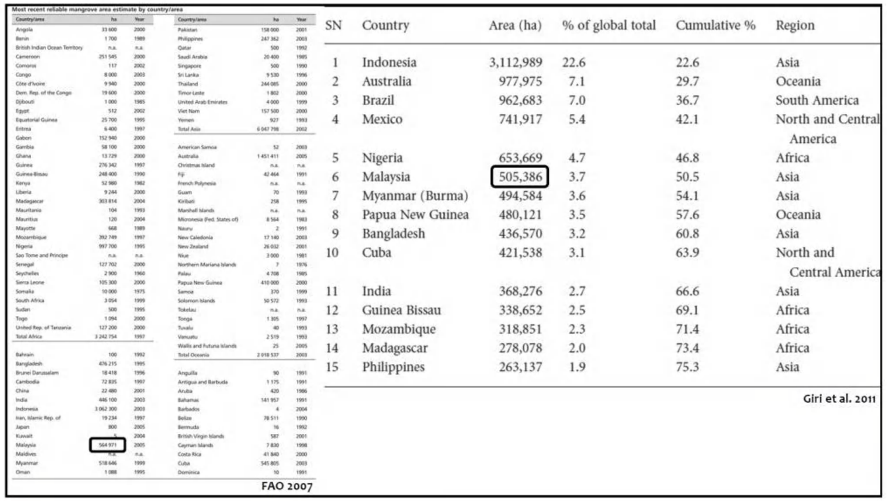


Table 2. Extents of mangroves in Malaysia

Region	Mangroves 1990 (ha)	Mangroves 2000 (ha)	Mangroves 2017 (ha)
Peninsular Malaysia	115,418	113,046	109,482
Sabah	385,630	382,448	378,195
Sarawak	147,936	145,263	139,890
Total	648,984	640,757	627,567

States	Mangrove PFRs and PAs (ha)
Johor	31,915
Kedah	6,201
Kelantan	-
Melaka	135
Negeri Sembilan	101
Pahang	2,416
Perak	43,878
Pulau Pinang	1,045
Selangor	18,998
Terengganu	1,037
Peninsular Malaysia	105,726
Sabah	403,873
Sarawak	72,545
Malaysia	582,144

75



SN	Country	Area (ha)	% of global total	Cumulative %	Region
1	Indonesia	3,112,989	22.6	22.6	Asia
2	Australia	977,975	7.1	29.7	Oceania
3	Brazil	962,683	7.0	36.7	South America
4	Mexico	741,917	5.4	42.1	North and Central America
5	Nigeria	653,669	4.7	46.8	Africa
6	Malaysia	505,386	3.7	50.5	Asia
7	Myanmar (Burma)	494,584	3.6	54.1	Asia
8	Papua New Guinea	480,121	3.5	57.6	Oceania
9	Bangladesh	436,570	3.2	60.8	Asia
10	Cuba	421,538	3.1	63.9	North and Central America
11	India	368,276	2.7	66.6	Asia
12	Guinea Bissau	338,652	2.5	69.1	Africa
13	Mozambique	318,851	2.3	71.4	Africa
14	Madagascar	278,078	2.0	73.4	Africa
15	Philippines	263,137	1.9	75.3	Asia

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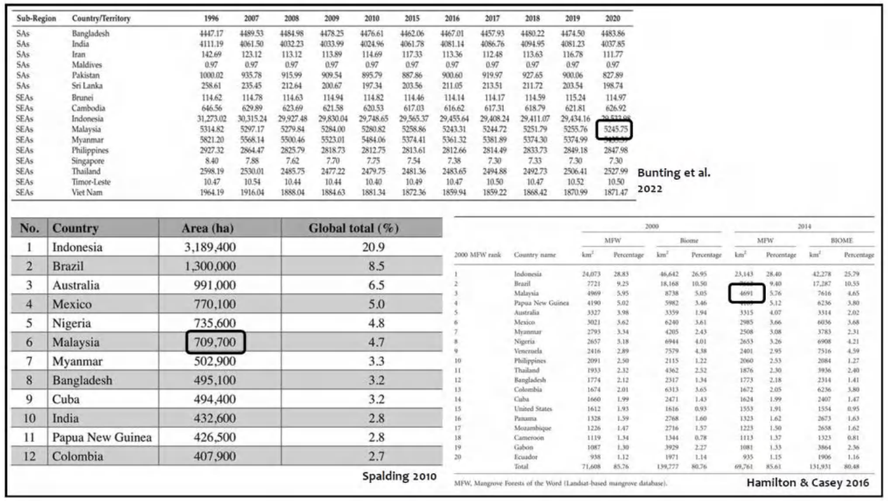

No.	Country	Area (ha)	Global total (%)
1	Indonesia	3,189,400	20.9
2	Brazil	1,300,000	8.5
3	Australia	991,000	6.5
4	Mexico	770,100	5.0
5	Nigeria	735,600	4.8
6	Malaysia	709,700	4.7
7	Myanmar	502,900	3.3
8	Bangladesh	495,100	3.2
9	Cuba	494,400	3.2
10	India	432,600	2.8
11	Papua New Guinea	426,500	2.8
12	Colombia	407,900	2.7

77

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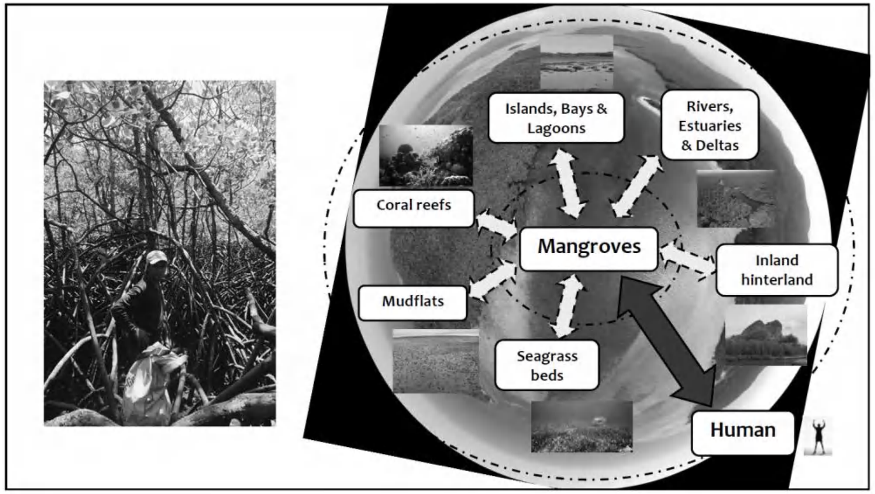

Islands, Bays & Lagoons
Rivers, Estuaries & Deltas
Coral reefs
Mangroves
Inland hinterland
Mudflats
Seagrass beds
Human

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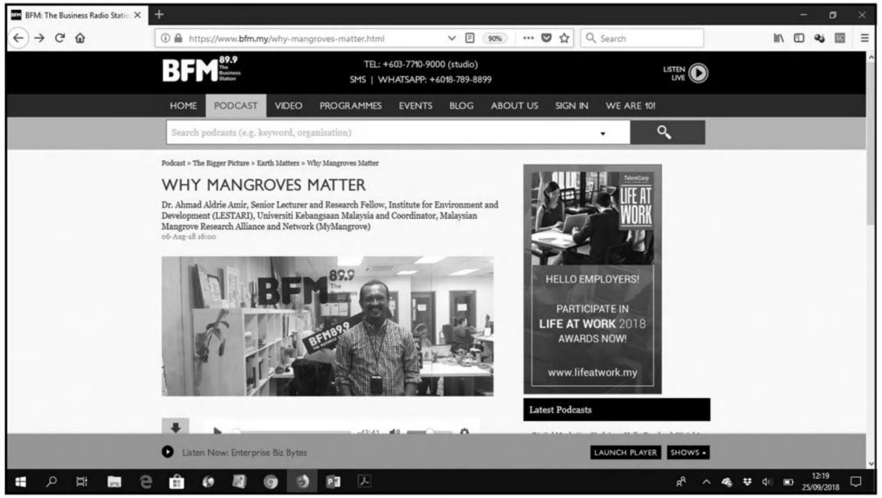

https://www.bfm.my/why-mangroves-matter.html
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TEL: +603-7710-9000 (studio)
SMS | WHATSAPP: +6018-789-8899
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Dr. Ahmad Aldrie Amir, Senior Lecturer and Research Fellow, Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia and Coordinator, Malaysian Mangrove Research Alliance and Network (MyMangrove)
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LETTERS
MASS TOURISM HURTS MANGROVES
OPINION
PROTECTING OUR MANGROVES AND COASTAL WETLANDS
A waste disposal and management system must be implemented to control plastic litter and marine pollution from affecting mangroves and coastal habitats, writes DR A. ALDRIE AMIR

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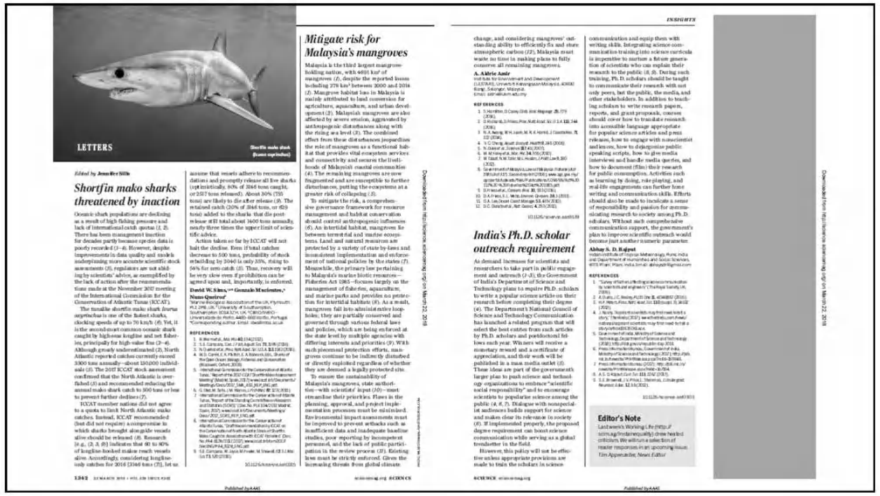
OPINION
THERE'S BENEFIT IN THEM MANGROVES
Studies have shown that mangrove forests can help blunt the impact of tsunamis, cyclones and destructive tropical storms, writes DR A. ALDRIE AMIR
LETTERS
The value of small mangrove patches

82


INSIGHTS

LETTERS

Shortfin mako sharks threatened by inaction

Mitigate risk for Malaysia's mangroves

India's Ph.D. scholar outreach requirement

Editor's Note

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Annex 3.7: Migratory Bird Flyways in Mangrove Wetlands


MOP12
Shorebird Colour Marking Protocol for the East Asian
CHINA


MOP12
DR MUSONDA MUMBA
Secretary General
Convention on Wetlands


MOP12
AMY FRAENKEL
Executive Secretary
Convention on Migratory Species
CMS

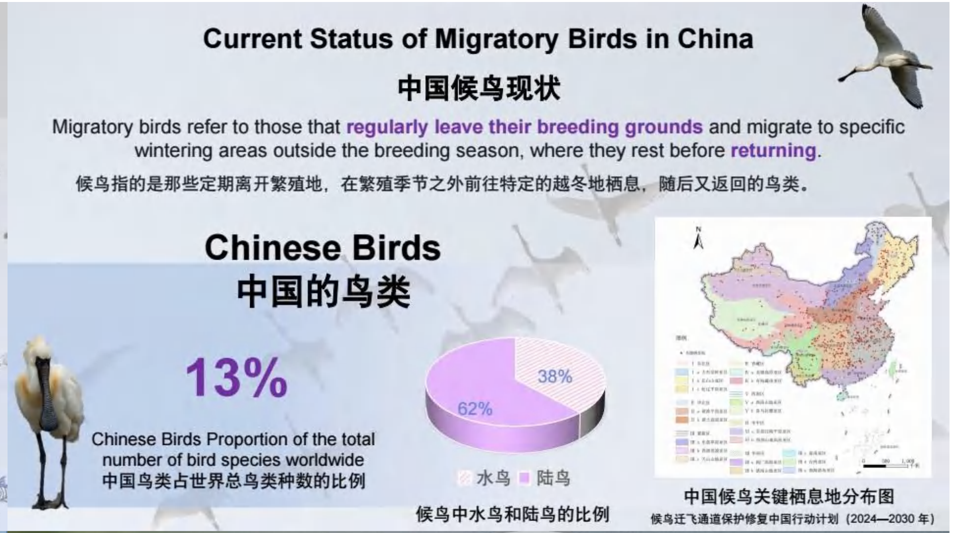

MOP12
NARELLE MONTGOMERY
Chair
East Asian-Australasian Flyway Partnership


ADB
POSCO INTERNATIONAL
MOP12


Mangrove and
Migratory bird
红树林和候鸟


Functions of mangrove wetlands 红树林的生态功能
Maintaining biodiversity
维持生物多样性
Wind and wave mitigation
净化海水
Purify seawater
防风消浪
Carbon sequestration
固碳储碳
Eco-farming
生态养殖
Ecotourism
生态旅游

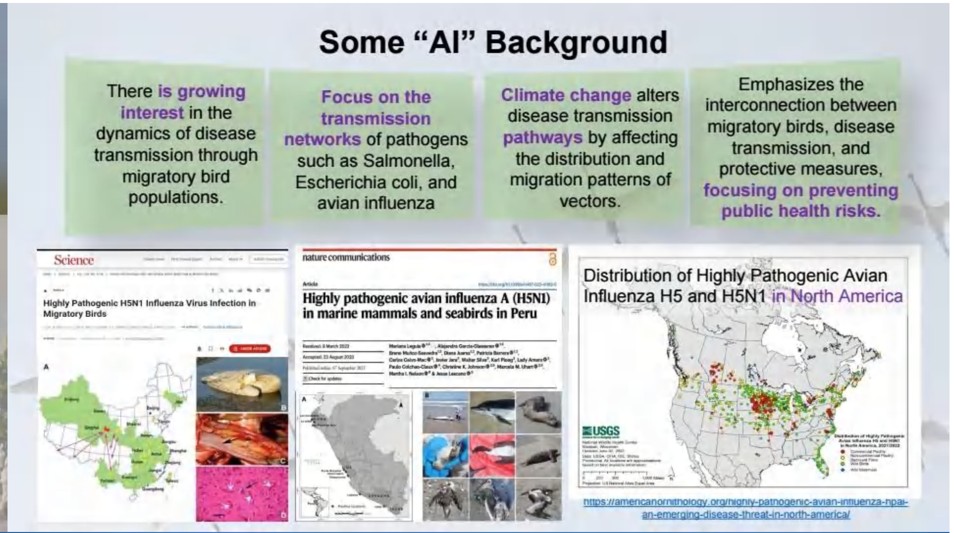

Mangrove wetlands are an important support for biodiversity, providing habitats, breeding grounds, and resting spots for many species, including migratory birds.
红树林湿地是生物多样性的重要支撑，
为许多物种（包括候鸟）提供栖息地、繁殖场所和中途停歇点。
Nagelkerken 2008; Li 2009; Ma 2014 et al.

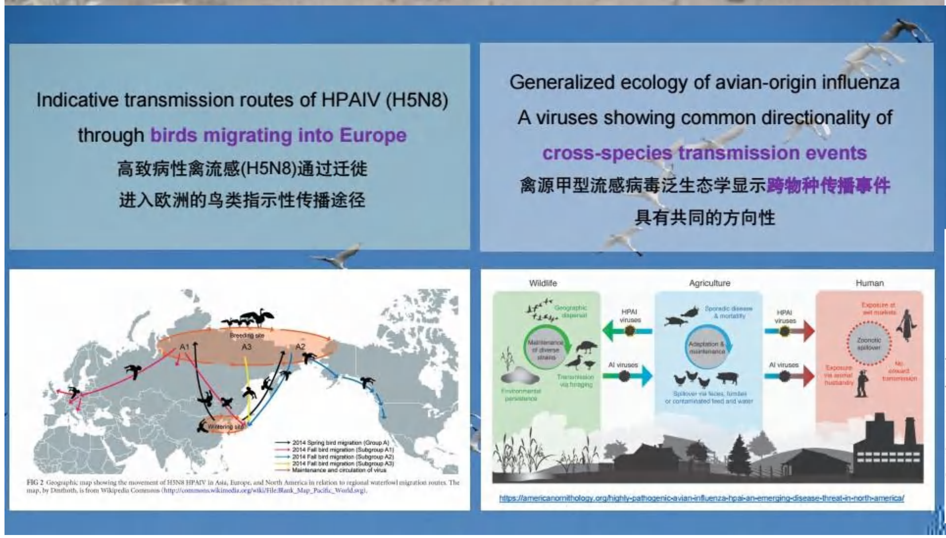

Current Status of Migratory Birds in China
中国候鸟现状
Migratory birds refer to those that regularly leave their breeding grounds and migrate to specific wintering areas outside the breeding season, where they rest before returning.
候鸟指的是那些定期离开繁殖地，在繁殖季节之外前往特定的越冬地栖息，随后又返回的鸟类。
Chinese Birds
中国的鸟类
13%
Chinese Birds Proportion of the total number of bird species worldwide
中国鸟类占世界总鸟类种数的比例
38%
62%
水鸟
陆鸟
候鸟中水鸟和陆鸟的比例
中国候鸟关键栖息地分布图
候鸟迁飞通道保护修复中国行动计划（2024—2030 年）

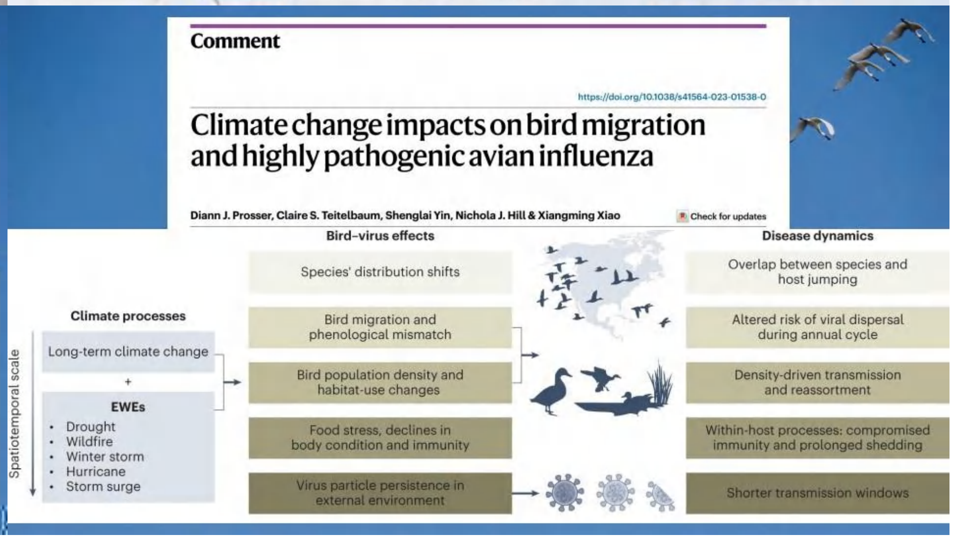

Migratory bird flyway 候鸟迁飞通道
Of the nine global migratory bird flyways, four pass through China.
Shenzhen Bay, located on the East Asia/Australasian and West Pacific migratory routes, is an important wintering wetland.
全球的9 条候鸟迁徙通道中，有 4 条经过中国。
深圳湾，位于东亚-澳大利西亚、西太平洋候鸟迁徙路线上，
是重要越冬地
广东内伶仃福田国家级自然保护区
Guangdong Neilingding Futian National Nature Reserve
深圳湾
(后海湾)
shenzhen bay
深圳河河口
米埔自然保护区
Mai Po Nature Reserve
2 个
拉 姆 萨 尔 国 际 重 要 湿 地
Ramsar International Important Wetland
图片源自国际涉禽研究组 https://pacificbirds.org/birds-flyways/the-flyways/


2
Avian Influenza(AI)
禽流感研究


Wild birds are a natural reservoir for "AI" virus
野生鸟类是禽流感病毒的天然库
Natural reservoir
天然宿主
The virus replicates in birds and is highly contagious in the wild environment, making it very easy for humans to become infected upon contact with contaminated environments.
Silent spreader
隐性传播
Wild birds are natural reservoirs for viruses, and the transmission and evolution of these viruses are inseparable from the ecology and behavior of birds.
Cross-regional vector
跨区域载体
A key mechanism for the spread of viruses between regions and even continents, creating conditions for the transmission of viruses among different populations and species.
Evolutionary pool
病毒库进化
Poultry trade and transport are the main ways of virus transmission. Wild birds may be asymptomatic or only show mild symptoms after infection, and can continue to migrate.
Olsen et al. 2006

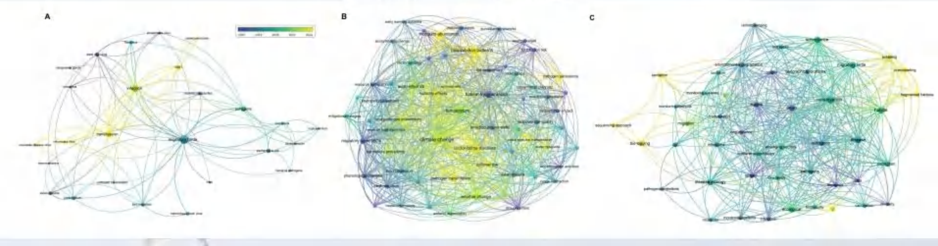

Some "AI" Background
There is growing interest in the dynamics of disease transmission through migratory bird populations.
Focus on the transmission networks of pathogens such as Salmonella, Escherichia coli, and avian influenza
Climate change alters disease transmission pathways by affecting the distribution and migration patterns of vectors.
Emphasizes the interconnection between migratory birds, disease transmission, and protective measures, focusing on preventing public health risks.
Science
Highly Pathogenic H5N1 Influenza Virus Infection in Migratory Birds
nature communications
Highly pathogenic avian influenza A (H5N1) in marine mammals and seabirds in Peru
Distribution of Highly Pathogenic Avian Influenza H5 and H5N1 in North America
USGS
https://americanornithology.org/highly-pathogenic-avian-influenza-hpai-an-emerging-disease-threat-in-north-america/

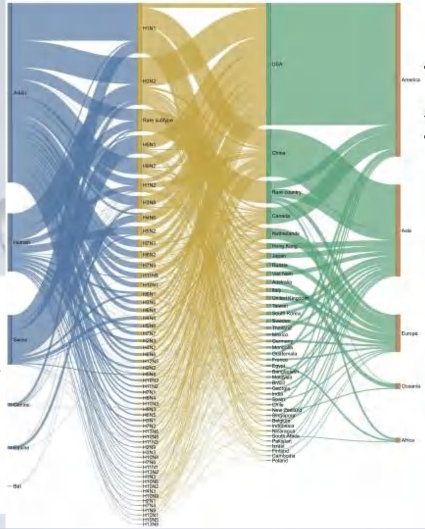

Indicative transmission routes of HPAIV (H5N8) through birds migrating into Europe
高致病性禽流感(H5N8)通过迁徙
进入欧洲的鸟类指示性传播途径
Generalized ecology of avian-origin influenza A viruses showing common directionality of cross-species transmission events
禽源甲型流感病毒泛生态学显示跨物种传播事件
具有共同的方向性
Wildlife
Agriculture
Human
HPAI viruses
AI viruses
https://americanornithology.org/highly-pathogenic-avian-influenza-hpai-an-emerging-disease-threat-in-north-america/


Comment
https://doi.org/10.1038/s41564-023-01538-0
Climate change impacts on bird migration and highly pathogenic avian influenza
Diann J. Prosser, Claire S. Teitelbaum, Shenglai Yin, Nichola J. Hill & Xiangming Xiao
Check for updates
Climate processes
Long-term climate change
+
EWEs
Drought
Wildfire
Winter storm
Hurricane
Storm surge
Spatiotemporal scale
Bird–virus effects
Species' distribution shifts
Bird migration and phenological mismatch
Bird population density and habitat-use changes
Food stress, declines in body condition and immunity
Virus particle persistence in external environment
Disease dynamics
Overlap between species and host jumping
Altered risk of viral dispersal during annual cycle
Density-driven transmission and reassortment
Within-host processes: compromised immunity and prolonged shedding
Shorter transmission windows

From one of our resent work, a total of 87 papers published from 2015 to 2025 were statistically analyzed, focusing mainly on **migratory birds** as vectors for pathogen transmission, the impact of climate variability on disease ecology, and conservation efforts aimed at maintaining ecosystems and **public health**.

统计2015年至2025年发表的87篇文献，主要关注**候鸟**作为病原体传播媒介、**气候变异**对疾病生态的影响以及维持生态系统和**公共健康**的保护努力（未发表数据）。





Migratory Birds–Poultry–Markets: The Full Chain of AIV Global Spread

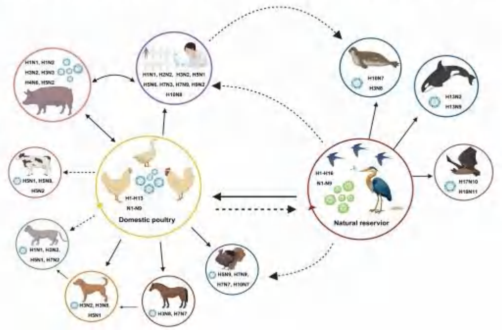
候鸟—家禽—市场：禽流感全球播散的完整链路

- AIV subtypes patch the planet by host and geography—wild waterfowl seed, poultry amplify, and trade/migration keep continents re-assorting

全球AIV亚型随宿主与地理呈斑块分布，野生水禽为源，家禽为放大器，各大洲流行株因贸易与迁徙持续重配。

- Migratory flights seed the virus; transient wild-poultry interfaces spark outbreaks; live-bird trade acts as the express lane, propelling local variants into the global market within days.

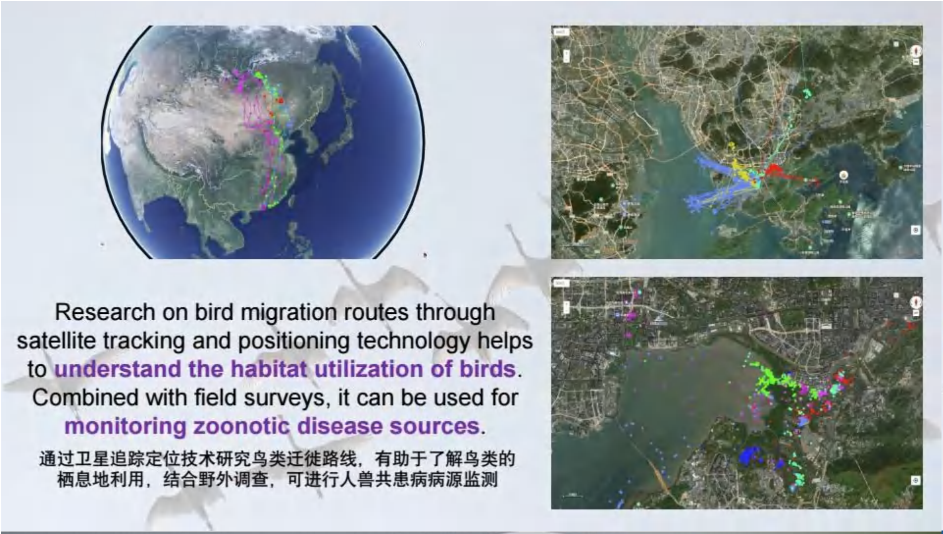
候鸟迁飞播毒，途中与家禽短暂接触"点火"；活禽贸易"快递"接力全球化

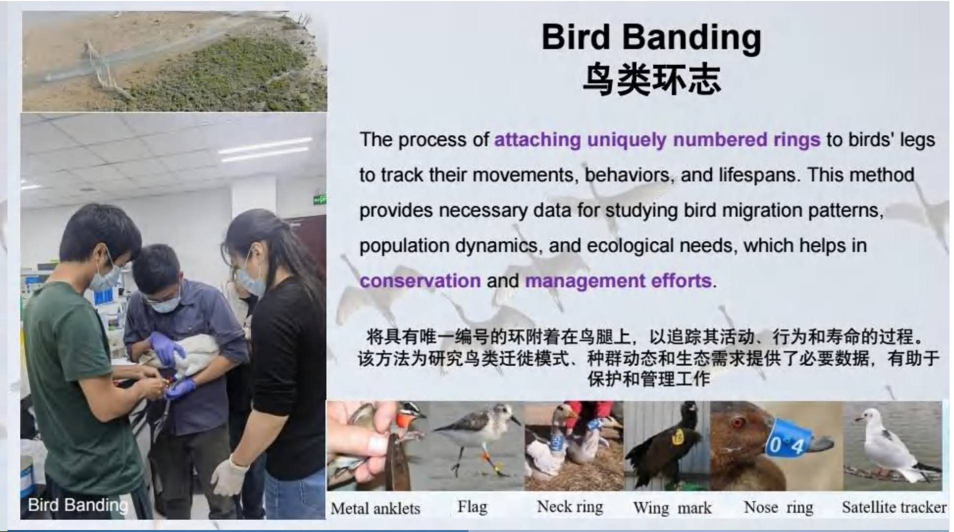


Migratory bird flyway via satellite tracking 鸟类卫星追踪

全球候鸟迁飞通道 Migratory bird flyway

途径深圳候鸟迁飞通道 Shenzhen flyway

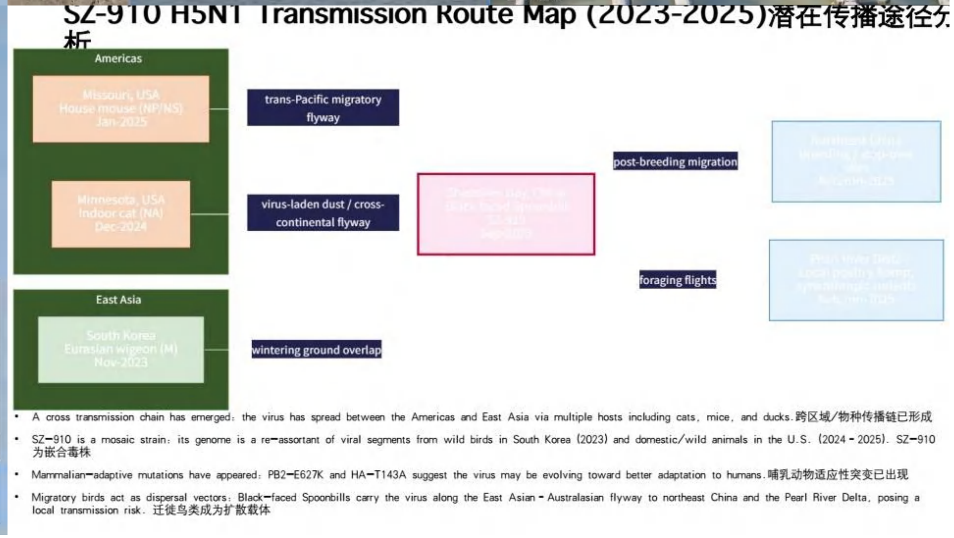

Research on bird migration routes through satellite tracking and positioning technology helps to understand the habitat utilization of birds. Combined with field surveys, it can be used for monitoring zoonotic disease sources.
通过卫星追踪定位技术研究鸟类迁徙路线，有助于了解鸟类的栖息地利用，结合野外调查，可进行人兽共患病病源监测


Bird Banding
鸟类环志
The process of attaching uniquely numbered rings to birds' legs to track their movements, behaviors, and lifespans. This method provides necessary data for studying bird migration patterns, population dynamics, and ecological needs, which helps in conservation and management efforts.
将具有唯一编号的环附着在鸟腿上，以追踪其活动、行为和寿命的过程。该方法为研究鸟类迁徙模式、种群动态和生态需求提供了必要数据，有助于保护和管理工作
Bird Banding
Metal anklets
Flag
Neck ring
Wing mark
Nose ring
Satellite tracker


3
Research on Black-faced Spoonbill
黑脸琵鹭的研究


Revised distribution map of the East Asian black-faced spoonbill
东亚黑脸琵鹭的修订分布图
The overwintering population is distributed in China (including Taiwan).
近 90% 的黑脸琵鹭越冬种群分布在中国大陆和台湾。
Chen et al. 2021
黑脸琵鹭
Platalea minor
保护等级：国家 I 级
IUCN：EN（濒危）
The results of the "2025 Global Synchronized Census of Black-faced Spoonbills" show a global population of 7,081 individuals. In the Shenzhen Bay (Shenzhen-Hong Kong) area, 328 individuals were recorded.
"黑脸琵鹭全球同步普查2025" 结果，全球数量7081只。深圳湾（深港）记录有328只。
7081
全球黑脸琵鹭普查结果1989 – 2025（36年）
Black-faced Spoonbill Census result of Deep Bay,1989 -2025
2025年 各地普查结果
Results of different sites in 2025 Census
https://cms.hkbws.org.hk/cms/

SZ-910基因片段	Highest Homologous Strain
HA	A/Dove/HI/24-033876-005-original/2024(H5N1)
NA	A/cat/MN/24-036601-001-original/2024(H5N1)
PB2	A/Duck/HI/24-033876-001-original/2024(H5N1)
PB1	A/Duck/HI/24-033876-001-original/2024(H5N1)
PA	A/Dove/HI/24-033876-005-original/2024(H5N1)
NP	A/House Mouse/MO/25-003474-005-original/2025(H5N1)
M	A/Eurasian wigeon/South Korea/23WS022-22/2023(H5N1)
NS	A/House Mouse/MO/25-003474-005-original/2025(H5N1)



Taking-home message
核心小结
H5N1 recovered from wintering Black-faced Spoonbills (368 fecal samples) in Shenzhen Bay mangroves—despite their low susceptibility—was fully traced to a North-American lineage, proving.
深圳湾红树林越冬黑脸琵鹭（368份粪样）虽为低易感濒危物种，却检出高致病H5N1，全基因组溯源锁定北美谱系。此发现首次实证病毒可随候鸟跨洲输入，非指示物种亦能充当“哨兵”，区域生态与公共卫生风险被低估。
Black-faced Spoonbill tells us: viruses know no borders—surveillance must cross them.
黑脸琵鹭告诉我们：病毒无国界，监测须跨国。
Trans-continental incursion via migratory birds
病毒可随候鸟跨洲输入
non-indicator species can serve as sentinels
非指示物种可作“哨兵”
Regional ecological and public-health risks are underestimated
深圳湾红树林为关键监测点

Management and Recommendations
管理与建议
4

Restoration and Conservation of Migratory Bird Habitats in Mangrove Wetlands
红树林湿地候鸟栖息地保护与修复
Systematic Conservation 系统保护
Protect and restore wetland ecosystems to sustain migratory bird habitats, prioritizing breeding, wintering, and stopover sites.
Stopover value 停歇地重要性
Vital for long migration, serving as critical staging posts where birds replenish energy, restore immune function, and defend against pathogens.
Protection strategies 保护策略
Secure food, restore habitats, designate stopover reserves, halt degradation and pathogen spread.
Ecological corridors 生态廊道
Ecological corridors link fragmented habitats, boost gene flow, ease crowding, and cut stress-linked immunosuppression and pathogen spread.
Surveillance approaches for monitoring bird pathogens

Ring banding Station Construction
环志站建设——科学监测研究
Jointly organize bird banding, bird tracking, etc. with the National Bird Banding Center of China and international organizations, focusing on migratory bird research
联合全国鸟类环志中心（中国）及国际组织开展鸟类环志、鸟类追踪等，重点关注迁徙候鸟研究
深圳首期鸟类环志培训班（2023年）
Bird Banding Training鸟类环志培训
Bird banding monitoring in Futian Mangrove Reserve

Ring banding Station Construction
环志站建设——科学监测研究

On June 15, 2023, the "National Bird Banding Center Shenzhen University Bird Banding Monitoring Station" was officially established at Shenzhen University

On June 15, 2023, the "National Bird Banding Center Shenzhen University Bird Banding Monitoring Station" (Shenzhen International Airport Bird Banding Monitoring Station) was officially established at Shenzhen International Airport

Carry out migratory bird conservation and science popularization education activities **for local community residents**
为当地社区居民开展候鸟保护与科普教育活动——公众科普宣传

Public Awareness Education on Bird Banding
关于鸟类环志的公众意识教育——公众科普宣传

Join hands to protect birds and share the beauty of nature - Shenzhen University School of Life Sciences and Oceanography participates in the third "**Mountain Sea Connected · Natural Shenzhen**" **Living Festival**

携手保护鸟类，共享自然之美-深圳大学生命与海洋科学学院参加第三届 "山海连城·自然深圳"生活节活动

Cross-departmental collaboration
跨部门合作——共建共管合作机制

Wildlife epidemic source and disease monitoring has shortcomings

such as a large number of management departments, complex functions, and poor circulation of monitoring data.

Future Management

Strengthening cooperation among multiple departments and establishing **a data sharing mechanism** are breakthrough points from the perspective of future management.

野生动物疫源疫病监测存在管理部门数量多、职能复杂，监测数据流通性差等缺点。加强多部门合作，建立数据共享机制是未来管理角度的突破点。

Schematic diagram of the supervisory departments at all levels for wildlife epidemic source and disease monitoring


Cross-departmental collaboration
跨部门合作——共建共管合作机制
Intelligent monitoring and sampling of mangrove migratory birds
深圳市科技计划项目合同书
深圳市科技创新委员会
二〇二三年十一月制
Special 2023N012 Research and Application Demonstration of Mangrove Migratory Bird and Human-Animal Co-Infectious Disease Monitoring and Tracing Technology
深圳大学
深圳市疾病预防控制中心
深圳市自然保护区管理中心
全国鸟类环志中心（中国）
深圳市优威视讯科技股份有限公司
广东内伶仃福田国家级自然保护区管理局
广东省科学院动物研究所
Establish Shenzhen Bird Banding Monitoring Station


International Exchange
国际交流——加强跨区域合作
IMC Workshops on Monitoring and Protection of Migratory Birds in Mangrove Wetlands
Africa
Asia
America


美丽
滨海生态优先
绿色发展
Dr. Haichao Zhou周海超
中国湿地保护协会理事
深圳大学研究员
E-mail: zhouhc@szu.edu.cn
Beautiful Coast:
Ecological Priority and Green Development

Annex 3.8: Bird Watchers: Valuable Partners to Mangrove Managers

Lecture 6, 3rd Workshop on Mangrove Conservation and Restoration

Bird Watchers: Valuable Partners to Mangrove Managers

Haibin Wang
November 5, 2025
Shenzhen, Guangdong, China

Domes de Fabedougou, Bukina Faso

Mangrove Bay, Moroni, Comoros

Parque Nacional Cienaga de Zapata, Cuba

Akanda National Park, Gabon

Guinea

Lesotho

Monrovia, Liberia

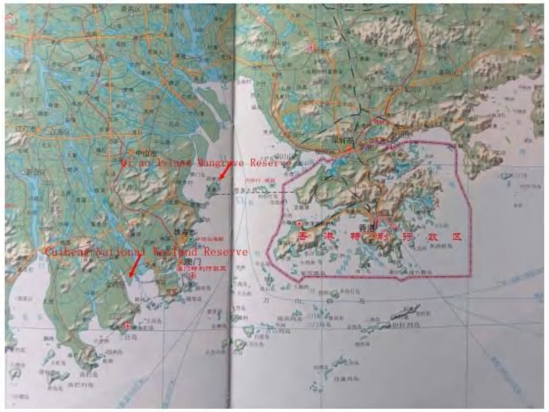
Mahajanga Bay, Madagasca

Indus Delta, Pakistan

Freetown, Sierra Leone

My Brief Experience with Mangrove

Bird watching around Zhuhai, Guangdong Province, covering Qi'aodao Mangrove Nature Reserve, Yakou Mangrove Wetland Park, Cuiheng National Wetland, September 2019 — Jan. 2024



Who Are They Really?

To Get to Know bird-watchers in China

Birders Profile (1): Predominantly RetiredMales

Birders Profile (2): Well-equipped

Cameras	Canon EOS 5D4, Sony a7m4, Sony a7r5
Zoom lens	Canon 100–400mm, Sigma 150–600mm, Sony 200–600mm, Sony 400–800mm, 1.4 Extender
Binocular	Bosma 8X42, Nikon 10x50
Telescope	20–40x
Monopod	1
Tripods	3
Field equipment	Boots, water pants, inflatable rubber dingy
4WD vehicle	1
Camping equipment	Tents, mattress, sleeping bags,

Birders Profile (3): Devoted

- Live on Pension and Savings
- Able and willing to pay travel, boarding costs for bird watching trips
- Keep buying state-of-the-the-art equipment
- To watch birds full time, over-time, anytime
- Often drive hundreds even thousand of kilometers to explore new opportunities to watch birds

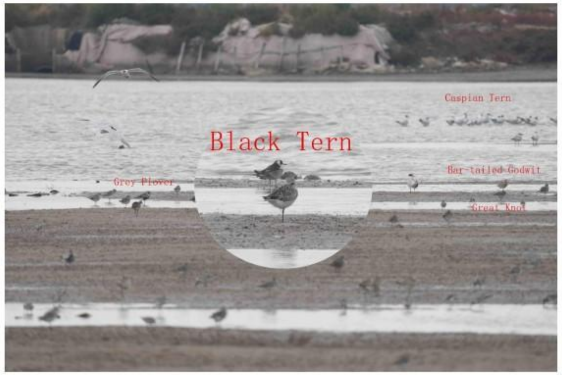
Birders Profile (4): Numerous and Well-connected

- 1 million bird watchers across the nation
- Bird watching societies at all levels
- Much more wildcat bird watchers connected by mobile phone via social media (WeChat APP)

Birders Profile (5): Really Know their Birds

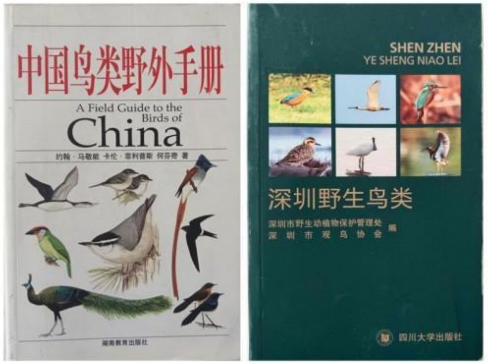
Bird Identification Know-Hows

You Hit a Jackpot



Where to Learn the Trick: From Mouth to Mouth

Field Guides



Bird Walk, Trip and Camp

Paul Holt is an internationally renowned British ornithologist and professional birder based at Beijing. Together with his Chinese wife, they organise & lead bird walks and trips across China.

He is famous for identifying birds by their sounds and has built up a vast collection of sound recordings that include more than 1,000 of China's species.

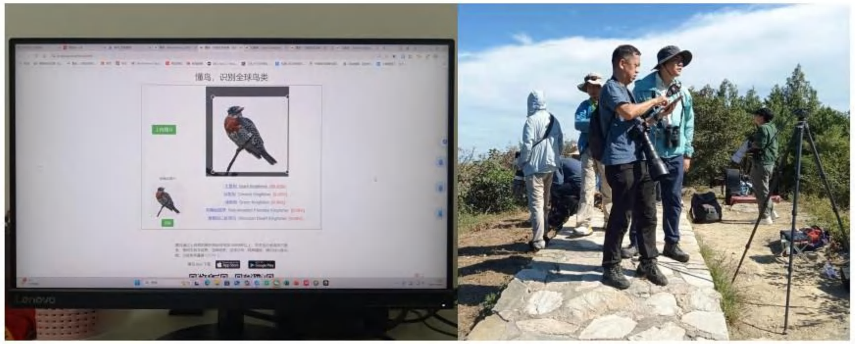
Birders Websites

Birders' APP: Aboutbirds

How to Use the Aboutbirds APP(1)

Birders' APP: Aboutbirds

How to Use Aboutbirds APP

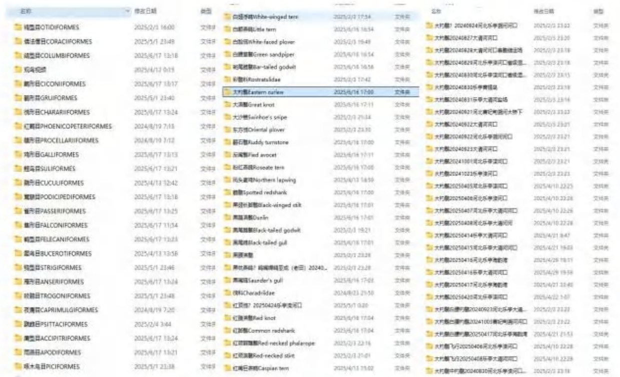


Birders Profile (6): Prolific

- Daily Outputs: 10,000 photos
- 470 species of birds
- Photos are stored in a
- Scientific systematic way
- 20 TB

In possession of Huge Amount of Bird Information, sightings

	A	B	C	D	E	F
392			山鹨?	Upland pipit		需要查相片
393			水鹨	Water pipit	北京奥森	
394			黄腹鹨	Buff-bellied pipit		崖口，三乡，桥头村
395			红喉鹨	Red-throated pipit		崖口，三乡，桥头村
396		燕雀科Fringillidae	燕雀	Brambling		
397			苍头燕雀	Common Chaffinch		
398			锡嘴雀	Hawfinch		
399			黑尾蜡嘴雀	Chinese grosbeak		珠海北理工校园
400			黑头蜡嘴雀	Japanese grosbeak		
401			普通朱雀	Common rosefinch		校园，赤花山
402			北朱雀	Pallas's rosefinch	北京管庄公园	
403			金翅雀	Grey-capped greenfinch		
404			红交嘴雀?	Red crossbill	北京兴隆郊野公园	
405			白翅交嘴雀	White-winged crossbill	北京兴隆郊野公园	
406			黄雀	Eurasian siskin	山东临沂兰山区	山西广灵笼养
407	PASSERIFORMES	鹀科Emberizidae	小鹀	Little bunting		
408			黄喉鹀	Yellow-throated bunting		
409			黄胸鹀	Yellow-breasted bunting	珠海后环	中山三乡
410			田鹀	Rustic bunting	江苏仪征市	三乡
411			灰头鹀	Black-faced bunting		
412			芦鹀	Reed bunting	北京温榆河	
413			白眉鹀	Tristram's Bunting	河北乐亭滦河口	
414			栗耳鹀	Chestnut-eared bunting	内蒙古磴口县奈伦湖国家湿地公园	河北曹妃甸溯河河口
415			苇鹀	Pallas's bunting	内蒙古磴口县奈伦湖国家湿地公园	河北曹妃甸溯河河口
416			黄眉鹀	Yellow-browed Bunting	河北乐亭滦河口	北京国家植物园
417			栗鹀	Chestnut Bunting	大清河盐场鸟类救助站	
418			红颈苇鹀	Ochre-necked reed bunting	乐亭县滦河口	
419			铁爪鹀	Lapland bunting	乐亭县滦河口	
420						



Other Vertebrates

Chinese Strip-necked Turtle
Tilapia
Corsac Fox
Oriental Garden Lizard
Greater Bandicoot Rat
Spot-legged Treefrog
Chinese Cobra
Günther's Frog

Tell Me What You Want!

Mangroves are Heaven to Birders

- Mosaic of Different Micro-habitats
  - Open water body
  - Shallow water
  - Mudflats
  - Sand dunes
  - Farmlands
  - Woodlands
  - Artificial facilities like fish and shrimp ponds, salt pans
- Sea, fresh and brackish waters
- Food supply is daily replete by tidal water
- Easy to spot birds in open landscape
- Easy accessibility

Birders Potential Contributions to Mangrove Managers

- To Produce Scientific Information to Support Management Decisions

Kinds of Data from Birders

Data Description	
Didn't see any birds	Absence
A group of common shelducks	Presence
15 common shelducks.	Quantitative
15 common shelducks, among them 2 adult females, 2 adult males, and 11 chicks.	Age, sex, breeding status
15 common shelducks, 10 mallards, 30 red shanks, 6 spoonbills, 1 osprey.	Species diversity
15 common shelducks, 10 mallards, 30 red shanks, 6 spoonbills, 1 osprey, on a 6-km transit line.	Density
15 common shelducks, 10 mallards, 30 red shanks, 6 spoonbills, 1 osprey. on a 6-km transit line by Pond A, by a team of 2 bird watchers using binocular on foot between 05:30 – 07:30 May 30, 2025.	Methodology
15 common shelducks, 10 mallards, 30 red shanks, 6 spoonbills, 1 osprey on a 6-km transit line by Pond A; 31 common shelducks, 20 mallards, 50 redshanks, 6 spoonbills, 1 osprey, 15 tufted pochards, 12 black-tailed godwits, 35 pied avocets on a 6-km transit line by Pond B, by a team of 2 bird watchers each using binocular on foot between 05:30 – 07:30 May 30, 2025.	Spatial variation
15 common shelducks, 10 mallards, 30 red shanks, 6 spoonbills, 1 osprey on a 6-km transit line by Pond A by a team of 2 bird watchers each using binocular on foot between 05:30 – 07:30 May 30, 2025, a significant decline compared with the result of an identical survey on Mar 30, 2024 when 31 common shelducks, 20 mallards, 50 redshanks, 6 spoonbills, 1 osprey, 15 tufted pochards, 12 black-tailed godwits, 35 pied avocets were recorded.	Trend (Temporal variation)

From Raw Data to Parameters with Conservation Application

Qualitative Data	Presence/absence	(1,0,0,1,1,0,1,1,0,1), 6/10=60%	Possibility of occurrence
		Found only in March–May, Sept – Oct	Migrant species
		Found in 30 out of 100 plots (1ha)	Distribution range
	Gender	(M,F,F,F,M,F,F,M,F,F,F)	Sex ration = M:F = 3:7
	Nesting Failure/success	(1,1,1,0,0,0,1,0,0,1)	Breeding performance
Quantitative Data			Population size, range, density
			Species diversity
			Age group
			Reproduction Rate
			Mortality
			…………

How Raw Data are Processed to Generate Relevant Information

Individual Biological Features	Population Parameters	Trend (Monitoring, Assessment & Evaluation)	Management Significance
Absence/Presence	Distribution, Spatial Variation	Habitat Selection	Habitat Quality
Species	Distribution		Intro-specific Competition
Sex	Sex Ratio	Population Structure	Population Health
Age	Age Group	Population Structure	
Breeding Status	Reproduction Rate, Annual Recruitment, Mortality		
Migratory Status	Migration Timing and Duration	Migratory Pattern	
Species (pl.)	Species Diversity		Inter-specific Competition, Predation
	Population Size	Population Dynamics	
	Population Density		

How to Use the Parameters: to Test Hypothesis

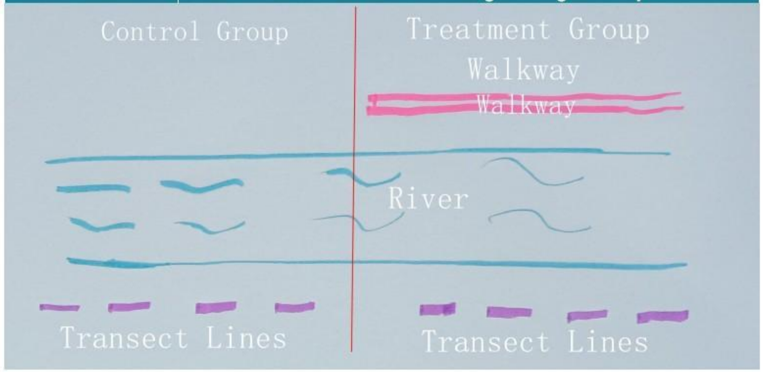
Problem:	Is Subject A different from Subject B?
Hypothesis	Ho: A = B
	Ha: A ≠B
Test hypothesis	The kind of data to be collected: weight, length, volume, speed,
	Take measures (n=10)
	Compile and analyze data:
	Statistical test:
Conclusion	Reject Ho, Accept Ha

To Tell the Difference: Exercise One

Problem Statement:	Which is a better place to see common shelducks, Pond A or Pond B?
Hypothesis	Ho: There is equal chance to find common shelducks at Pond A and Pond B;
	Ha: The chance is different to find common shelducks at Pond A and Pond B.
Test hypothesis	The kind of data to be collected: the numbers of visits that finds common shelducks.
	Take measures: Pond A (1,0,1,1,0,1,1,1,1,1) (n=10) 8/10 = 80%
	Pond B (0,1,0,0,1,0,0,0,1,0) (n=10) 3/10 = 30%
	Compile and analyze data: The chance to see common shelducks at Pond A is 8/10 = 80%; and 30% at Pond B.
	Statistical test:
Conclusion	Accept Ha: The chance is different to find common shelducks at Pond A and Pond B.
Conservation application	Pond A would be a better place to set up a bird watching site for common shelducks

To Establish Causal Effects: Exercise Two

Problem Statement: Does Tourism affect Bird A breeding in a negative way.



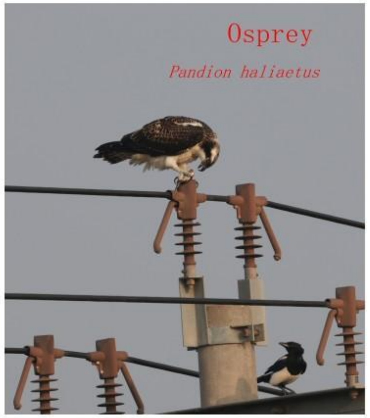
To Establish Causal Effects: Exercise Two

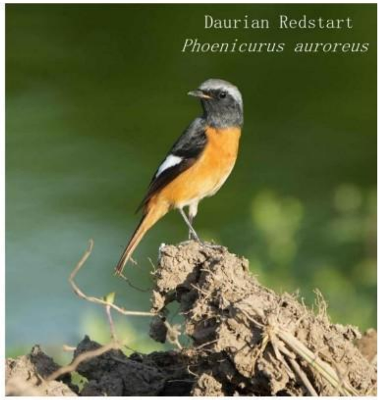
Problem Statement:	Does Tourism affect Bird A breeding in a negative way.
Hypothesis	Ho: Tourism has no effect on the breeding of Bird A;
	Ha: Tourism has a negative effect on the breeding of Bird A.
Test hypothesis	To count the number of active nests (number of chicks hatched, fledged etc) on transect lines in treatment and control groups, respectively.
	Take measures: number of nests in control group (25, 31, 32, 40)
	number of nests in treatment group (5, 8, 2, 5)
	Average in control group = 32; average in treatment group = 5
	Statistical test:
Conclusion	Accept Ha: Tourism has a negative effect on the breeding of Bird A.
Conservation application	To reduce volume of visitation, demolish walkways, and to scrutinize suggestion to put up more walkways more carefully.

Birders Potential Contributions to Mangrove Managers

- To Produce Scientific Information to Support Management Decisions
- To help Promote Public Image of Mangroves Reserves by Providing:
  - High-quality Photos and Vlog for promotional materials and website
  - Organize and Participate in Campaigns like Birds Count, Birds Walk, and Natural Interpretation Trips
  - Dissemination of Information to friends, family members and general public


Pied Harrier
Circus melanoleucos


Osprey
Pandion haliaetus

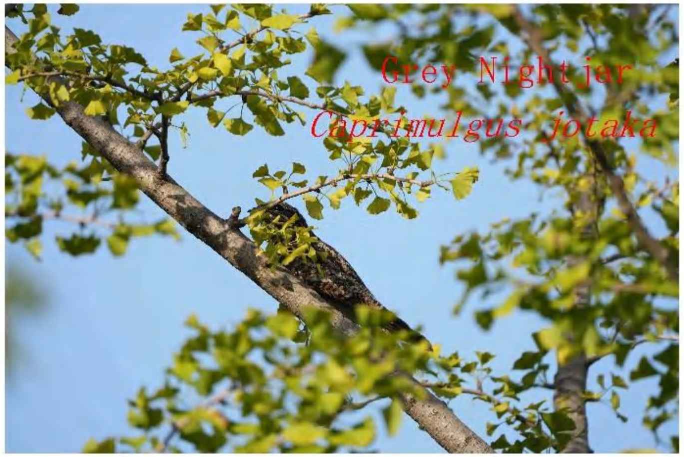

Daurian Redstart
Phoenicurus auroreus


Reed Warbler
Acrocephalus orientalis


Greater Painted Snipe
Rostratula benghalensis


Common Tern
Sterna hirundo


Common Shelducks
Tadorna tadorna


Grey Nightjar
Caprimulgus jotaka


Verditer Flycatcher
Eumyias thalassinus


Red-flanked Bush Robin
Tarsiger cyanurus


Common Snipe
Gallinago gallinago


Eurasian Oystercatcher
Haematopus ostralegus

A Common Snipe and a Green Sandpiper Feeding

Birders Potential Contributions to Mangrove Managers

- To Produce Scientific Information to Support Management Decisions
- To help Promote Public Image of Mangroves Reserves by Providing:
- To directly participate in survey, monitoring, research projects

12th New Year Birds Count, Qi'ao Island, Zhuhai, January 1, 2025

Bejing Migratory Raptors Monitoring Program

- Organized by The Friends of Nature
- Baiwangshan Mr., Beijing
- Started since 2012
- 146 days/year in operation
- 42 species of raptors recorded so far
- Over 2000 raptors spotted on May 13, 2025

Birders Potential Contributions to Mangrove Managers

- To Produce Scientific Information to Support Management Decisions
- To help Promote Public Image of Mangroves Reserves by Providing:
- To directly participate in survey, monitoring, research projects
- To share bird-watching know-hows to reserve staffs
- To support law enforcement

Poaching by Mist Net is a Big Threat

Hell and Haven for a Bull-headed Shrike

Labor-division between Mangrove Managers and Birders

Mangrove Managers

- To design project based on goal and objectives, resources, time frame and technical knowhow;
- To decide on the data required and methodology to collect them;
- To coordinate and participate in data collection
- To compile, collate and analyze data coming in;
- To reach conclusion according to the project results;
- To take adequate interventions.

Bird Watchers

- To identify and record the species of birds, numbers, sex, age, breeding status at designated time and sites.

Activities by Mangrove Managers to Facilitate Successful Cooperation

- Timely and Full Communications
- Training in Data Collection, Methodology
- Project Ownership
- Necessary Logistic Support
- Rewards, like accession perks, e.g., areas not open to general public
- Acknowledgement

Q & A

- Question: We do not birders back home?
- Answer: To arrange birding tour package via IMC

HANK YOU

Haibin Wang
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++86-13011638284

Annex 3.9: Mangrove: Pollution, Wastewater Treatment, and Bioremediation

Pollution, Wastewater Treatment and Bioremediation of mangroves

Nora F. Y. Tam
Chair Professor
City University of Hong Kong / Hong Kong Metropolitan University
7 November 2025, Shenzhen

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President Xi: visited Guangxi mangroves in 2017 and announced the establishment of International Mangrove Centre in 2022

Significant ecological values

Mangroves offer diverse habitats, breeding sites and feeding grounds for a large variety of coastal and marine species, such as juvenile fish, crabs, shrimps and mollusks, and provide prime nesting and migratory sites for hundreds of bird species and wildlife.

Mangroves in Hong Kong

Benefits of sewage discharge

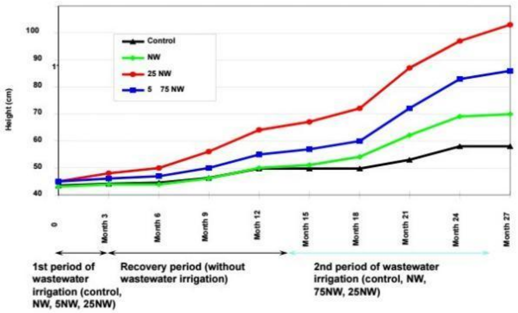
- Domestic sewage, discharge from agriculture and aquaculture
- Rich in nutrients, including nitrogen and phosphorus
- Essential for plant growth in nutrient-limited mangrove environments, enhance primary productivity and microbial activities

Mangrove Microcosms

Computerized tide-tanks with tidal flushing

Sewage of different strengths

Height of *K. obovata* received municipal sewage



% increases in population sizes of N-bacteria due to sewage addition

Bacterial groups	NW to microcosm with *Kandelia*
Ammonium oxidizers	20.5
Nitrite oxidizers	22.6
Denitrifiers	24.4

Beneficial effects of municipal wastewater

- Increases in biomass and density of dominant species: beneficial effects
- No change in plant community structure, litter production and decomposition
- Stimulate more production of bacteria, algae and benthic diatoms although community structure may be similar

Mangrove plants well established with sewage discharge

Close-up showing vigorous growth of *Aegiceras corniculatum* and unplanted control 10 years after construction

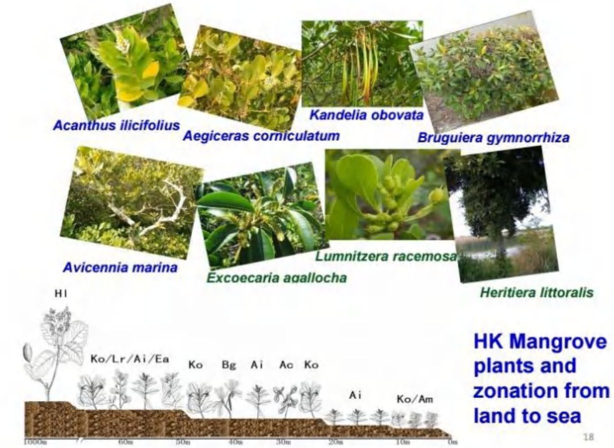
Average effluent conc (mg/L) and removal % in 10-year treatment in Futian

Species	COD	BOD_5	TN	NH_3-N	TP	SP
Influent	119.03	53.02	16.17	13.53	1.61	1.26
S. caseolaris	43.35 64.9%	13.38 75.5%	8.56 53.6%	6.87 52.6%	0.65 65.0%	0.45 69.2%
A. corniculatum	37.75 67.8%	13.61 74.1%	7.98 55.1%	6.00 58.4%	0.45 74.5%	0.32 76.9%
K. candel	41.98 62.8%	13.75 73.8%	8.25 50.0%	7.27 45.2%	0.64 62.2%	0.47 64.8%

- Treatment performance satisfactory
- >70% of samples meeting the discharge standard for COD (60 mg/L), BOD (20 mg/L), TN and NH_3 (15 mg/L), >40% for TP (<0.5 mg/L)

How about industrial discharge?

- Industrial wastewater discharge leads to soil and sediment contamination with heavy metals, polycyclic aromatic hydrocarbons (PAHs), etc.



HK Mangrove plants and zonation from land to sea

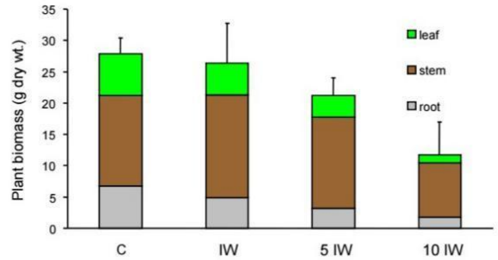
Tolerance of mangrove plants to heavy metals

(No. survival / total No. of plants)

	A. ilicifolius	*A. marina*	*A.corniculatum*	*B. gymnorrhiza*
Control	12/12	12/12	12/12	12/12
T1	6/12	12/12	12/12	12/12
T2	3/12	9/12	9/12	12/12
T3	0/12	9/12	6/12	9/12
T4	0/12	6/12	3/12	6/12

T1: 50, 50 and 100 mg/kg Cu, Pb and Zn, respectively; T2: 2 times of T1; T3: 4 times of T1; T4: 6 times of T1

Effects of electroplating effluent on mangrove *K. obovata*



Mangroves are efficient in removing heavy metals from industrial wastewater

Fe^{3+}, Zn^{2+}, Pb^{2+}, Cr^{6+} → More than 99% were removed from strong industrial wastewater and concentrations in effluent all met discharge standard in HK

Cu^{2+}, Cd^{2+} → 100% were removed by the three mangrove species

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Fate of contaminants

- Heavy metals: >90% heavy metals in wastewater are retained in sediment/soil, and their concentrations are proportional to contaminant levels in wastewater

Heavy metals conc. ($\mu g\ g^{-1}$ dw)	Background	C	IW	5 IW	10 IW
Total Cu	3.94 ± 2.62	4.22 ± 1.49	22.68 ± 0.09	118.46 ± 37.20	172.02 ± 6.34
Total Zn	16.06 ± 1.20	17.19 ± 2.83	51.93 ± 3.50	232.75 ± 50.70	389.09 ± 43.64
Total Cd	ND	1.30 ± 0.55	1.97 ± 1.71	7.92 ± 3.37	12.81 ± 1.72
Total Cr	9.94 ± 2.81	6.28 ± 0.63	13.99 ± 0.60	42.18 ± 9.15	74.95 ± 3.43
Total Ni	ND	ND	17.37 ± 0.50	114.35 ± 8.45	211.27 ± 23.50

ND: Not detected as the concentration is below the detection limit of AAS.

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Plant uptake of heavy metals (%)

Heavy metals	Industrial wastewater (IW)		10 x IW	
	Ko	Bg	Ko	Bg
Cu	0.93	1.12	0.46	1.69
Zn	0.51	2.93	0.74	2.69
Cd	0	2.95	0.41	3.01
Cr	1.18	5.45	1.58	4.99
Ni	0.38	3.31	0.70	3.01

Total uptake of heavy metals: <6%, max 10%, depend on plant and metal species, Bg > Ko, more uptake of Cr and Ni

Phytoremediation of heavy metals by plant uptake

- Mangrove plants such as *Kandelia* exclude metals primarily at the root level, minimizing translocation to aerial tissues, which helps reduce metal stress in the plant system
- Iron plaque formed on root surface can immobilize heavy metals and prevent them entering root tissues

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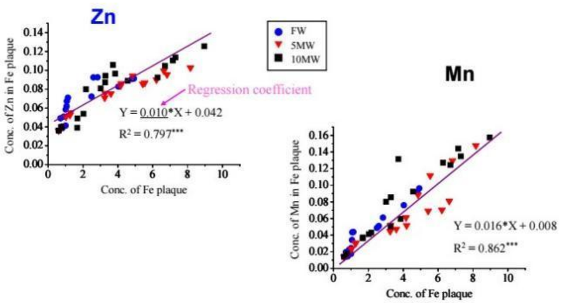

Relationship between concentration of Fe plaque (mg/g dw) on root surface of *B. gymnorrhiza* and Zn and Mn immobilized in Fe plaque

Same for Cr, Ni, Pb, Cu and Cd, also for other mangrove plants

Phytoremediation of heavy metals by plant uptake

- **Other than Ko and Bg, *Avicennia* and *Rhizophora* are effective in accumulating heavy metals like Pb, Cr, Cu, Ni, Zn and Cd from sediments by translocate metals from roots to shoots, facilitating metal removal from contaminated environment**
- **Plant species-specific, also depend on heavy metal species: Need more research**

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Bioremediation of heavy metals in mangrove sediments

- **Associated microbial communities on root surface, rhizosphere sediments and bulk sediments**
- **Rich biodiversity**
- **Resistant microbial species**
- **Accumulate and transform heavy metals**
- **Reduce metal toxicity and bioavailability in environment**

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Microbes with bioremediation traits

- **Zhang et al. 2025 (JHM) isolated 56 bacterial strains from *Acanthus ilicifolius* and *Sonneratia apetala* rhizosphere sediment in Shenzhen Futian National Nature Reserve with heavy metal bioremediation traits**
- **Novel strain *Aestuariibaculum* sp. JKB11 with high adsorption (Cd^{2+} 12.25 mg/g; Ni^{2+} 10.19 mg/g) and tolerance (Cd^{2+} 150 mg/L, Ni^{2+} 400 mg/L)**
- **Genomic analysis identified 53 metal-resistance genes in JKB11, enabling extracellular-dominated adsorption (97-99%)**

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Enhanced bioremediation of heavy metals by immobilization

- Immobilization in SA/PVA hydrogel enhanced removal efficiency (Cd^{2+} 48.24%, Ni^{2+} 54.03%, Cu^{2+} 68.28%, Zn^{2+} 55.11%) through matrix synergy (Zhang et al. 2025, JHM)
- Microbial strains isolated from mangrove rhizospheres exhibit high tolerance to metals and strong adsorption capacities, and immobilized microbes in supportive matrices such as hydrogels enhance bioremediation efficiency

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Integration approach

- Integration of phytoremediation with microbial assistance and emerging nanotechnology methods for enhanced heavy metal removal in mangrove and coastal ecosystems
- Select tolerant and bio-accumulative plant species
- Isolate microbes with bioremediation traits with appropriate immobilization matrix
- Plant Growth-Promoting *Rhizobacteria* (PGPR) and nanoparticles can synergistically improve remediation effectiveness while safeguarding ecosystem health

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How about pollutants other than heavy metals?

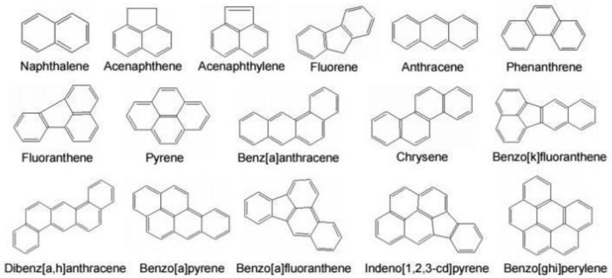
Persistent organic pollutants (POPs):

- Polycyclic aromatic hydrocarbons (PAHs)
- Polybrominated biphenyl ethers (PBDEs)

- **Plastic and microplastic**

PAHs: persistent organic pollutants (POPs), toxic and carcinogenic

PAHs (Polycyclic Aromatic Hydrocarbons)
16 USEPA priority pollutants, with different number of rings and molecular weights



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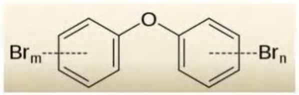
PAHs Concentrations in Mangrove Sediment

Mangrove sediments	Total PAHs (ng g^{-1} dw)
Ma Wan	1058.37±363.38
Mai Po	556.94±224.49 (hot spot: 4680)
Sai Keng	429.15±117.95 (hot spot: 1811)
Sheung Pak Lai	334.16±264.69
Yi O	311.10±94.74
Ho Chung	258.85±70.26 (hot spot: 11098)
Kei Ling Ha	169.41±51.92
Puerto Rico	1820 (hot spot: 6000)
Caribbean Island	502 (hot spot: 1657)

Mangrove sediments are seriously contaminated by PAHs, even Mai Po RAMSAR, important world wetland

Marine sediment:
- Hong Kong (553 ng g^{-1})
- Pearl River Estuary (2196 ng g^{-1})
- South China Sea (146 ng g^{-1})
- Xiamen Harbor (367 ng g^{-1})

Another POPs: PBDEs (Polybrominated Diphenyl Ethers)



209 congeners: numerous combinations of number and position of bromine atoms on the two phenyl rings, e.g. BDE-47 (4 Br), BDE-99, BDE-153, BDE-209 (10 Br)

Highly hydrophobic and strongly adsorbed onto sediment

Penta- and octa-BDE have been banned in Europe since 2004 and in the State of California, USA since 2008,
The production of deca-BDE has only been ceased in 2013
Still serious problem because of their long-term usage and new productions with recycled PBDE-containing materials and disposal of e-waste

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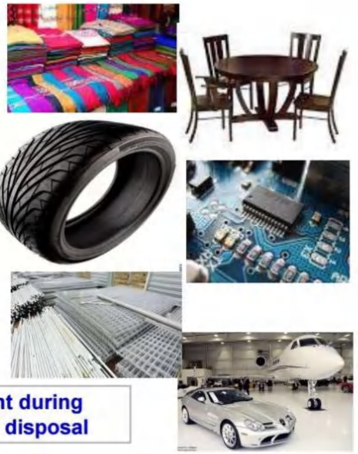
E-waste illegally dumped and piled up in villages (heavy metals, Polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), etc.)

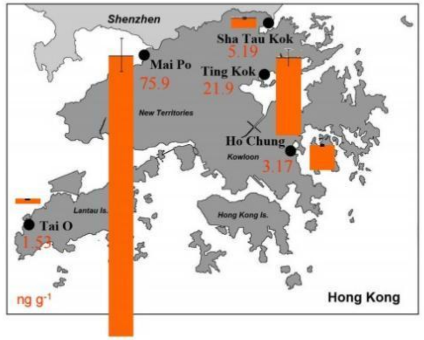
Commonly used brominated flame retardants (BFR), widely found in:

- textiles
- foams
- furniture
- rubber
- electronic components
- construction materials
- automobiles
- airplanes



Release to environment during manufacture, use, and disposal

BDE-209 in surface mangrove sediments in HK: spatial variations, extremely high level in Mai Po



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Plastic and microplastic

Microplastic pollution in mangroves

Table 1
Abundance, dominant shape and polymer type of microplastics in mangrove sediments (d.w.: dry weight; N.P.: not provided; N.A.: not analyzed).

Location	Sampling depth	Analytical procedure	Abundance (items/kg sediment)	Dominant shape (%)	Dominant polymer type (%)	Reference
Futian Mangrove (interior)	10 cm	$ZnCl_2$ Density separation + digestion + FT-IR & μFTIR	1920 ± 509	Fiber (78.79 ± 4.59)	PET (43.83 ± 6.12)	This study
Mai Po Mangrove (interior)	10 cm		1110 ± 195	Fiber (84.97 ± 5.03)	PET (38.10 ± 6.93)	This study
Sonneratia caseolaris (interior)	10 cm		4754 ± 416	Fiber (88.90 ± 3.17)	PET (54.19 ± 2.14)	This study
Kandelia obovata (interior)	10 cm		4627 ± 425	Fiber (76.39 ± 3.75)	PET (45.36 ± 3.09)	This study
S. apetala (interior)	10 cm		3548 ± 638	Fiber (75.48 ± 0.49)	PET (46.47 ± 1.12)	This study
Futian Mangrove	10 cm	$ZnCl_2$ Density separation + digestion + FTIR & ATR-FTIR	1200 ± 98 to 4007 ± 152 d.w.	N.A.	PS (N.A.)	Duan et al. (2020)
Qinzhou Bay Mangrove, South China	2 cm	$CaCl_2$ Density separation + digestion + ATR-FTIR & SEM-EDS	42.9 ± 26.8	Fragment (94)	PS (> 98)	Li et al. (2018)
Maowei Sea Mangrove, South China	N.P.	Digestion + Potassium formate aqueous Density separation + Micro-Raman	520 ± 8 to 940 ± 17	N.A.	PET (47.5–79.2)	Li et al. (2019)
Shenzhen Mangrove, South China	2 cm	NaCl & NaI Density separation I & II + ATR-FTIR, μ-FTIR & SEM	157.0	N.A.	PS (75.2)	Zhou et al. (2020)
Futian Mangrove, South China	5 cm	$ZnCl_2$ Density separation + digestion + Micro-Raman & SEM-EDS	980–3100 d.w.	Fiber (N.A.)	PP (75.2–84.7)	Li et al. (2020)
Mangrove in Pearl River Estuary	5 cm	Digestion + NaCl Density separation + μ-FTIR	100–7900 d.w.	Fiber (>69.7)	PE (36)	Zuo et al. (2020)
Persian Gulf mangrove	5 cm	NaCl & NaI I & II Density separation + FTIR & SEM-EDS	19.5–34.5 d.w.	Fiber (>56)	N.A.	Naji et al. (2019)
Ciénaga Grande de Santa Marta mangrove	N.P.	Water Density separation + ATR-FTIR	31–2863 d.w.	Films (N.A.)	N.A.	Garcés-Ordóñez et al. (2019)
Singapore's coastal mangrove	3–4 cm	NaCl Density separation + ATR-FTIR	36.8 ± 23.6 d.w.	Fibers (72.0)	N.A.	Nor and Obbard (2014)

Duan et al. 2021 STE Vol 767

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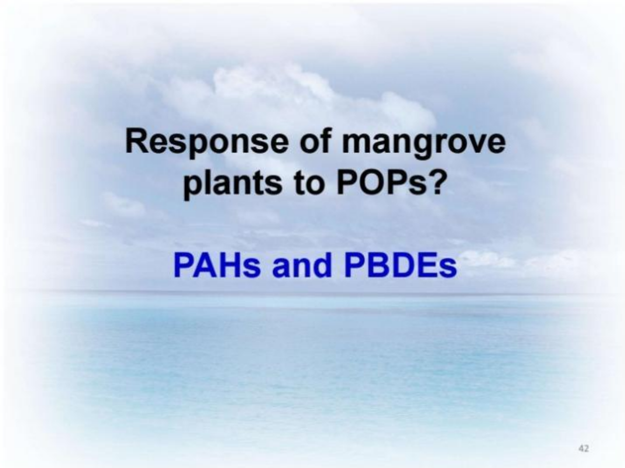
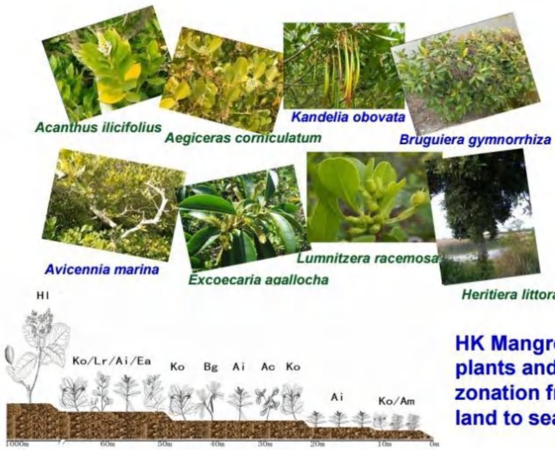
Mangroves are sink of pollutants





HK Mangrove plants and zonation from land to sea

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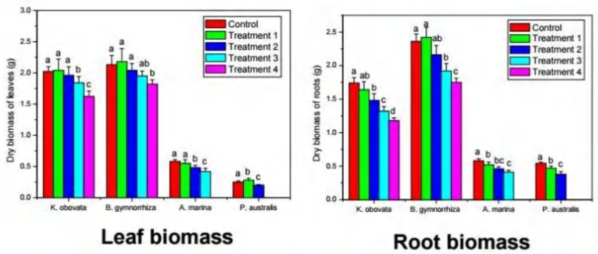
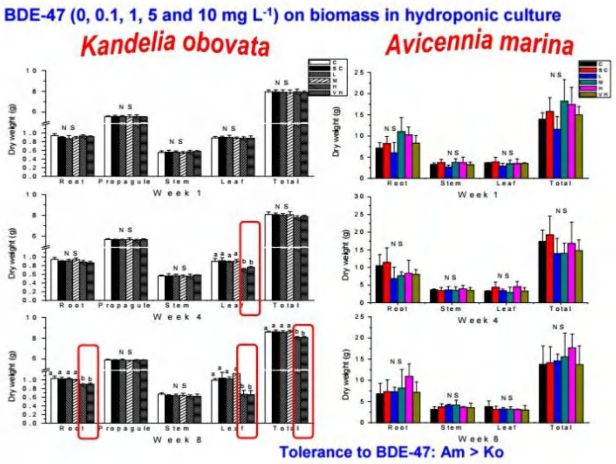
B. gymnorrhiza was very resistant to PAHs



Control no PAH; T1: 1 mg/g for each of Fl (fluorene), Phe (phenanthrene), Ant (anthracene), Fla (fluoranthene), Pyr (pyrene), Chr (chrysene), BaP (benzo[a]pyrene) and BkF (benzo[k]fluoranthrene); T2: 2xT1; T3: 12xT1; T4: 24xT1

Also to PBDEs, e.g., BDE-47 and -209



Mangrove tolerance to toxic POPs

- **Most mangrove plant species are more tolerant to PAHs than other wetland plants, e.g. *Phragmites australis* (common reeds)**
- **Within mangrove group, tolerance varies among species, most tolerant species is *Bruguiera gymnorrhiza*, followed by *Kandelia obovata*, and *Avicennia marina* is most sensitive**
- **But *A. marina* is more tolerant to PBDEs**
- **Species-specific**




Why mangrove plants can tolerate toxic POPs?

- **Inter-tidal location and adapt to stressed environment**
  - **Fluctuating salinity (0 to 35 ppt)**
  - **Various oxygen levels (aerobic, anoxic, anaerobic)**
  - **Wet and dry condition**
- **Extensive root system and large root biomass**
- **Specialized root systems**
- **High concentrations of tannins and polyphenols**
- **Activities of antioxidant enzymes**

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Biomass ratio of aboveground to belowground

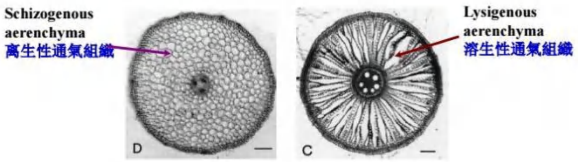
Genus and species	Tidal position in Hong Kong	Biomass ratio
Aegiceras corniculatum	Mostly outer (seaward) mangrove fringe	1.47
Acanthus ilicifolius	Littoral region, upper and middle reaches of estuarine rivers	0.91
Avicennia marina	Foreshore and seaward region, pioneer species	0.91
Bruguiera gymnorrhiza	Middle but also extends into the transitional landward	0.45
Excoecaria agallocha	Back mangrove, near terrestrial fringe	1.67
Heritiera littoralis	Back mangrove, forest edge	1.62
Kandelia obovata	All areas	0.22
Lumnitzera racemosa	Back mangrove, more landward	3.04

Specialized root systems (1)

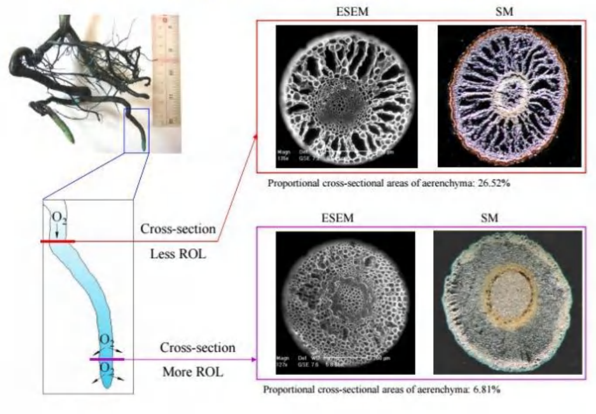
- Pneumatophores and knee joint for aeration

Specialized root systems (2)

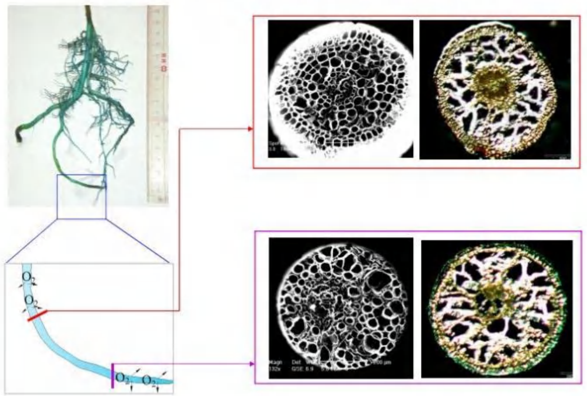
- Extensive aerenchyma: spongy tissue with large air spaces or cavities, mainly exist in root cortex
- Able to transfer oxygen from aerial parts to root tips and rhizosphere, maintain aerobic pockets in anoxic sediment by releasing excess oxygen from roots (radial oxygen loss) for oxidation and detoxification
- Form iron plaque



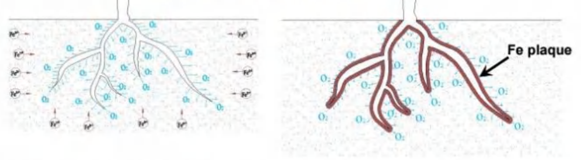
Root anatomy of *Bruguiera gymnorrhiza*



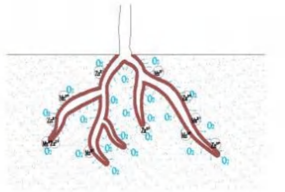
Root of *Acanthus ilicifolius*

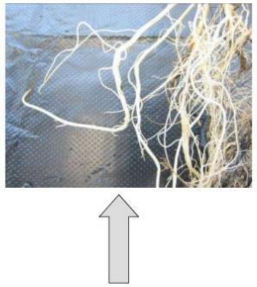


What is Fe plaque?

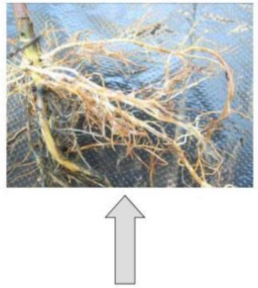


- ROL induces a partial precipitation of Fe under oxidized forms on root surfaces, creating Fe-rich root coatings, generally called Fe plaque
- Fe plaque is a mixture of crystalline and amorphous ferric hydroxides goethite and lepidocrocite
- More ROL around the rhizosphere may induce more Fe plaque formed on root surface to immobilize pollutants

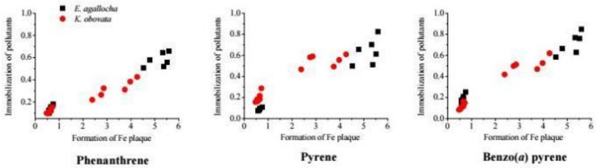




Without Fe plaque on root surface



With Fe plaque on root surface



Relationship between the formation of Fe plaque on root surface and immobilization of PAHs in Fe plaque

Positive relationships also found between Fe plaque and immobilization of PBDEs, e.g. BDE-47, -99, -100, -153, -154, -209

Specialized root system, such as ROL leading to formation of Fe plaque to:

Immobilize toxic contaminants

Reduce their uptake in mangrove plants, especially the sensitive plant parts such as leaves: total plant uptake is small

e.g., Uptake of PBDEs: <1% (exclude immobilized on Fe plaque)

Specialized root systems (3)

- **Root exudates:** Low molecular weight organic acids, e.g., lactic, benzoic, succinic, maleic, oxalic, malic and citric acids, are released by mangrove plants, provide carbon sources for microorganisms
- **Root surface: support diverse groups of POP-resistant and POP-degrading microbes**

Correlation coefficients between organic acids and BDE-47,99,209 concentrations in rhizosphere sediment

PBDE	Lactic	Oxalic	Benzoic	Maleic	Succinic	Malic	Citric
BDE-47	-0.135	0.135	-0.135	-0.287	-0.413*	-0.207	-0.435*
BDE-99	0.138	0.442*	-0.215	-0.406*	-0.630**	-0.233	-0.603**
BDE-209	-.346	-.208	.065	-.212	.014	.274	-.271

**. Correlation is significant at the 0.01 level
*. Correlation is significant at the 0.05 level

Oxidative stress and anti-oxidative defense

- Toxic contaminants such as PAHs and PBDEs often produce reactive oxygen species (ROS)
  - Free radicals: Superoxide radical ($O_2^{\cdot -}$), hydroxyl radical (OH·) and peroxyl radical ($RO_2\cdot$)
  - Non free radicals: Hydrogen peroxide (H_2O_2)
- Pose oxidative stress
- Plants develop anti-oxidative defense system

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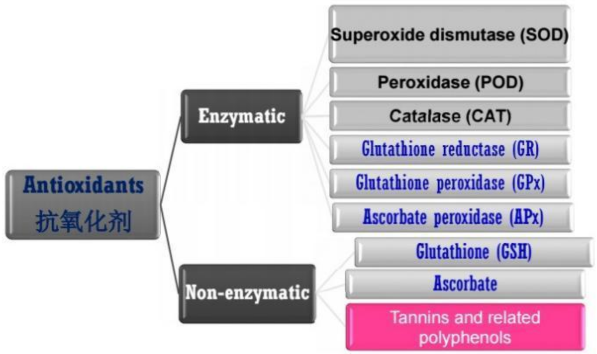
Anti-oxidative defense



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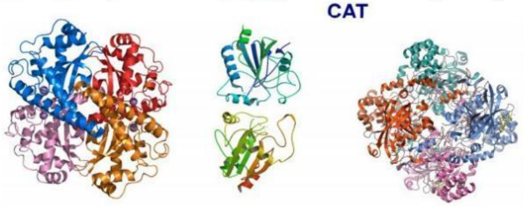
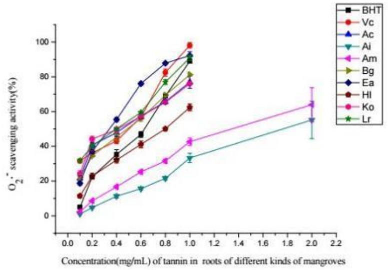
Three common antioxidative enzymes

superoxide radical ($O_2^{\cdot -}$) $\xrightarrow{SOD}$ $O_2 + H_2O_2$

hydrogen peroxide (H_2O_2) $\xrightarrow[CAT]{POD}$ $O_2 + H_2O$



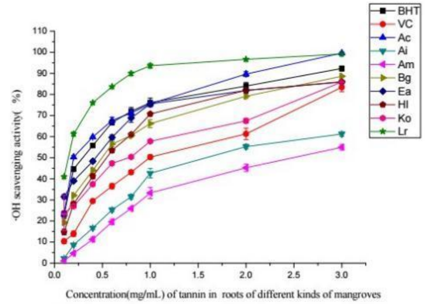
Superoxide radical scavenging activity



	BHT	Vc	Ac	Ai	Am	Bg	Ea	Hl	Ko	Lr
EC_{50}	0.629	0.510	0.447	1.771	1.360	0.488	0.343	0.802	0.414	0.404

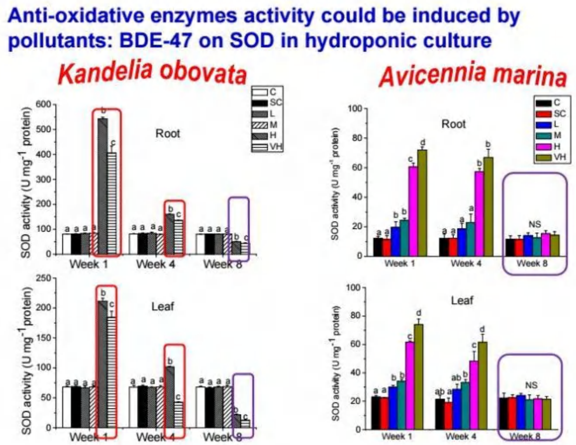
Ea > Lr > Ko > Ac > Bg > Vc (ascorbic acid) > BHT (butylated hydroxytoluene) > Hl > Am > Ai

Hydroxyl radical scavenging activity



	BHT	Vc	Ac	Ai	Am	Bg	Ea	Hl	Ko	Lr
EC_{50}	0.289	0.998	0.205	1.588	2.495	0.495	0.436	0.536	0.799	0.150

Lr > Ac > BHT > Ea > Bg > Hl > Ko > Vc > Ai > Am


Anti-oxidative enzymes activity could be induced by pollutants: BDE-47 on SOD in hydroponic culture
Kandelia obovata
Avicennia marina
Root
Leaf
SOD activity (U mg^{-1} protein)
Week 1
Week 4
Week 8
NS
C
SC
L
M
H
VH


Can mangroves remove and detoxify POPs?
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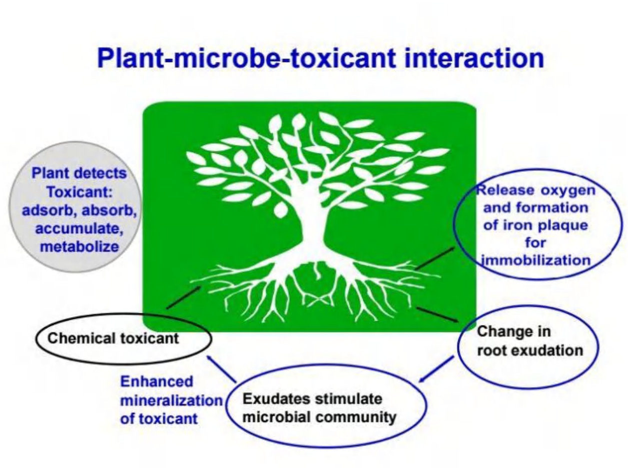
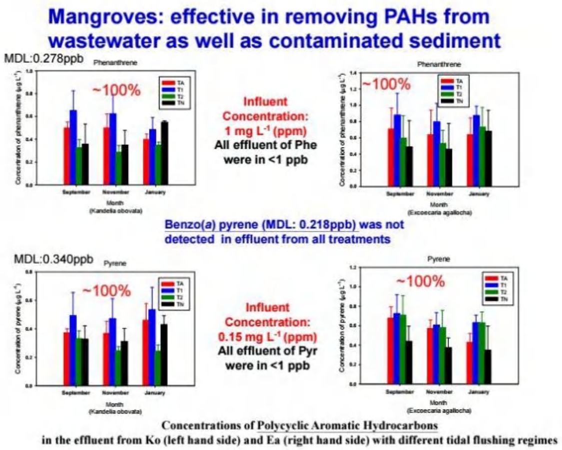
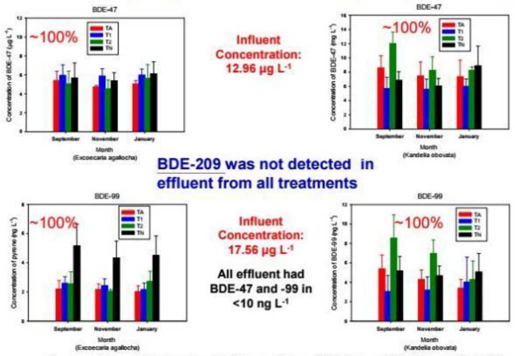

Plant-microbe-toxicant interaction
Plant detects Toxicant: adsorb, absorb, accumulate, metabolize
Release oxygen and formation of iron plaque for immobilization
Chemical toxicant
Change in root exudation
Enhanced mineralization of toxicant
Exudates stimulate microbial community

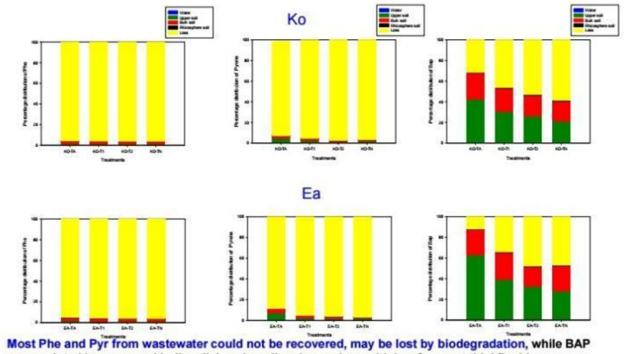

Mangroves: effective in removing PAHs from wastewater as well as contaminated sediment
MDL:0.278ppb
Phenanthrene
~100%
Influent Concentration: 1 mg L^{-1} (ppm)
All effluent of Phe were in <1 ppb
Benzo(a) pyrene (MDL: 0.218ppb) was not detected in effluent from all treatments
MDL:0.340ppb
Pyrene
Influent Concentration: 0.15 mg L^{-1} (ppm)
All effluent of Pyr were in <1 ppb
Concentrations of Polycyclic Aromatic Hydrocarbons in the effluent from Ko (left hand side) and Ea (right hand side) with different tidal flushing regimes

PBDEs (Polybrominated Diphenyl Ethers)



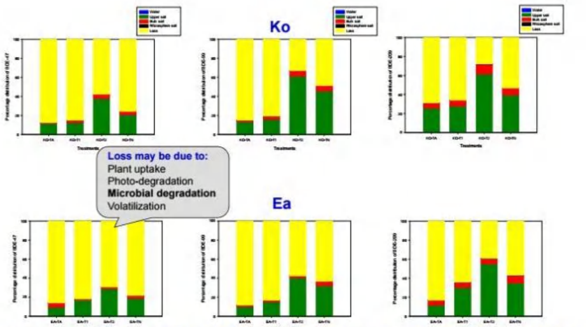
Concentrations of Polybrominated Diphenyl Ethers (BDE-47 and BDE-99 and BDE-209) in the effluent from Ea (left hand side) and Ko (right hand side) with different tidal regimes

Percentage distribution of Phenanthrene, Pyrene, Benzo(*a*) pyrene in mangrove system



Most Phe and Pyr from wastewater could not be recovered, may be lost by biodegradation, while BAP accumulated in upper and bulk soil, less in soil and more loss with low frequent tidal flushing

Percentage distribution of BDE-47, BDE-99, BDE-209



Similar to PAHs, most of BDE-47, BDE-99 and BDE-209 from wastewater could not be recovered in the system, i.e. loss by biodegradation or debromination, and those retained were in upper soil. Opposite to PAHs, less retained in soil but higher loss under frequent tidal flushing (e.g. daily tidal flushing)

PAHs and PBDEs in wastewater cannot be detected in effluent

Plant uptake is minimal

Some retain in sediment / soil

But

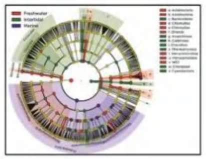
Most are lost from the system (>80%), esp. PAH with less rings (Phe) and PBDEs with less bromine atoms (BDE-47)

- **How PAHs / PBDEs lost from the mangrove system (>80%)**
  - **Volatilization** (little for highly brominated BDE congeners and also PAHs with large molecular size)
  - **Photo-degradation** (not much in sediment)
  - **Microbial degradation (bioremediation):** more important

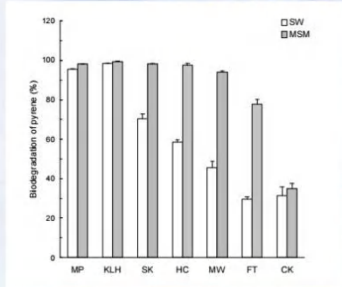
- **Mangroves: aerobic and anaerobic processes for microorganisms to break down organic pollutants**
- **Intrinsic degradation or natural attenuation**
- **Both reduced and oxidized environments strongly influence soil chemistry**
- **Intrinsic relationship between redox potential (Eh) and metabolic activities of microbes in sediment and root surface (rhizosphere)**

Root for microbes

- **Root surface: support diverse groups of POP-resistant and POP-degrading microbes**
- **Root exudates: Low molecular weight organic acids, e.g., lactic, benzoic, succinic, maleic, oxalic, malic and citric acids, are released by mangrove plants, provide carbon sources for microorganisms**
- **Microorganisms in mangrove root and sediment have intrinsic degrading potential**



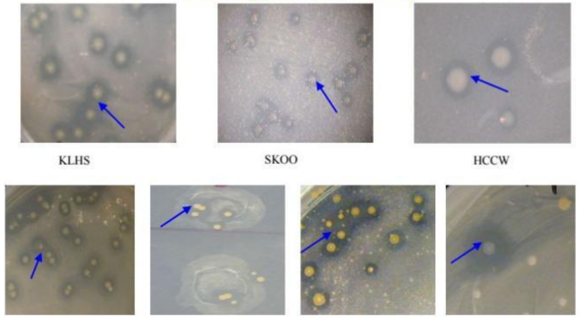
Pyrene (4-ring PAH) degradation by indigenous microorganisms in mangrove sediment under aerobic conditions



Total PAHs ranged from 169-1058 ng/g while pyrene varied from 15-208 ng/g
SW: seawater; MSM: Mineral salt medium. Minerals enhanced degradation (Bio-stimulation) 76

PAH-degrading aerobic bacteria in sediments

Bacterial colony grown on Phe-coated MSM agar (Arrow showing the clear zone)



KLHS SKOO HCCW

MWFG YOWG SPNY MPFG

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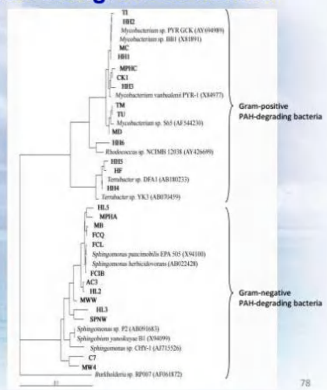
Diversity of PAH-degrading isolates from Hong Kong and Shenzhen mangrove sediment

- **More than 30 isolates from 6 mangrove sediments of Ho Chung (HC), Mai Po (MP), Ma Wan (MW), Chek Keng (CK), Sheung Pak Nai (SPN) and Fu Tian (FT)**
- **16 G+: *Mycobacterium* (11), *Terrabacter* (4), *Rhodococcus* (1),**
- **16 G-: *Sphingomonas* (14), *Sphingopyxis* (1), *Sphingobium* (1)**



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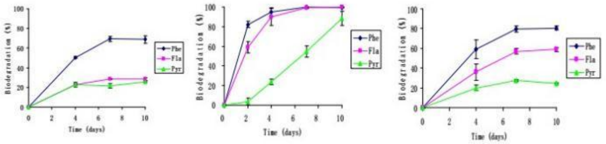
Degradation of Phe, Fla and Pyr by bacterial isolates: Bacteria and PAH compound- specific



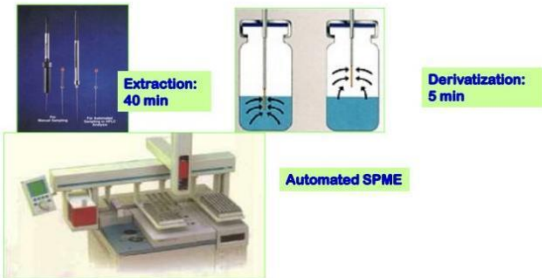
HCCS- ***Rhodococus* sp.**

SPNT – ***Paracoccus* sp.**

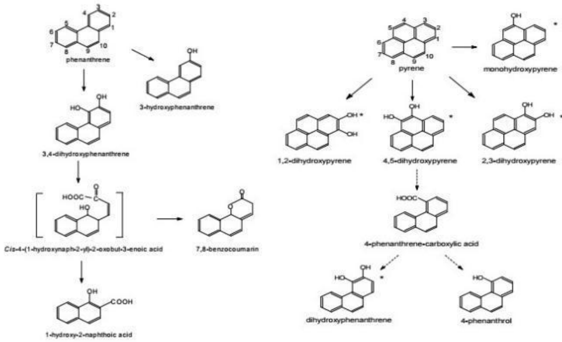
MWFG – ***Sphingomomas* sp.**

SPME: Solid-phase microextraction

SPME-GC-MS for analysis of metabolites of PAHs produced at different time during biodegradation



Proposed degradation pathway of Phe and Pyr by Isolates (ring opening)



Degrading microorganisms

- **Mangrove sediment/soil: diverse groups of indigenous degrading microorganisms**
- **Will bacterial community shift and induce more degraders in contaminated environments?**

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PAH-degrading bacterial strains isolated from control (T0) and contaminated slurries (T4-T6)

Strain	Sources*				Bacterial name (similarity %)
	T0	T4	T5	T6	
SKDOP	D0	D0	D0	D0	*Pseudomonas abikonensis* (98)
SAFY	-n	D15	D15	D15	*Sphingobium yanoikuyae* (97)
SKET	-n	-n	-n	D15	*Sphingomonas adhaesiva* (97)
SCFL	-n	-n	-n	D15	*Sphingobium yanoikuyae* (98)
SASS	-n	D30	D30	D30	*Sphingopyxis composta* (97)
SBSW	-n	-n	D30	D30	*Mycobacterium chlorophenolicum* (100)
SKEW	-n	-n	-n	D30	*Mycobacterium farcinogenes* (99)
SCSH	-n	D30	D30	D30	*Mycobacterium parafortuitum* (98)
SKEY	-n	-n	D30	D30	*Mycobacterium austroafricanum* (99)
SCSO	-n	-n	-n	D30	*Sphingomonas cloacae* (97)

*D0: at the beginning of the experimental period; D15: after 15-day exposure time
D30: after 30-day exposure time; -n: no bacterial strain was isolated

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Induction of degrading microorganisms

- **Bacterial community structure could be shifted to induce more degraders in contaminated environments, e.g.**
  - **Dominant bacteria changed with exposure of PAHs, from *Pseudomonas* sp. → Sphingomonads → *Mycobacterium* sp.**
  - **More diverse *Mycobacterium* are found in slurries with more PAH contamination**

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PAHs biodegradation was easier under aerobic conditions because of hydroxylation by dioxygenase genes

But

Relatively slow under anaerobic environments: enhanced by biostimulation with electron acceptors

How about another POP, PBDEs?

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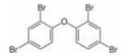
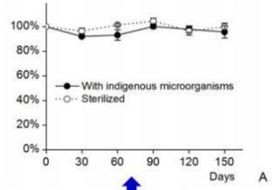
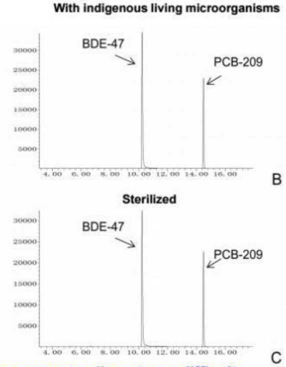
Under aerobic condition







Concentration of BDE-47 did not show significant changes in 5 months

No new peak with smaller molecular weight (no debromination product)

Aerobic degradation of PBDEs in mangrove sediment was difficult

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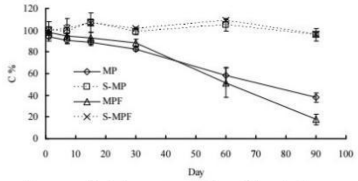
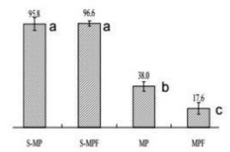
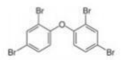
Under anaerobic condition, PBDE degradation of PBDEs is faster: Reductive debromination



Changes of relative concentrations (C, scaled as a percentage of initial concentration) of BDE-47 in anaerobic Mai Po mangrove sediment slurries during the experiment



Relative concentrations of BDE-47 in anaerobic mangrove sediment slurries at Day 90 (S: sterilized sediment without microbes)



BDE-47 with 4 Br atoms

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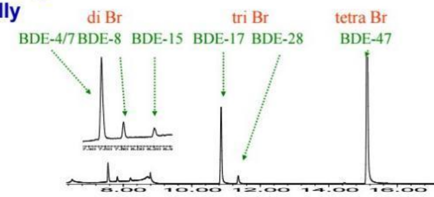
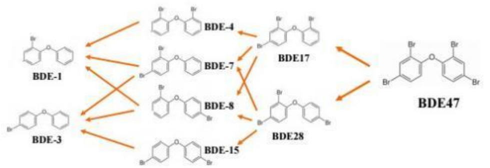
BDE-47 in mangrove sediment could be debrominated anaerobically





PBDE-related microbial groups

- Based on 16S rDNA gene copies from qPCR, PBDE-related groups for anaerobic debromination were detected:
  - *Dehalobacter (Dhb)*
  - *Dehalococcoides (Dhc)*
  - *Dehalogenimonas (Dhg)*
- Debrominated product from BDE-47 such as BDE-15 might be further degraded under aerobic conditions:
  - Dioxygenases genes (*Bph*) for aerobic degradation of PBDEs were also detected

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Shift in microbial community structure (Same as in PAH bioremediation)

- Temporal shift in microbial community
- e.g., transformation of BDE-153 in mangrove sediment:
  - Initial rapid debromination of BDE-153 to penta- and tetra-BDEs by Delta-proteobacteria and Chloroflexi (e.g., *Dehalococcoides*)
  - Further debrominated into di and tri-BDEs by α-proteobacteria
  - Leading to nearly complete debromination of BDE-153

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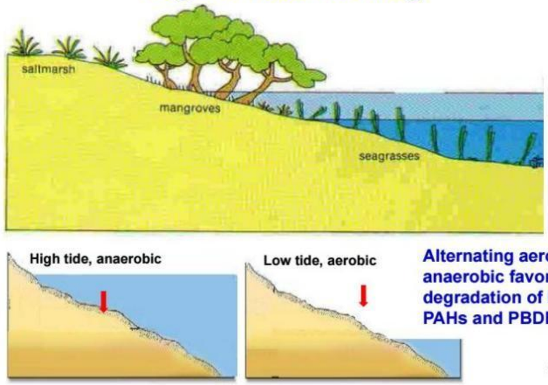
Mangrove wetlands: inter-tidal with regular tidal flushing



Alternating aerobic-anaerobic favor degradation of both PAHs and PBDEs

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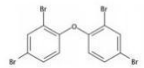
Tidal regime on PBDE degradation and removal

- 3 tidal regimes
  - 1:1d: 1-day high tide and 1-day low tide
  - 1:1w: 1-week high tide and 1-week low tide
  - 2:2w: 2-week high tide and 2-week low tide
- BDE (BDE-47) at 1 μg/g spiking level (simulated severe contamination in sediments in South China)



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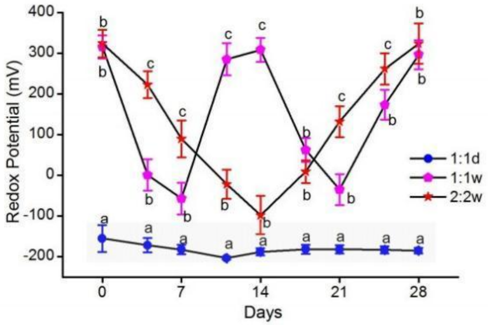
Changes of redox potential (Eh, mV) in sediment during 28 days



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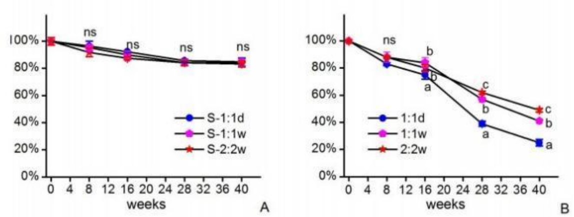
Degradation of BDE-47 in different tidal regimes



Abiotic loss of BDE-47 in the sterilized controls was around 20%.

1:1d regime (75.2%)
>
1:1w regime (58.8%)
>
2:2w regime (51.4%)

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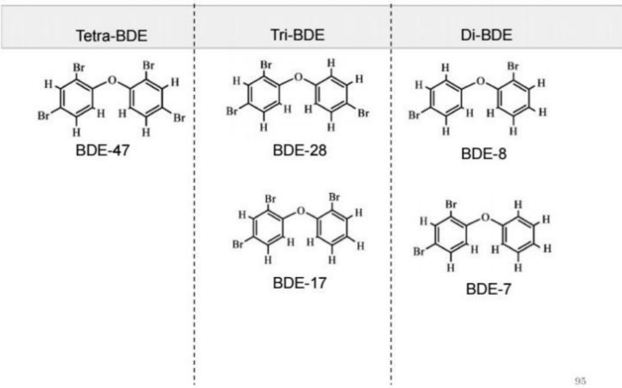
PBDE congeners



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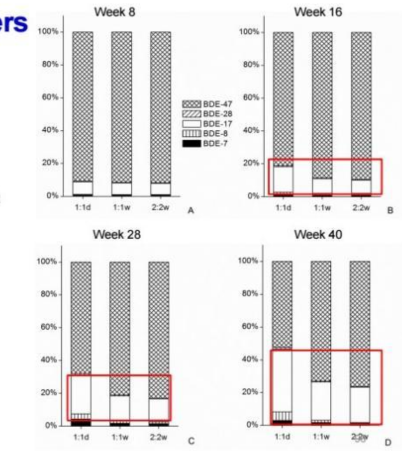
PBDE congeners

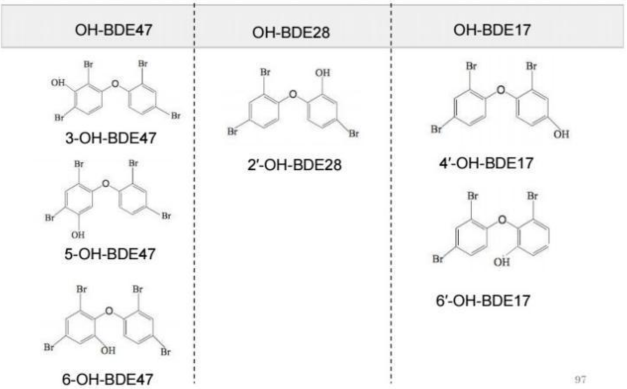
Dominant debromination product: BDE-17

Debromination product:

1:1d regime
>
1:1w regime
>
2:2w regime



Hydroxylation products (OH-PBDEs)



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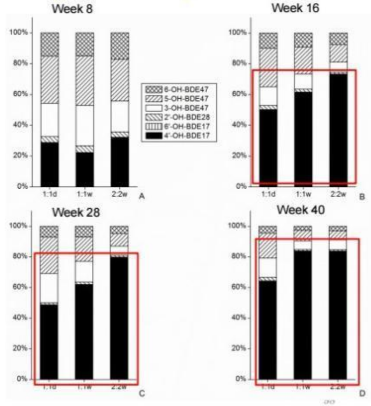
Hydroxylation products (OH-PBDEs)

2:2w regime
V
1:1w regime
V
1:1d regime



Percentages of BDE-47, debromination products (de-PBDEs) and hydroxylation products (OH-PBDEs) in sediments of different treatments at Week 40

	Sterilized control			Non-sterilized		
	1:1d	1:1w	2:2w	1:1d	1:1w	2:2w
BDE-47	80.73	80.26	79.26	26.76	44.48	52.5
De-PBDEs	ND	ND	ND	24.28	16.49	16.25
OH-PBDEs	0.29	0.24	0.19	0.99	2.38	2.11
% not recovered	18.37	18.87	19.87	47.36	36.03	28.50

<0.5% of BDE-47 in tidal water
In sterilized control without any microbes, 80% BDE-47 remained
In sediment with indigenous microbes, more than half BDE-47 transformed, mostly in debrominated PBDEs, while only 1-2% hydroxylated (very difficult process: molecular size and hydrophobicity and ortho-position of Br atom)
Tidal regime significantly affected BDE-47 degradation and removal

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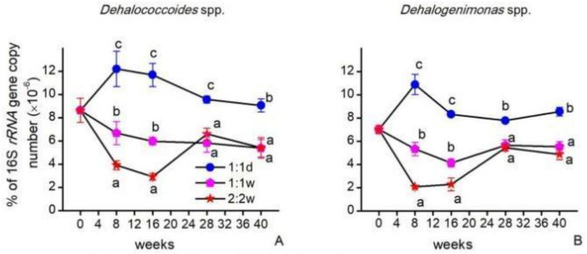
Relative abundances of *Dehalococcoides* spp. (A) and *Dehalogenimonas* spp. (B) 16S rRNA genes in sediments under different tidal regimes during 40-week experiment

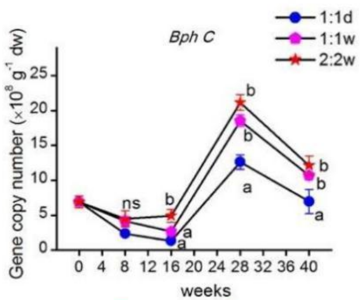


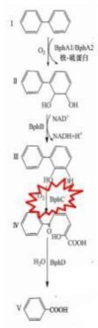
Dehalococcoides spp. > *Dehalogenimonas* spp.

1:1d regime > 1:1w regime ≈ 2:2w regime

100

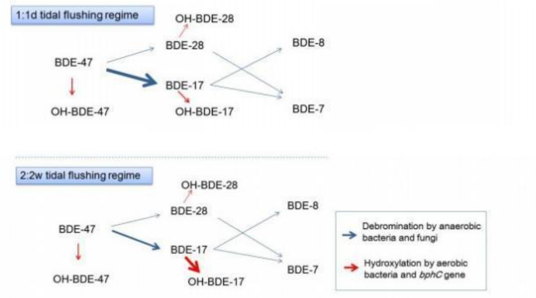
Bph gene: encoding biphenyl dioxygenase enzyme responsible for ring-cleavage of less brominated PBDEs





2:2w regime ≈ 1:1w regime > 1:1d regime

Effect of tidal regime with alternating aerobic-anaerobic condition



Removal and degradation pathways of BDE-47 under alternating anaerobic-aerobic conditions

Tidal flushing regime significantly affect accumulation and transformation (debromination) of PBDEs

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Take Home Messages

- **Mangroves: sinks of pollutants**
- **Mangrove plants have tolerance: Specialized root systems: radial oxygen loss (ROL), iron (Fe) plaque formation, anti-oxidative defense system**
- **Toxic pollutants such as heavy metals, polycyclic aromatic hydrocarbons (PAHs) and polybrominated diphenyl ethers (PBDEs) are immobilized in sediment, with relatively minimal plant uptake and translocation**
- **Mangrove sediments harbor diverse microbial (bacterial) communities**
- **High potential to transform heavy metals, degrade or remove POPs, such as PAHs and PBDEs**
- **Contamination induces relevant degraders and shift bacterial community structure**

Take home messages

- **Tidal flushing in mangrove wetlands creates alternating anaerobic-aerobic conditions**
- **Anaerobic: negative redox potential favors reductive debromination, produce less brominated congeners (de-PBDEs)**
- **Aerobic: oxidation and hydroxylation with ring opening for PAHs and PBDEs**

- **Cost-effective and environmental friendly constructed wetland technology for wastewater treatment and bioremediation of contaminated environments**

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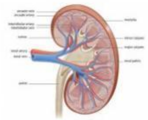
Mangrove: Green kidney

- Nature's kidney in coastal environments: perform kidney-like functions
- Store and assimilate nutrients and useful chemicals
- Transform contaminants or toxic pollutants to less harmful materials
- Remove harmful materials from water, dilute and filter pollutants from industrial and agricultural discharges, contaminated soil/sediment
- Retain water on land, prevents flooding in wet years and drought in dry years



105

Tolerance and purification abilities of mangroves are not unlimited, just like our kidney

We all protect our kidney!
Any failure: kidney transplant
BUT
No transplant of mangrove ecosystem!!

Hope we all protect our green kidney: the mangroves!!!

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Thank you

E-mail: bhntam@cityu.edu.hk

Annex 3.10: Mangroves, Blue Carbon, and Climate Change Mitigation

IMC Mangrove Training Workshop (Shenzhen；3 November, 2024)

Lecture 9: Mangroves, Blue Carbon and Climate Change Mitigation

Guanghui Lin[1,2]

[1]Tsinghua University, Beijing, China
[2]Hainan International Blue Carbon Research Center, Haikou, China
lingh@tsinghua.edu.cn; 13911768246 (wechat)

About my educational and research backgroud:

Educational background:

- ✓ BSc. & MSc. on mangrove ecology, Xiamen University-supervised by academician Peng Lin, "the father of mangroves in China;
- ✓ Ph.D. on mangrove ecophysiology, University of Miami USA-supervisor: Prof. Leonel Sternberg;
- ✓ Postdoctoral fellow on global change biology, University of Utah-Supervised by NAS academician James Ehleringer;

Academic experiences with mangroves and blue carbon:

- ◆ Principal investigator at Institute of Botany, CAS;
- ◆ Professor and Assoc Dean, School of Life Science, Xiamen Univ.;
- ◆ Professor and Chairperson for Ecology, Tsinghua University;
- ◆ Chief Scientist, Hainan International Blue Carbon Research Center.

3

IMC国际红树林漫谈 International Mangrove Talks (2025.11.6)

红树林蓝碳与气候变化应对
Mangrove Blue Carbon and Climate Change Mitigation

林光辉 Guanghui Lin

My major academic achievements

- ◆ Research on mangrove ecology and conservation more than 40 years
- ◆ Key promoter and practician of mangrove blue carbon in US and China for mitigating climate change
- ◆ Authors of more than 200 papers on these topics
- ◆ Authors of 5 books and >10 chapters of books on these topics
- ◆ Lead authors for IPCC guidance on coastal wetland GHG emission, Several methodology for coastal blue carbon projects in China;
- ◆ Recipient of numerous awards from USDA, CAS, Chinese Society of Ecology, Chinese University Press Association.

主要内容 Outline

◆ 气候变化及其后果

Climate change and consequences

◆ 蓝碳与气候变化减缓

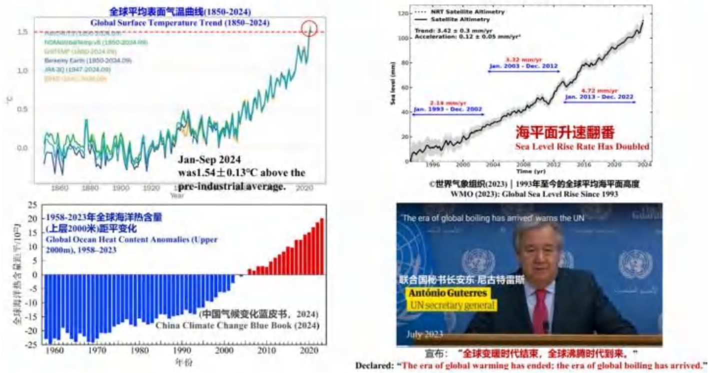
Blue carbon and climate change mitigation

◆ 红树林蓝碳在应对气候变化中的作用

Mangrove blue C for mitigating climate change

气候变化应对是21世纪最大挑战之一

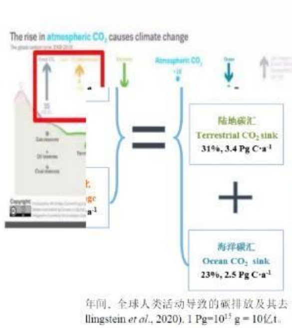
Mitigating climate change is one of most challenges in 21st century

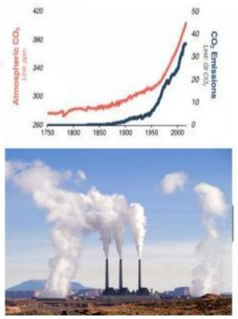


6

人类活动造成的二氧化碳排放，是大气中二氧化碳浓度升高的最主要原因

Global CO_2 Budget （2010-2019）





地球限度中的九个，已有六个被超越

6 of 9 Planetary Boundaries Exceeded

地球限度随时间的变化

Changes in Planetary Boundaries Over Time

- 气候变化 Climate Change
- 生物圈的完整性 Biosphere Integrity
- 陆地系统变化 Land-System Change
- 淡水变化 Freshwater Change
- 生物地球化学 Biogeochemical Processes
- 新奇实体 Emerging New Entities
- 海洋酸化 Ocean Acidification
- 大气气溶胶载荷 Atmospheric Aerosol Loading
- 平流层臭氧耗损 Stratospheric Ozone Depletion

(Azote for Stockholm Resilience Centre based on analysis in Richardson et al, 2023)

人类活动与气候变化的影响
Impact of human activities & climate change impact

✓ 人类活动是气候变暖的主要驱动力
Human activities are the main driving force behind climate change

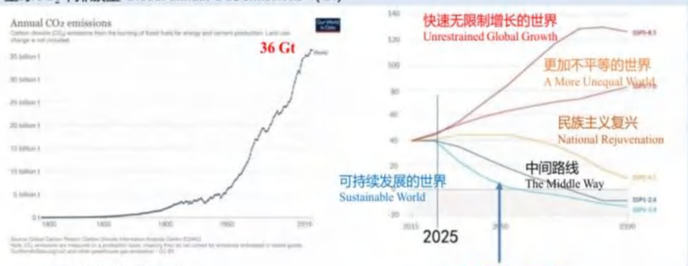
✓ 高碳发展模式带来系统性风险
The high carbon development model brings systemic risks

✓ 气候反馈机制加剧变化速度与不可逆性
Climate feedback mechanism intensifies the speed and irreversibility of change

✓ 影响人类安全与全球稳定
Impact on human security and global stability

留给人类的排放空间非常有限 → 碳中和，措施得当还有救
Emission Space is Tight → Carbon Neutrality Remains Achievable

全球CO_2年排放量 Global annual CO_2 emissions (Gt)



1.5度目标(1.5° C Target)
全球碳排放余额：~500 Gt
Remaining Global Carbon Budget: ~500 Gt
全球每年排放：~40 Gt
Annual Global Emissions: ~40 Gt
耗尽年限：12.5年（2025~2037）
Exhaustion Timeline: 12.5 years (2025~2037)

2050年全球碳中和
Global Carbon Neutrality by 2050

大幅、快速、持续减少温室气体排放是减缓全球变暖的最安全措施。
Deep, Rapid and Sustained Reductions are the Key to Climate Mitigation.

(IPCC AR6, 2021)

11

Serious consequences of global change

- **global warming**
- **sea level rise**
- **heat wave, heavy rains, drought, etc.**

蓝碳：实现碳中和的重要路径
Blue Carbon: A key path to carbon neutrality

- 蓝碳由联合国2009年提出，是**地球碳汇的主体，通过蓝碳减少大气中的二氧化碳将是应对全球气候变化的最有效对策之一。**
  - Blue carbon was introduced by the UN in 2009 as a principal component of the Earth's carbon sinks. Utilising blue carbon to reduce atmospheric carbon dioxide is considered one of the most effective strategies for combating global climate change.
- **三大滨海蓝碳生态系统：红树林、海草床、滨海盐沼地。**
  - Three key coastal blue carbon ecosystems: mangroves, seagrass, and salt marshes.
- **蓝碳特点**：固碳量大、效率高、储存时间长等。
  - Key features of blue carbon: high sequestration capacity, high efficiency, and long-term storage.
- 海洋经济与蓝碳：**充满希望的蓝碳新经济**
  - Ocean Economy and Blue Carbon: A Promising Blue Carbon Economy
- 蓝碳核算与交易：**蓬勃发展新方向**
  - Blue Carbon Accounting and Trading: A Rapidly Emerging Direction
- **蓝碳是被严重低估的固碳实力派**
  - Blue Carbon Accounting and Markets: A Promising Pathway for Climate and Finance
  《自然•地球科学》Nat Geosci最新研究发现海洋碳汇被严重低估(Ford et al., 2024)。
  - Nature Geoscience (2024): Ocean Carbon Sinks Severely Underestimated.

红树林、盐沼、海草床和大型海藻是四大海岸带蓝碳，在缓解全球气候变化方面发挥重要作用！

主要内容 Outline

◆气候变化及其后果

Climate change and consequences

◆蓝碳与气候变化减缓

Blue carbon and climate change mitigation

◆红树林蓝碳在应对气候变化中的作用

Mangrove blue C for mitigating climate change

Coastal blue carbon refers to the carbon stored in the vegetation and soils of salt marshes (left), like this one at Assateague Island on the Maryland-Virginia shore; seagrass meadows (center), like this one in Tonga, in the South Pacific; and mangrove forests (right), like this one in Queensland, Australia. Photo by (left to right) Zach Frailey, Steven Lutz/GRID-Arendal, and David Unger. Used under a Creative Commons license.

蓝碳生态系统
（滨海蓝碳生态系统）

BC Ecosystems
(BCEs)
or
Coastal BC Ecosystems
(CBCEs)

What is blue carbon?

Blue Carbon: organic carbon that is captured and stored by the oceans and coastal ecosystems, particularly by seagrass meadows, tidal marshes, mangroves & kelps

2009年联合国环境署、粮农组织和教科文组织政府间海洋学委会共同发布《蓝碳》、《滨海自然碳汇管理》等报告

为何蓝碳这么重要?
Why Blue Carbon So Import?

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2nd International Symposium: Effects of Climate Change on the World's Oceans
Monday, May 14 - W3
Workshop 3 (W3)
Coastal Blue Carbon: Mitigation opportunities and vulnerability to change
Co-Convenors:
Ik Kyo Chung (PNU, Korea)
Gabriel Grimsditch (UNEP)
Jerker Tamelander (UNEP)
Effects of Climate Change on the World's Oceans
Coastal Blue Carbon:
BLUE CARBON


Blue carbon: Science developments of relevance to the UNFCCC
Blue carbon is the carbon stored in coastal and marine ecosystems. Mangroves, tidal marshes and seagrasses sequester and store large quantities of blue carbon in both the plants and the sediment below. For example, over 95% of the carbon in seagrass meadows is stored in the soils.
These coastal blue carbon ecosystems are found on every continent except Antarctica. Mangroves, tidal marshes and seagrasses cover between 13.8 and 15.2 million hectares (Mha), 2.2 and 40 Mha, and 17.7 and 60 Mha, respectively. Combined, these ecosystems cover approximately 49 Mha.
Despite the proven importance for ocean health and human wellbeing, mangroves are being lost at a rate of 2% per year. Experts estimate that carbon emissions from mangrove deforestation account for up to 10% of emissions from deforestation globally, despite accounting for just 0.7% of land coverage.
◆ IPCC（2019）发布的《气候变化中的海洋与冰冻圈特别报告》指出“易于管理的海洋系统所有生物驱动碳通量及存量可以被认为是蓝碳”，并指出“易于管理”是界定蓝碳的必要条件；
◆ 特别指出：红树林、盐沼、海草床和大型海藻是四大海岸带蓝碳，在缓解全球气候变化方面发挥重要作用。
Mangroves
Salt marshes
Seagrass beds
Kelp forests
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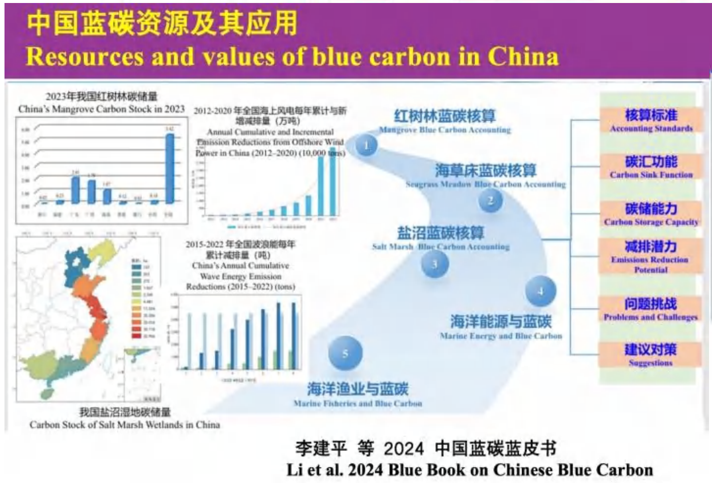
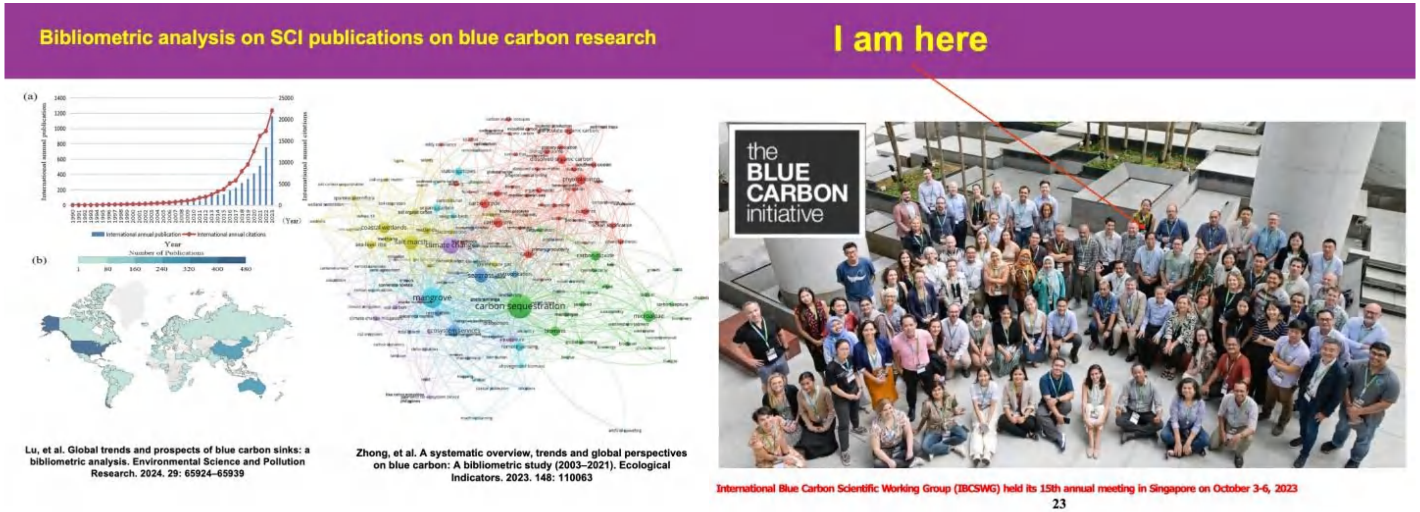
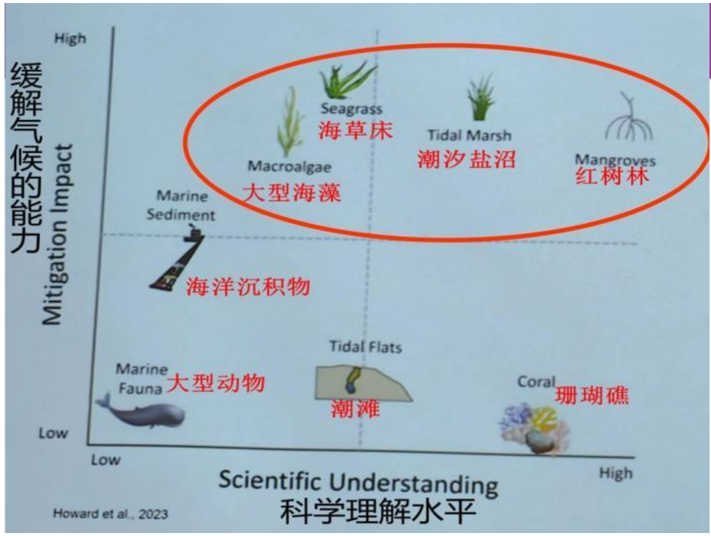
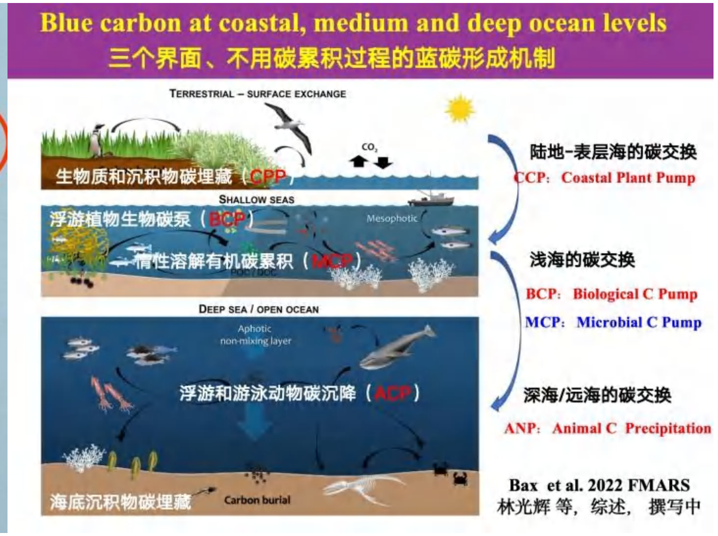

中国蓝碳资源及其应用
Resources and values of blue carbon in China
2023年我国红树林碳储量
China's Mangrove Carbon Stock in 2023
2012-2020 年全国海上风电每年累计与新增减排量（万吨）
Annual Cumulative and Incremental Emission Reductions from Offshore Wind Power in China (2012-2020) (10,000 tons)
2015-2022 年全国波浪能每年累计减排量（吨）
China's Annual Cumulative Wave Energy Emission Reductions (2015-2022) (tons)
我国盐沼湿地碳储量
Carbon Stock of Salt Marsh Wetlands in China
红树林蓝碳核算
Mangrove Blue Carbon Accounting
海草床蓝碳核算
Seagrass Meadow Blue Carbon Accounting
盐沼蓝碳核算
Salt Marsh Blue Carbon Accounting
海洋能源与蓝碳
Marine Energy and Blue Carbon
海洋渔业与蓝碳
Marine Fisheries and Blue Carbon
核算标准
Accounting Standards
碳汇功能
Carbon Sink Function
碳储能力
Carbon Storage Capacity
减排潜力
Emissions Reduction Potential
问题挑战
Problems and Challenges
建议对策
Suggestions
李建平 等 2024 中国蓝碳蓝皮书
Li et al. 2024 Blue Book on Chinese Blue Carbon


2024: New era of blue carbon research
OXFORD
所有受潮汐影响的湿地都是蓝碳生态系统
All tidal wetlands are blue carbon ecosystems
本期好文推送为您精选了发表在BioScience上的一篇文章。澳大利亚昆士兰格里菲斯大学河流研究所的Maria Fernanda Adame及其团队指出，蓝碳项目在全球范围内呈指数级增长，但对碳信用的需求远远超过了供给。目前大多数蓝碳项目都在红树林中进行。然而，许多潮汐湿地具有的特征与蓝碳定义高度一致，尚待充分利用和有效管理。因此，作者建议所有直接或间接受潮汐和恢复潮汐湿地，可以减少碳排放。
Blue Carbon (BC)
Blue Carbon (BC)
Blue Carbon (BC)
Global Change Biology
WILEY
OPINION
It's time to broaden what we consider a 'blue carbon ecosystem'
是时候拓展所谓的“蓝碳生态系统”了！
Kelly James | Peter I. Macreadie | Heidi L. Burdett | Ian Davies | Nicholas A. Kamenos
本期好文推送为您精选了发表在Global Change Biology上的一篇文章，作者提供了一个通用框架，可以评估一个特定的生态系统在特定情况下作为蓝色碳汇的可能性。总体而言，本文旨在鼓励在国家统计局战略中考虑非经典的蓝碳生态系统，从而实现更完整的蓝碳核算。希望能够为您提供新的思路和参考，欢迎阅读和转发。


Bibliometric analysis on SCI publications on blue carbon research
I am here
Lu, et al. Global trends and prospects of blue carbon sinks: a bibliometric analysis. Environmental Science and Pollution Research. 2024. 29: 65924–65939
Zhong, et al. A systematic overview, trends and global perspectives on blue carbon: A bibliometric study (2003–2021). Ecological Indicators. 2023. 148: 110063
the BLUE CARBON initiative
International Blue Carbon Scientific Working Group (IBCSWG) held its 15th annual meeting in Singapore on October 3-6, 2023
23

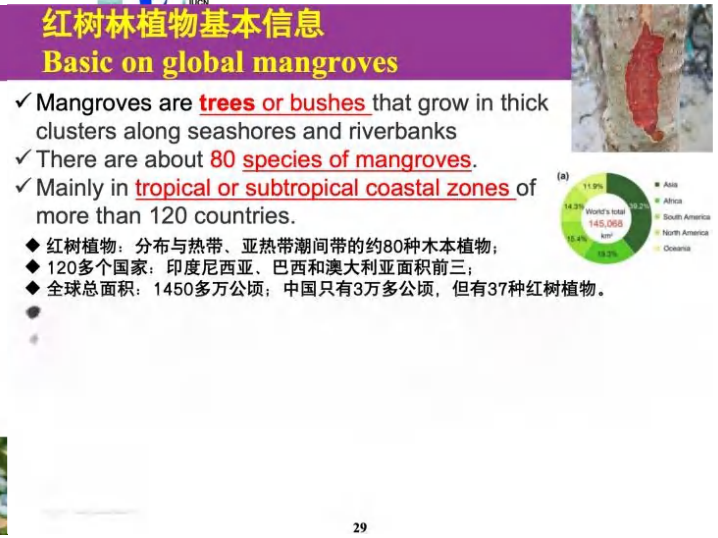

High
缓解气候的能力
Mitigation Impact
Seagrass
海草床
Tidal Marsh
潮汐盐沼
Macroalgae
大型海藻
Mangroves
红树林
Marine Sediment
海洋沉积物
Tidal Flats
Marine Fauna
大型动物
潮滩
Coral
珊瑚礁
Low
Low
High
Scientific Understanding
科学理解水平
Howard et al., 2023

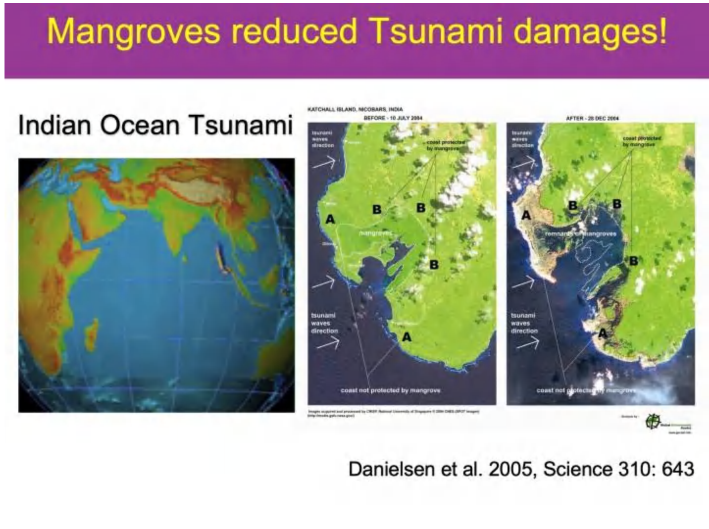

Blue carbon at coastal, medium and deep ocean levels
三个界面、不用碳累积过程的蓝碳形成机制
TERRESTRIAL – SURFACE EXCHANGE
生物质和沉积物碳埋藏（CPP）
SHALLOW SEAS
浮游植物生物碳泵（BCP）
惰性溶解有机碳累积（MCP）
Mesophotic
DEEP SEA / OPEN OCEAN
Aphotic non-mixing layer
浮游和游泳动物碳沉降（ACP）
海底沉积物碳埋藏
Carbon burial
陆地-表层海的碳交换
CCP: Coastal Plant Pump
浅海的碳交换
BCP: Biological C Pump
MCP: Microbial C Pump
深海/远海的碳交换
ANP: Animal C Precipitation
Bax et al. 2022 FMARS
林光辉 等，综述， 撰写中


常用的蓝碳标准、方法学和指南
Common standards, methodologies and guidance
Verified Carbon Standard
A VERRA STANDARD
PLAN VIVO
For nature, climate and communities
Gold Standard
for the Global Goals
ipcc
COASTAL BLUE CARBON


International standards and methodology for BC
联合国批准的红树林CDM碳汇计量方法：
AR0014:退化的红树林生境上造林、恢复方法
Danone Fund for Nature (DFN)
Expert Workshop
November 2009
Achieving Carbon Offsets through Mangroves and Other Wetlands
Meeting Report
Guanghui Lin as the only co-author from China
AR-AM0014 Afforestation and reforestation of degraded mangrove habitats
红树林
潮汐盐沼
海草床
UNFCCC (CDM AM0014) +VCS
VCS
VM0033
VCS

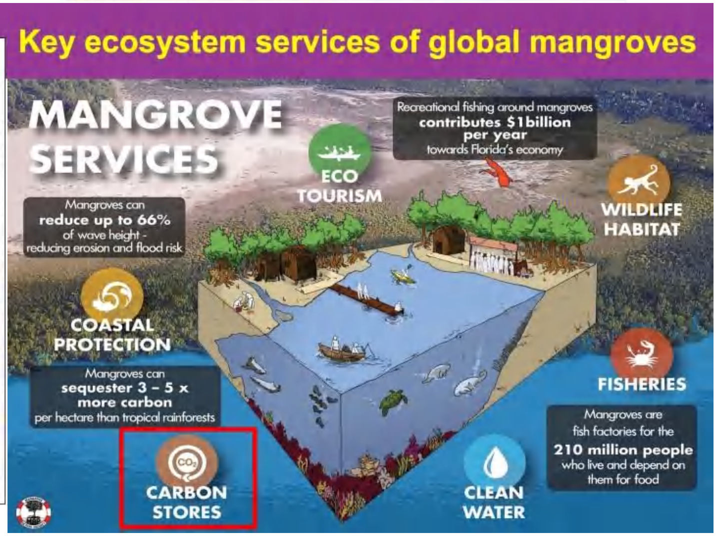

主要内容 Outline
◆气候变化及其后果
Climate change and consequences
◆蓝碳与气候变化减缓
Blue carbon and climate change mitigation
◆红树林蓝碳在应对气候变化中的作用
Mangrove blue C for mitigating climate change


红树林植物基本信息
Basic on global mangroves
✓Mangroves are trees or bushes that grow in thick clusters along seashores and riverbanks
✓There are about 80 species of mangroves.
✓Mainly in tropical or subtropical coastal zones of more than 120 countries.
World's total 145,068 km²
Asia
Africa
South America
North America
Oceania
◆ 红树植物：分布与热带、亚热带潮间带的约80种木本植物；
◆ 120多个国家：印度尼西亚、巴西和澳大利亚面积前三；
◆ 全球总面积：1450多万公顷；中国只有3万多公顷，但有37种红树植物。
29

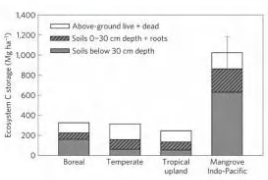

Mangroves reduced Tsunami damages!
Indian Ocean Tsunami
Danielsen et al. 2005, Science 310: 643

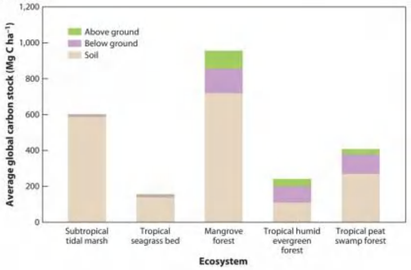

Mangrove forests can protect the coasts!
The 2004 tsunami broken a long boat jetty in to pieces, while mangroves intact without damage in Parangipettai, south east India


Disasters raise attentions!
Source: The Star newspaper, Malaysia
Save mangroves to fight tsunamis
GLOBAL TRENDS
Mangroves can protect coasts
Tsunami Aftermath
Natural barriers against tsunamis


Key ecosystem services of global mangroves
MANGROVE SERVICES
ECO TOURISM
Recreational fishing around mangroves contributes $1billion per year towards Florida's economy
WILDLIFE HABITAT
Mangroves can reduce up to 66% of wave height - reducing erosion and flood risk
COASTAL PROTECTION
Mangroves can sequester 3 – 5 x more carbon per hectare than tropical rainforests
FISHERIES
Mangroves are fish factories for the 210 million people who live and depend on them for food
CARBON STORES
CLEAN WATER

Mangrove forest is one of the best blue carbon ecosystems





Example: Indus Delta Blue Carbon Project

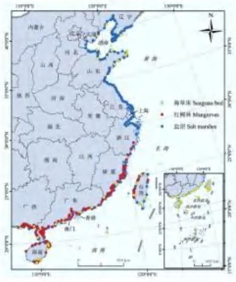
Indus Delta BC Project

- Restoration of 224,997 ha of mangroves
  75,000 ha already planted
- 60 year long project: 2015 - 2075
- Approximately 1 BILLION mangroves planted over 12 years
- Estimated 140 million t CO_2e removals over 60 years
- Applied Landsat, SRTM, field survey and calibration.

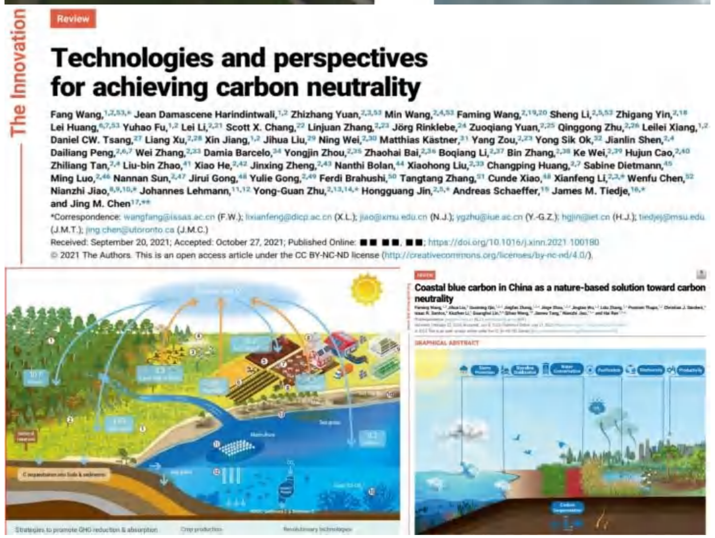
Mangrove forests as the most important coastal wetlands of SE China

■ Coastal wetlands in China

The total area of BCEs in China is about 5,000 km², including mangroves, tidal saltmarshes, and seagrass beds. They are habitats for rare and endangered species, maintaining extremely high biodiversity and a wide range of ecosystem services.



Chen et al., 2021



Review

The Innovation

Technologies and perspectives for achieving carbon neutrality

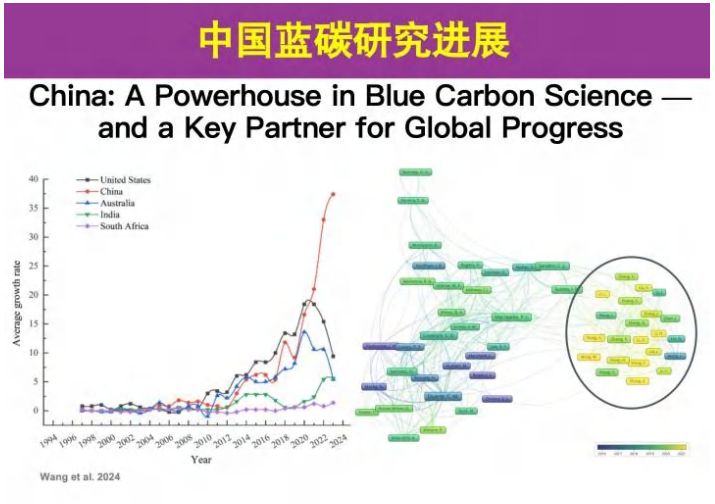
Fang Wang,[1,2,53,*] Jean Damascene Harindintwali,[1,2] Zhizhang Yuan,[2,3,53] Min Wang,[2,4,53] Faming Wang,[2,19,20] Sheng Li,[2,5,53] Zhigang Yin,[2,18] Lei Huang,[6,7,53] Yuhao Fu,[1,2] Lei Li,[2,21] Scott X. Chang,[22] Linjuan Zhang,[2,23] Jörg Rinklebe,[24] Zuoqiang Yuan,[2,25] Qinggong Zhu,[2,26] Leilei Xiang,[1,2] Daniel CW. Tsang,[27] Liang Xu,[2,28] Xin Jiang,[1,2] Jihua Liu,[29] Ning Wei,[2,30] Matthias Kästner,[31] Yang Zou,[2,23] Yong Sik Ok,[32] Jianlin Shen,[2,4] Dailiang Peng,[2,6,7] Wei Zhang,[2,33] Damia Barcelo,[34] Yongjin Zhou,[2,35] Zhaohai Bai,[2,36] Boqiang Li,[2,37] Bin Zhang,[2,38] Ke Wei,[2,39] Hujun Cao,[2,40] Zhiliang Tan,[2,4] Liu-bin Zhao,[41] Xiao He,[2,42] Jinxing Zheng,[2,43] Nanthi Bolan,[44] Xiaohong Liu,[2,33] Changping Huang,[2,7] Sabine Dietmann,[45] Ming Luo,[2,46] Nannan Sun,[2,47] Jirui Gong,[48] Yulie Gong,[2,49] Ferdi Brahushi,[50] Tangtang Zhang,[51] Cunde Xiao,[48] Xianfeng Li,[2,3,*] Wenfu Chen,[52] Nianzhi Jiao,[8,9,10,*] Johannes Lehmann,[11,12] Yong-Guan Zhu,[2,13,14,*] Hongguang Jin,[2,5,*] Andreas Schaeffer,[15] James M. Tiedje,[16,*] and Jing M. Chen[17,**]

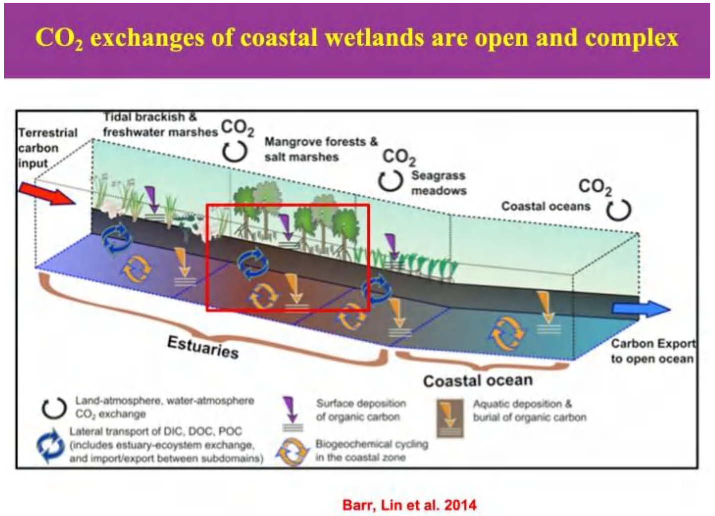
*Correspondence: wangfang@issas.ac.cn (F.W.); lixianfeng@dicp.ac.cn (X.L.); jiao@xmu.edu.cn (N.J.); ygzhu@iue.ac.cn (Y.-G.Z.); hgjin@iet.cn (H.J.); tiedjej@msu.edu (J.M.T.); jing.chen@utoronto.ca (J.M.C.)

Received: September 20, 2021; Accepted: October 27, 2021; Published Online: ■■ ■■, ■■; https://doi.org/10.1016/j.xinn.2021.100180

Coastal blue carbon in China as a nature-based solution toward carbon neutrality

GRAPHICAL ABSTRACT


中国蓝碳研究进展
China: A Powerhouse in Blue Carbon Science — and a Key Partner for Global Progress
United States
China
Australia
India
South Africa
Average growth rate
Year
Wang et al. 2024


CO₂ exchanges of coastal wetlands are open and complex
Terrestrial carbon input
Tidal brackish & freshwater marshes
CO2
Mangrove forests & salt marshes
Seagrass meadows
Coastal oceans
Estuaries
Coastal ocean
Carbon Export to open ocean
Land-atmosphere, water-atmosphere CO2 exchange
Lateral transport of DIC, DOC, POC (includes estuary-ecosystem exchange, and import/export between subdomains)
Surface deposition of organic carbon
Biogeochemical cycling in the coastal zone
Aquatic deposition & burial of organic carbon
Barr, Lin et al. 2014

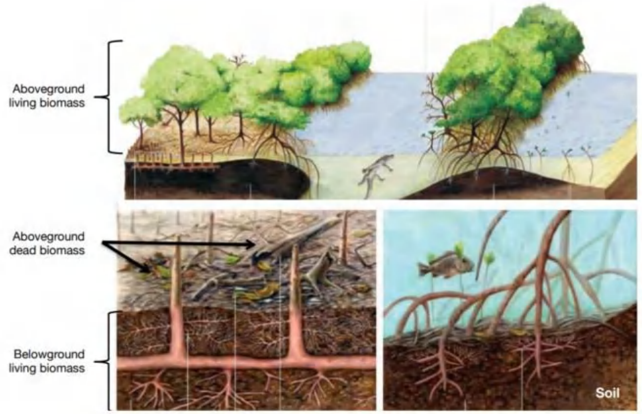

Field surveys of mangrove community structures and carbon pools
Fujian
Guangxi
Guangdong
Hainan
广东湛江
广东雷州
福建云霄
海南东寨港
海南文昌
◆164 plots (2009-2016)
◆52 soil profiles
◆>300 literatures


COASTAL BLUE CARBON
methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows
the BLUE CARBON initiative
46
IUCN

How to select sites and measure carbon stocks?

Figure 4.1 Classification of mangroves. (A) Oceanic fringing mangroves (© Enrico Marone, CI), (B) Riverine or estuarine mangroves (© Ginny Farmer, CI), (C) Basin mangroves (© Colin Foster, CI), and (D) Dwarf or scrub mangroves (© Catherine Lovelock, UQ)

How to select sites and measure carbon stocks?



How to select sites and measure carbon stocks?

50

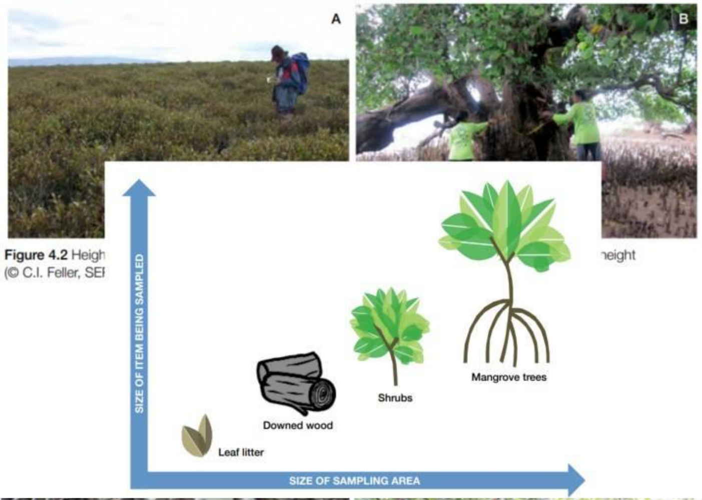


Figure 4.2 Heigh ... eight
(© C.I. Feller, SE

Figure 4.10 Pneumatophores. (A) Measuring pneumatophore height, (B) Pneumatophores can be measured n or next to microplots. These microplots can be the same plots used to sample litter (described below). (© Boone Kauffman, OSU)

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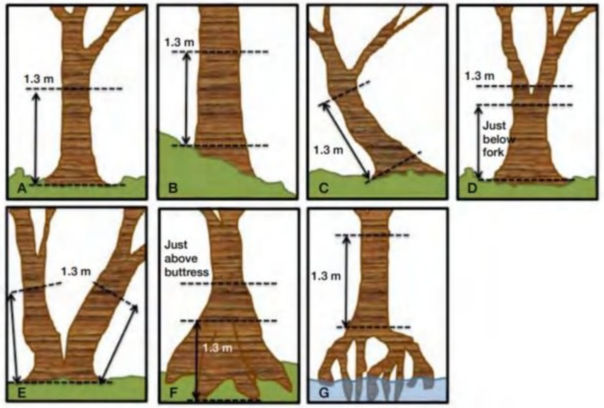
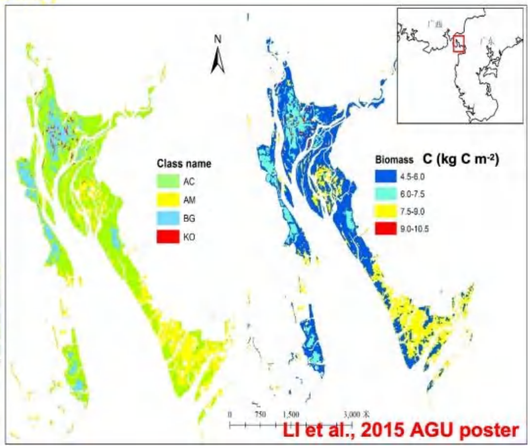
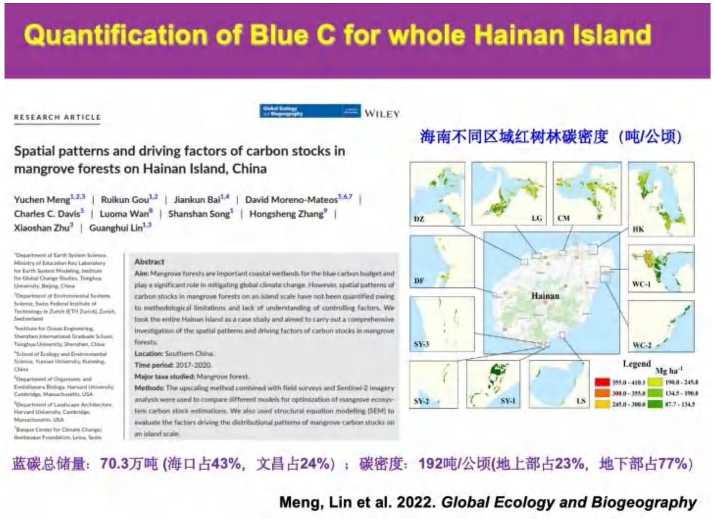


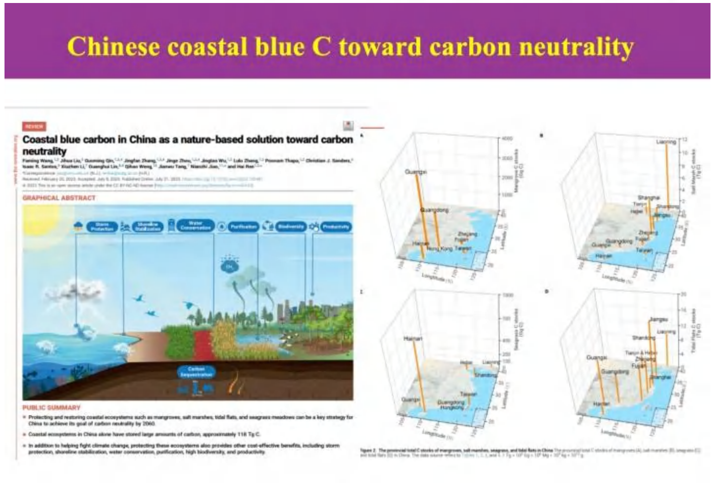
Figure 4.4 Estimating diameter at breast height for irregular mangrove trees (modified from Pearson, *et al.* 2005)

52

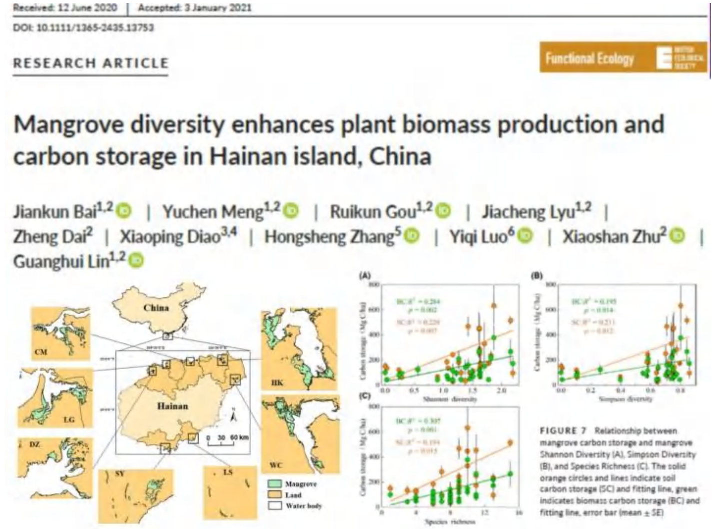
Classification of mangrove vegetation distribution and estimation of biomass C by remote sensing







57



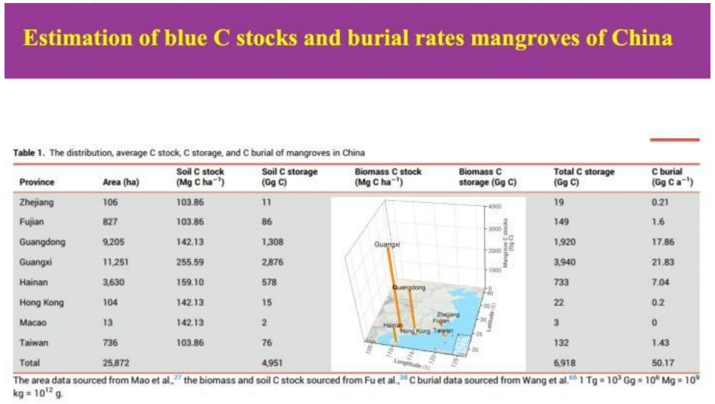


Table 1. The distribution, average C stock, C storage, and C burial of mangroves in China

Province	Area (ha)	Soil C stock ($Mg\ C\ ha^{-1}$)	Soil C storage (Gg C)	Biomass C stock ($Mg\ C\ ha^{-1}$)	Biomass C storage (Gg C)	Total C storage (Gg C)	C burial ($Gg\ C\ a^{-1}$)
Zhejiang	106	103.86	11			19	0.21
Fujian	827	103.86	86			149	1.6
Guangdong	9,205	142.13	1,308			1,920	17.86
Guangxi	11,251	255.59	2,876			3,940	21.83
Hainan	3,630	159.10	578			733	7.04
Hong Kong	104	142.13	15			22	0.2
Macao	13	142.13	2			3	0
Taiwan	736	103.86	76			132	1.43
Total	25,872		4,951			6,918	50.17

The area data sourced from Mao et al.,[27] the biomass and soil C stock sourced from Fu et al.,[38] C burial data sourced from Wang et al.[65] 1 Tg = 10^3 Gg = 10^6 Mg = 10^9 kg = 10^{12} g.

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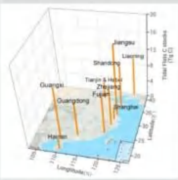
Carbon stocks and burial rate of tidal flats in China

Table 4. The distribution, average C stock, C storage, and C burial of tidal flats in China

Provinces	Area (ha) Low	Area (ha) High	C stock (Mg C ha^{-1})	Total SOC storage (Tg C) Low	Total SOC storage (Tg C) High	C burial rate (g C m^{-2} year^{-1})	Soil C burial amount (Gg C year^{-1}) Low	Soil C burial amount (Gg C year^{-1}) High
Liaoning	0.54	133,100	69.9	0.00	9.30	107.45	0.00	143
Tianjin and Hebei	8,305	73,200	53.6	0.45	3.92	146.02	12	107
Shandong	34,208			2.81	10.15	192.95	66	239
Jiangsu	6,277			0.37	17.31	153.84	10	448
Shanghai	10,981			0.81	2.79	91.51	10	35
Zhejiang	21,740			1.48	9.02	153.84	33	204
Fujian	28,285			2.14	9.26	139.38	39	170
Guangdong	34,807			2.61	8.15	74.55	26	81
Guangxi	69,732			14.43	12.38	74.55	52	45
Hainan	5,031			0.63	2.48	136.63	7	27
Taiwan	18,075			1.37	–	139.38	25	–
Hongkong	2			0.00	–	74.55	0	–
Macao	7			0.00	–	74.55	0	–
Total	237,450	1,102,400		27.1	84.8		280	1,499



The area data sourced from Mao et al.[77] and the global tidal flat map,[57,59] the soil C stock sourced from Chen et al.,[59] C burial data sourced from Chen et al.[59] 1 Tg = 10^3 Gg = 10^6 Mg = 10^9 kg = 10^{12} g.

各地无植被滩涂（潮滩、光滩）具有高得多的碳库和碳埋速率!

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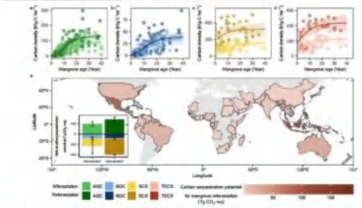
nature communications

Our new paper

Article

Mangrove reforestation provides greater blue carbon benefit than afforestation for mitigating global climate change



Song, Lin* et al. 2023 *Nature Communications*

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Ecological connectivity increases Coastal BC

Contents lists available at ScienceDirect

ELSEVIER

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

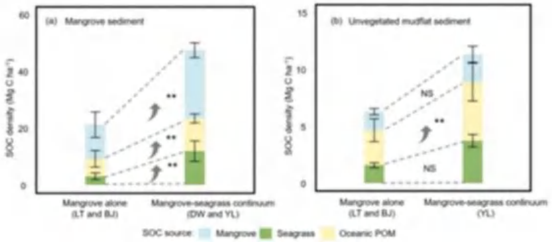
生态连通性提高了滨海蓝碳!

Ecological connectivity between mangroves and seagrasses increases sediment blue carbon storage

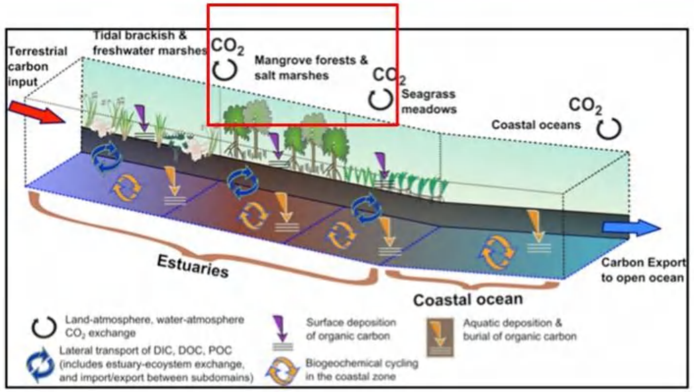
Xinao Guo, Shanshan Song, Lieyi Chen, Conghe Zhang, Shengbin Ye, Yali Ding, Ruikun Gou, Xiaoping Huang, Shuguo Lv, Neil Saintilan, Daniel A. Friess, Guanghui Lin

Applications of stable isotopes to trace BC origin

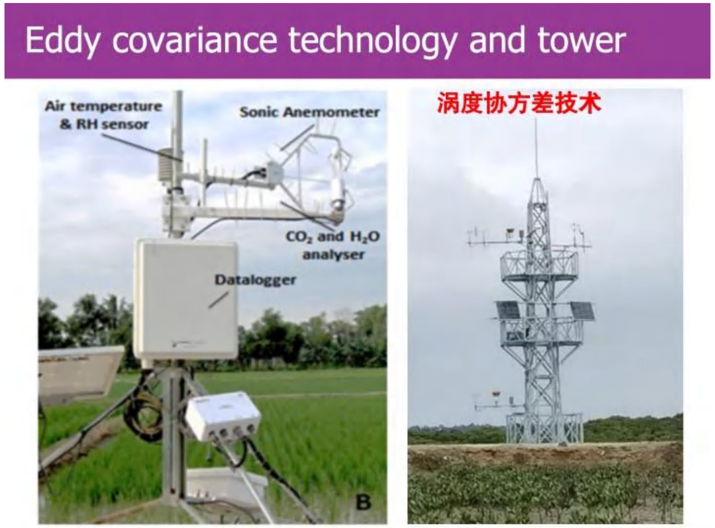
利用稳定同位素技术区分蓝碳来源

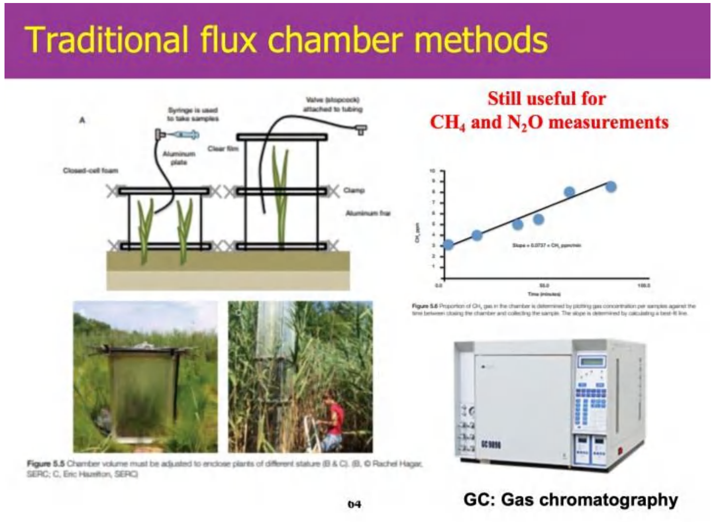


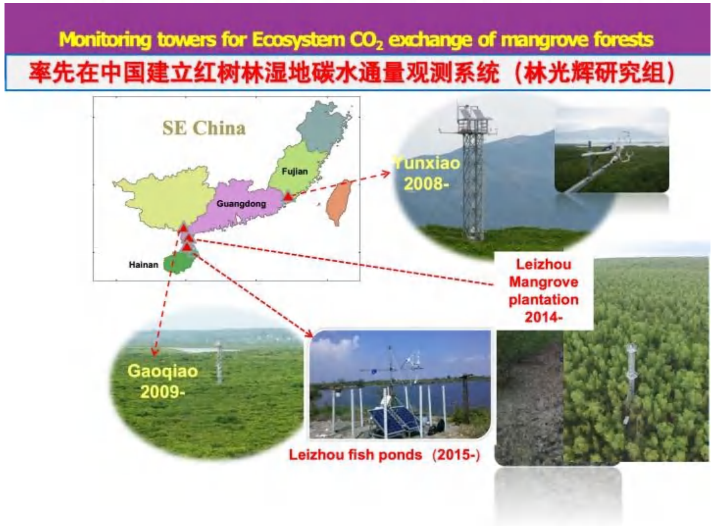
CO_2 exchanges of coastal wetlands are open and complex

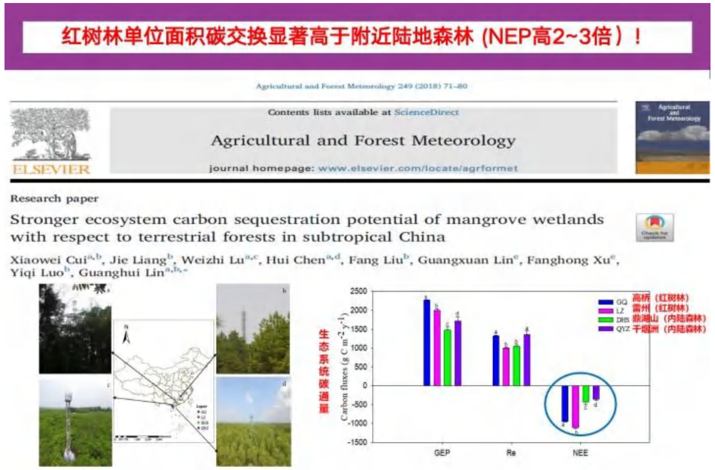


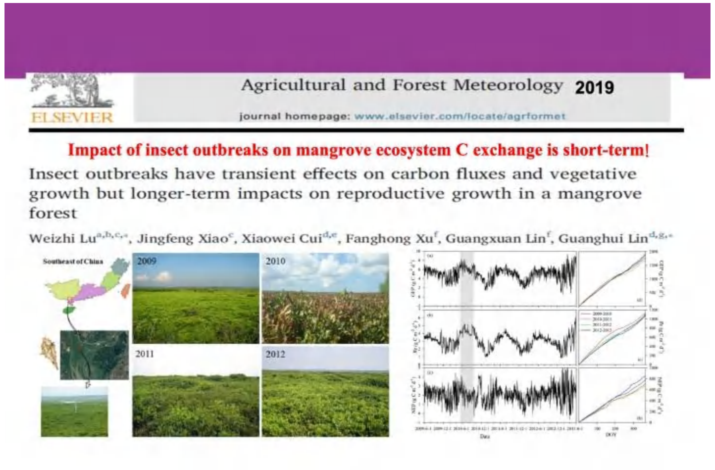
Barr, Lin et al. 2014

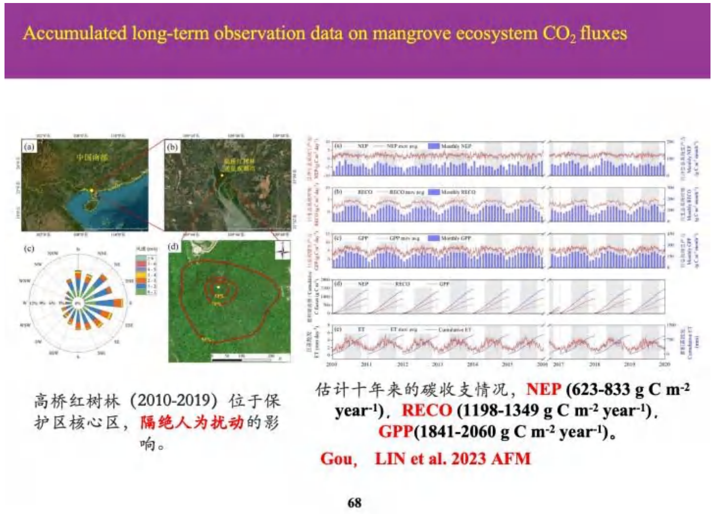

Eddy covariance technology and tower
Air temperature & RH sensor
Sonic Anemometer
CO_2 and H_2O analyser
Datalogger
B
涡度协方差技术


Traditional flux chamber methods
Still useful for
CH_4 and N_2O measurements
GC: Gas chromatography


Monitoring towers for Ecosystem CO_2 exchange of mangrove forests
率先在中国建立红树林湿地碳水通量观测系统（林光辉研究组）
SE China
Fujian
Guangdong
Hainan
Yunxiao
2008-
Leizhou
Mangrove
plantation
2014-
Gaoqiao
2009-
Leizhou fish ponds（2015-）


红树林单位面积碳交换显著高于附近陆地森林 (NEP高2~3倍）！
Agricultural and Forest Meteorology 249 (2018) 71–80
Contents lists available at ScienceDirect
Agricultural and Forest Meteorology
journal homepage: www.elsevier.com/locate/agrformet
ELSEVIER
Research paper
Stronger ecosystem carbon sequestration potential of mangrove wetlands with respect to terrestrial forests in subtropical China
Xiaowei Cui, Jie Liang, Weizhi Lu, Hui Chen, Fang Liu, Guangxuan Lin, Fanghong Xu, Yiqi Luo, Guanghui Lin
生态系统碳通量
高桥（红树林）
雷州（红树林）
鼎湖山（内陆森林）
千烟洲（内陆森林）
GEP
Re
NEE


ELSEVIER
Agricultural and Forest Meteorology 2019
journal homepage: www.elsevier.com/locate/agrformet
Impact of insect outbreaks on mangrove ecosystem C exchange is short-term!
Insect outbreaks have transient effects on carbon fluxes and vegetative growth but longer-term impacts on reproductive growth in a mangrove forest
Weizhi Lu, Jingfeng Xiao, Xiaowei Cui, Fanghong Xu, Guangxuan Lin, Guanghui Lin
Southeast of China
2009
2010
2011
2012


Accumulated long-term observation data on mangrove ecosystem CO2 fluxes
(a)
(b)
(c)
(d)
高桥红树林（2010-2019）位于保护区核心区，隔绝人为扰动的影响。
估计十年来的碳收支情况，NEP (623-833 g C m-2 year-1)，RECO (1198-1349 g C m-2 year-1)，GPP(1841-2060 g C m-2 year-1)。
Gou， LIN et al. 2023 AFM
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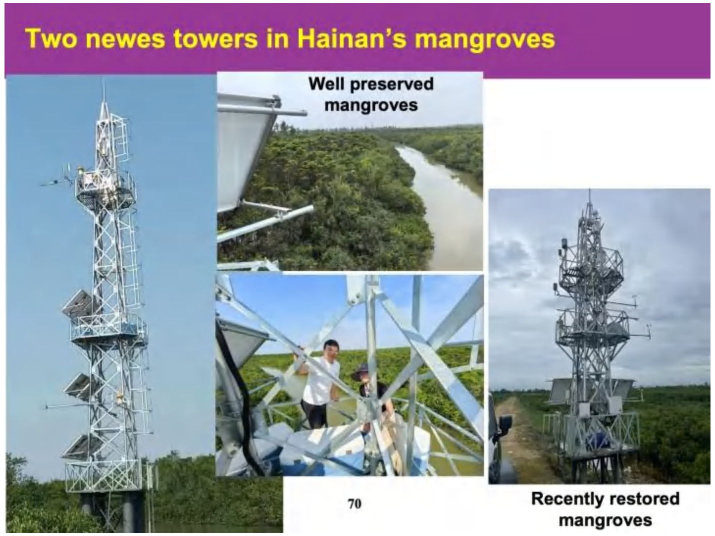
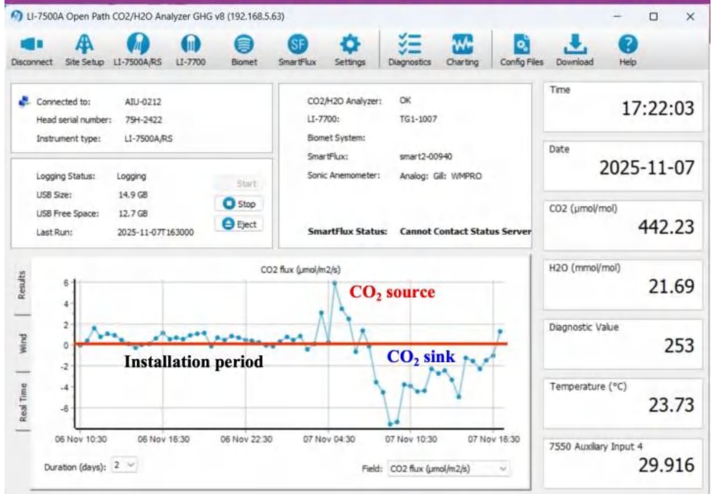
New four Eddy flux towers in Hainan's mangroves
Xinying National Wetland Park in Danzhou
Comparison between the restored and pristine mangrove forests
Established in 2022 for CO2, CH4 and H2O fluxes
Dongzhaigang National Mangrove Nature Reserve
Well protected and most recent restored forests
Build in 2025
Mangrove Carbon Flux Observation System built by Hainan International Blue Carbon Research Center


Two newes towers in Hainan's mangroves
Well preserved mangroves
Recently restored mangroves
70

The newest mangrove flux tower (Putian, Fujian)

71

New data from Putian Mangrove Eddy Flux Tower 莆田红树林通量塔的最新数据



Launch of a new consortium: CBCC

Mission of CBCC:

- ✓ Standardize the methods and Share the data
- ✓ Publish influential papers and Train new scientists
- ✓ Serve the needs of whole country and local communities

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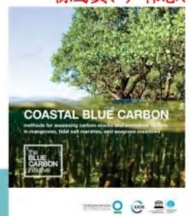
Methodology development for coastal blue carbon

陈鹭真、卢伟志、林光辉（主译, 2019)



Translated by Lin's group

Trading Blue Carbon using CDM and CCB mechanisms

- 1st BC project in China
- Mangrove afforestation project in Zhanjiang, Guangdong
- CDM (AM-AR0014)
- June 2021, Verra

“广东湛江红树林造林项目”是中国首个符合核证碳标准(VCS)和气候社区生物多样性标准(CCB)的红树林碳汇项目。该项目由自然资源部第三海洋研究所组织并与广东湛江红树林国家级自然保护区管理局合作开发完成。

"Guangdong Zhanjiang Mangrove Afforestation Project" is the first mangrove blue carbon project in China that meets the Verified Carbon Standard (VCS) and the Climate Community Biodiversity Standard (CCB). This project was organized and completed in collaboration with the Guangdong Zhanjiang Mangrove National Nature Reserve Administration by the Third Institute of Oceanography

Trading Mangrove Blue Carbon using Chinese methodology

- Mangrove restoration project in Fujian
- 1st BC METHODLOGY in CHINA
(Developed by Prof. Luzhen Chen et al.)
- Traded on 12 Sept, 2021

2021年9月12日，福建省红树林生态修复项目2000吨海洋碳汇在厦门产权交易中心海洋碳汇交易平台顺利成交，这是福建首宗海洋碳汇交易。该宗交易实现了红树林碳汇功能与生物多样性保护的协同增效、红树林保护与周边社区生态建设协同发展的两大目标

On Sept.12, 2021, the 20,000-tCO_2 of the mangrove restoration project in Fujian Province was successfully traded on Xiamen Property Rights Exchange Center. This is the first blue carbon trade in Fujian Province. The transaction achieved the two major goals of synergistic effects of mangrove carbon sink function and biodiversity protection, and the ecological construction of mangrove protection and livelihood of surrounding communities.

Trading of Mangrove Blue Carbon in China

Restored mangrove forests in Sanjiang, Haikou becomes 1st Blue C trade Project in Hainan Province (2022)

More and more trades on mangrove Blue C!

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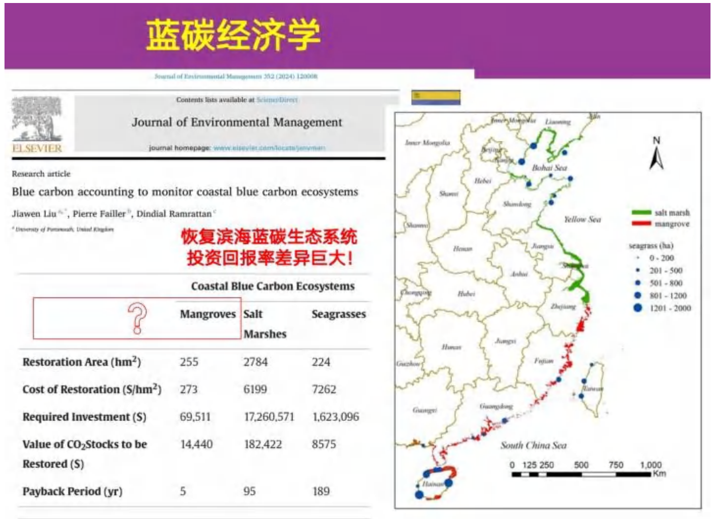
China Certified Emission Reductions (CCER)—Mangrove Afforestation Methodology

Methodology developed on CCER framework: Mangroves (October, 2023)

9 方法学编制单位

在本方法学编制工作中，自然资源部第三海洋研究所，以及北京市企业家环保基金会、大自然保护协会北京代表处、北京林业大学、厦门大学、海南省环境科学研究院、国家海洋信息中心，国家海洋环境监测中心等单位作出积极贡献。

The only one of blue carbon ecosystems is officially qualified for CCER!



蓝碳经济学
Journal of Environmental Management
Research article
Blue carbon accounting to monitor coastal blue carbon ecosystems
Jiawen Liu, Pierre Failler, Dindial Ramrattan
恢复滨海蓝碳生态系统
投资回报率差异巨大!
Coastal Blue Carbon Ecosystems
	Mangroves	Salt Marshes	Seagrasses
Restoration Area (hm²)	255	2784	224
Cost of Restoration ($/hm²)	273	6199	7262
Required Investment ($)	69,511	17,260,571	1,623,096
Value of CO₂Stocks to be Restored ($)	14,440	182,422	8575
Payback Period (yr)	5	95	189
Bohai Sea
Yellow Sea
South China Sea
salt marsh
mangrove
seagrass (ha)
0 - 200
201 - 500
501 - 800
801 - 1200
1201 - 2000
0 125 250 500 750 1,000 Km

重视蓝碳与蓝色经济的关联
Blue Carbon and Blue Economy
Journal of the Indian Ocean Region
A new narrative for the Blue Economy and Blue Carbon
Andrew D. L. Steven, Mathew A. Vanderklift & Narnia Bohler-Muller
Current blue carbon
Redefining blue carbon
Policy
Research
Finance
Aligning blue carbon with policy and eco-social-economics approach
Sheehy et al. 2024 STE
ARTICLES
https://doi.org/10.1038/s41558-021-01089-4
nature climate change
OPEN
The blue carbon wealth of nations
Christine Bertram, Martin Quaas, Thorsten B. H. Reusch, Athanasios T. Vafeidis, Claudia Wolff and Wilfried Rickels

Co-benefits of mangrove conservation and restoration as NbS
结论：红树林生态服务多样且价值巨高，大于8000亿万美元/年！
Blue carbon and biodiversity conservation
Coastal restoration and community sustainability
High-Quality Blue Carbon
UNFCCC
CBD
SDGs
RAMSAR
联合国
IUCN
WWF
等国际
组织的
评估：
ECOSYSTEM SERVICES
服务价值：3.3~5.7万美元/公顷/年！
The benefits people derive from mangroves
12亿多人居住在
红树林附近的海岸带！
碳储存能力
比附近森林高3~
Mangrove ecosystem services
Worth US$ 33,000-57,000 per hectare per year
x 14 million hectares
= up to US$ 800 billion per year
Livelihoods
120 million people living near mangroves
Wood
Climate regulation
Coastal protection
2~5公顷的红树林可以
净化1公顷鱼塘的养殖污水！
Water filtration
Fisheries
红树林生态系
支撑3000多种
对海岸带的保护比
防水海堤高5倍!
红树林带动2000
多种休闲旅游活动
作为基于自然解决方案的红树林保护与修复可以带来其
它协调价值，助力可持发展目标的实现！


Thank you for your attentions!
Let’s work together to protect
the global mangroves!

Annex 3.11: Conservation, Restoration and Carbon Potential of ARID Mangroves

CONSERVATION, RESTORATION AND CARBON POTENTIAL OF ARID MANGROVES

Mr. Kashif Khan Durrani.
Divisional Forest Office/ Deputy Provincial Project Director Upscaling of Green Pakistan Program.

MANGROVE SPECIES

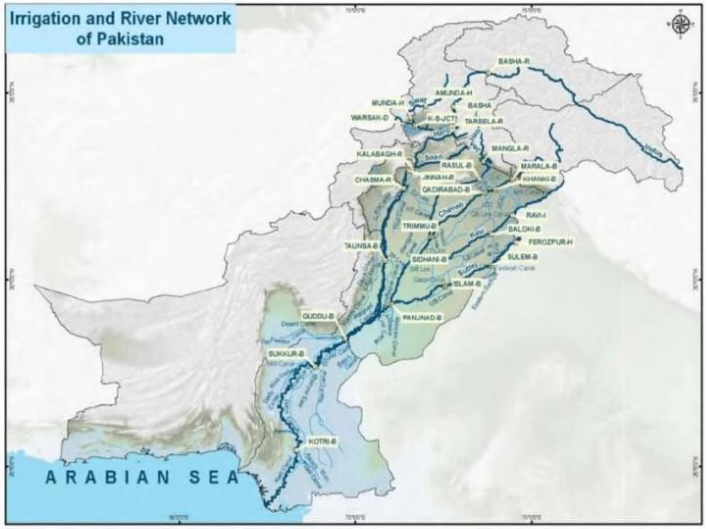
Avicennia marina (Teemer) — Rhizophora mucronata (Kumri)

Ceriops Tagal (Kirri) — Aegicerus corniculatum (Chaunr)

Fig. 9: Views of different mangrove species seen in the Indus Deltaic Region

INTRODUCTION THE ARID ZONE MANGROVE

- Arid zone mangroves are mangrove ecosystems found along coastal regions with low rainfall, high evaporation, and limited freshwater inflow. These environments occur in semi-arid to arid climates where conditions such as high salinity, extreme temperatures, and nutrient-poor soils restrict vegetation growth.
- The term "mangrove" refers to an assemblage of tropical trees and shrubs that grow in the inter-tidal zone, mangroves are halophytes: this means that they have evolved mechanisms for salt resistance.
- Having specialized root system called "Pneumatophores" and Vivapary germination capability .
- Pakistan possesses 24th largest block of Mangroves in the World and 8th largest block in Asia (FAO 2007)
- Early records show eight species of mangroves used to exist along the delta. Presently, only four are found i.e. Avicennia marina, Rhizophora mucronata, Aegiceras corniculatum and Ceriops tagal.



DISTRIBUTION OF MANGROVES ALONG SINDH COAST

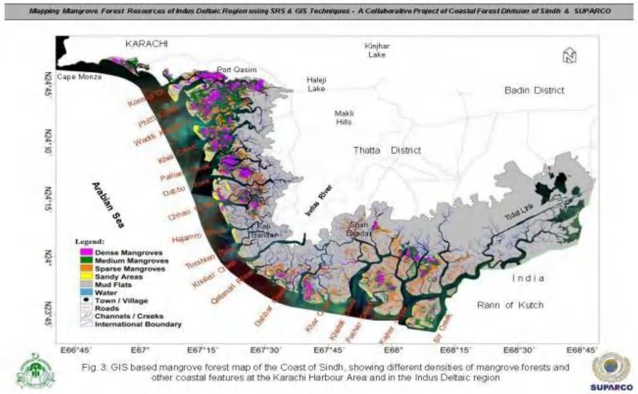


Fig. 3. GIS based mangrove forest map of the Coast of Sindh, showing different densities of mangrove forests and other coastal features at the Karachi Harbour Area and in the Indus Deltaic region

Economic Importance of Mangroves

- Important supplier of nutrient and oxygen
- Nurseries for many species of fish and shrimp
- Stabilize shorelines and reduce coastal erosion
- Protect coastal areas from storm damage, cyclones, etc.
- Renowned source of Ecotourism
- Mangroves are recognized as the most carbon-rich forests in the tropics. There sequestration rates are about two to four times greater than rates observed in mature tropical forests .
- **One Ha. of properly managed mangroves can annually yield:**
  - **100 kg of Fish; 25 kg of Shrimp and 15kg of Crab meat (FAO)**
  - **In Dollars terms:**
  Total Economic values of Mangrove habitat range from US$ 2772 per ha/year to US$ 80,334 per ha/year (Average US$ 28,662)



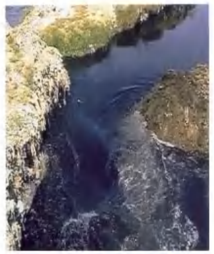
Threats to the mangroves

- Shortages of required freshwater and reduced silt deposition from the River Indus have increased salinity levels in the delta, leading to a higher rate of coastal erosion and sea intrusion into fertile inland areas.
- The cutting of mangroves for fuel and fodder, along with uncontrolled grazing, has further exacerbated the problem.
- Environmentalists recommend maintaining a minimum freshwater discharge of 10 MAF into the delta to ensure its sustainable management. Historically, this flow has declined drastically—from about 150 MAF(Million-Acre-feet) in the 1930s to less than 0.5 MAF in 2008 and 2017.



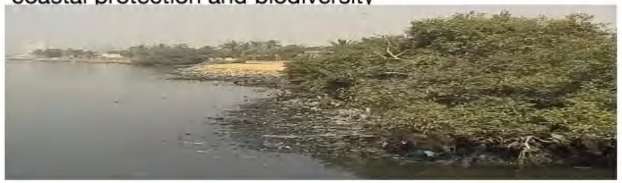
Threats to the mangroves

Approximately 500 MGD industrial and domestic wastewater is being generated, and discharged ..." in the coastal areas including Karachi-Gharo Creek, with "mangrove ecosystems ... facing continuous pressures ... and resultant degradation of water quality, habitat loss, localized eutrophication" being reported.(SCP)



Threats to the mangroves

Expansion of cities, industries, and infrastructure in the Indus Delta has led to large-scale land reclamation, putting pressure on the area's delicate ecosystem. Converting coastal wetlands and mangrove forests into residential or industrial zones disturbs tidal flow and accelerates shoreline erosion. Growing urban settlements also contribute to pollution and restrict the space available for the natural regeneration of mangroves, which are vital for coastal protection and biodiversity



Threats to Mangroves - Eutrophication

Eutrophication occurs when a water body becomes overloaded with nutrients such as nitrogen and phosphorus. These nutrients usually come from sources like fertilizer runoff, domestic wastewater, and aquaculture waste. The surplus nutrients encourage rapid growth of algae and microscopic plants (phytoplankton), which upsets the natural ecological balance of the aquatic system.

Land Reclamation-Near Mai Kolachi

Threats to the mangroves

Cutting for fuel-wood and fodder Dependency on mangroves by local communities as a source of cooking (18,000 tons/yr) and fodder (8,000 camels)

MANGROVE CONSERVATION

Conservation Practices

- **1. Legal Protection.**
- Most of the mangrove areas are declared as **protected forests** and **wildlife sanctuaries,** so that cutting or encroachment is not allowed.
- Forest Act (Law) and environmental laws help stop **logging, land grabbing, and pollution**.

Buffer zones are Mandatory to me made near the coasts, to protect mangroves from nearby human development and other hazardous activities.

- **2. Monitoring and Patrolling**
- **Forest Staff** and local watchers keep an eye on mangrove areas to stop illegal activities.
- **Satellite images and drones footages** are used to check forest condition and area changes.
- Regular surveys are carried out to assess tree health, wildlife populations, and carbon storage potential areas.

- **3. Community Involvement.**
- Local Community people work with the **Forest Officials** to protect and manage mangroves.
- **Awareness programs** need to be conducted in nearby villages, schools, universities, and among the officials of sister organizations to help people understand the importance of mangroves.
- **Alternative livelihood** activities such as controlled fishing, honey collection, and eco-tourism may be encouraged for local communities to discourage them from cutting mangroves.

- **5. Pollution and Land Use Control**
- Strict vigilance, in collaboration with sister departments, is required to prevent untreated **industrial and domestic waste** from entering mangrove areas and to ensure the healthy sustenance of mangroves and aquatic creeks.
- Improving water flow by **reopening of blocked creeks** is essential for enhancing the overall health and growth of mangroves. Restoring natural tidal exchange helps maintain proper salinity levels, nutrient circulation, and sediment balance, all of which are vital for the sustainable regeneration of mangrove ecosystems.

- **6. Research and Cooperation.**
- **Regular studies and surveys** are important for maintaining the sustainability of the mangrove ecosystem. Continuous monitoring helps track changes in mangrove health, species diversity, and regeneration, allowing timely action against issues like pollution, encroachment, and climate impacts
- **National and international organizations** should be engaged to provide technical and scientific support for mangrove conservation and management
- **Organizing training programs** to enhance the skills of forest staff and local communities for effective mangrove conservation and management

Restoration of Mangroves

PROCESS OF REHABILITATION

- Recruitment & Training of local labour force
- Propagule/Seed Collection from Delta & Its Storage
- Transportation of Propagules to the nursery & Planting sites
- Nursery raising near planting sites
- Field Planting in various soil types
- Watch & Ward – restocking & protection of planting sites from grazing & browsing
- Community engagement & incentivization
- Outcome of plant[illegible]fforts

COLLECTION & STORAGE OF SEED

TRANSPORTATION OF SEED / PROPAGULES

NURSERY RAISING

VARIOUS FIELD PLANTING TECHNIQUES

WATCH & WARD SYSTEM THROUGH LOCALS

OUTCOME OF PLANTING & PROTECTION ACTIVITIES BY SFD

REHABILITATION OF INDUS DELTA BY SFD AND STAKEHOLDERS

- *Rhizophora* *mucronata* was re-introduced in the Indus Delta in 1986

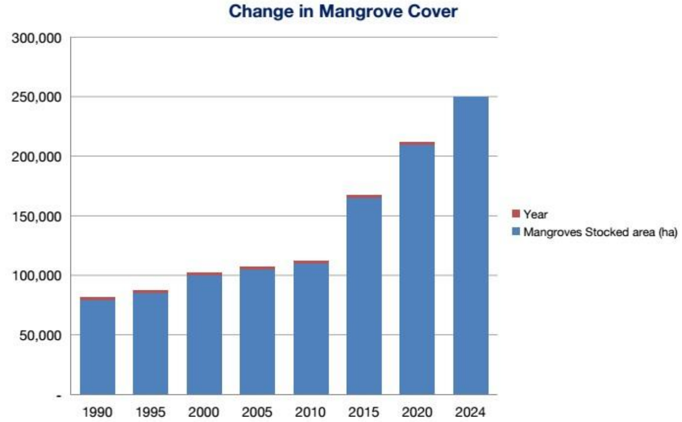
Rehabilitation of Indus Delta by SFD in Keti Bundar

REHABILITATION OF INDUS DELTA BY SFD & STAKEHOLDERS

REHABILITATION OF INDUS DELTA BY SFD & STAKEHOLDERS

Restored Mangrove Ecosystem

Change in Mangrove Cover in 25 Years



Restoration Documentry
(Hyperlink)

CARBON POTENTIAL OF ARID ZONE MANGROVE

Steps to Access Carbon Credits from Mangrove Forests

- **1. Project Identification & Feasibility**
- Select the mangrove site for **conservation, restoration, or new plantation.**
- Conduct a **technical feasibility study**:
  - Ecological condition of mangroves.
  - Potential for carbon storage and biodiversity benefits.
- Review **legal rights and ownership** of the land to ensure clarity on who can claim credits.
- Engage local communities early to secure cooperation and benefits sharing.

2. Baseline Assessment

- Establish the **"without-project" scenario** (degradation, deforestation, or continued pressure).
- Collect data on **existing carbon stoc**
  - **Aboveground biomass (AGB)** – trees, shrubs.
  - **Belowground biomass (BGB)** – roots.
  - **Soil organic carbon (SOC)** – the largest carbon pool in mangroves.
- This baseline acts as a **benchmark** to measure future gains.

3. Choose a Standard / Methodology

- Select an internationally accepted standard that ensures credibility in global markets:
  - **Verra VCS + CCB (Verified Carbon Standard + Climate, Community & Biodiversity)**
  - **Gold Standard**
- Apply a **methodology tailored to wetlands and mangroves** to quantify sequestration.
- Choosing the right standard increases **market trust** and **credit value**.

4. Project Design Document (PDD)

- Develop a **comprehensive blueprint** for the project.
- Key elements include:
  – Project goals and expected outcomes.
  – Methods for carbon measurement and monitoring.
  – Community engagement and co-benefits (livelihoods, fisheries, protection against storms).
  – Safeguards for biodiversity and ecosystem health.
- The PDD demonstrates **transparency and accountability** to potential buyers and validators.

5. Validation by Third Party

- A recognized **Validation and Verification Body (VVB)** reviews the PDD.
- They check compliance with the selected standard.
- Validation ensures the project is **technically sound** and meets global quality benchmarks.
- Examples of VVBs: DNV, SGS, Bureau Veritas, TÜV.

6. Project Registration

- Once validated, the project is officially **registered** in the chosen standard's registry (e.g., Verra).
- Registration makes the project **visible to investors, buyers, and markets**.
- It also provides a **unique ID** for tracking and transparency.

7. Implementation & Monitoring

- Begin on-ground activities:
  – **Planting and restoring mangroves**
  – **Protecting existing forests** from cutting or conversion.
- Develop a **monitoring plan** to track:
  – Growth of mangroves (biomass increase).
  – Soil carbon changes.
  – Social and environmental benefits to communities.
- Regular monitoring ensures that results are **verifiable and reliable**.

8. Verification

- Independent auditors revisit the project to **verify the reported results**.
- They confirm:
  - How much carbon has actually been sequestered.
  - Whether monitoring and safeguards were followed.

- Verified results are submitted to the registry, which gives **confidence to credit buyers**.

9. Issuance of Carbon Credits

- The registry issues **carbon credits** (e.g., Verified Carbon Units – VCUs).

- Each credit represents **1 ton of CO_2 removed or avoided**.

- These credits are **tradable assets** and can be tracked transparently in the registry.

10. Selling in the Market

- Once issued, credits can be sold through different channels:
  - **Direct sale** to corporations or governments aiming for carbon neutrality.
  - **Brokers and traders** who connect sellers with buyers globally.
  - **Carbon exchanges** like AirCarbon Exchange or Climate Impact X.
- The price depends on:
  - Quality and certification of the credits.
  - Co-benefits (community, biodiversity).
  - Market demand.

Documentary

CARBON POTENTIAL OF ARID ZONE MANGROVE (DELTA BLUE CARBON)

- DELTA BLUE CARBON is one of the largest mangrove carbon credits project in the world and the size of project is more than 600,000 hectares.
- Currently there are 02 projects of DELTA BLUE CARBON, which are
- DBC-I
- DBC-II

CARBON POTENTIAL OF ARID MANGROVE ZONE

- Total numbers of 5.3 million tons of carbon are verified from verification and validation body (V.V.B) till to date.

- The 3.0 million tons on carbons cradit trading has been done, out of 5.3 million tons, and remaining 2.3 million tons is under process for trading

4. CARBON POTENTIAL OF ARID MANGROVE ZONE

- The total area of project is more than 600,000 No's of hectare.

Amongst above project, DBC-I &DBC-II

- DCB-I is (VERRA) validated project. (running)
- DBC-II is in the process for validation.

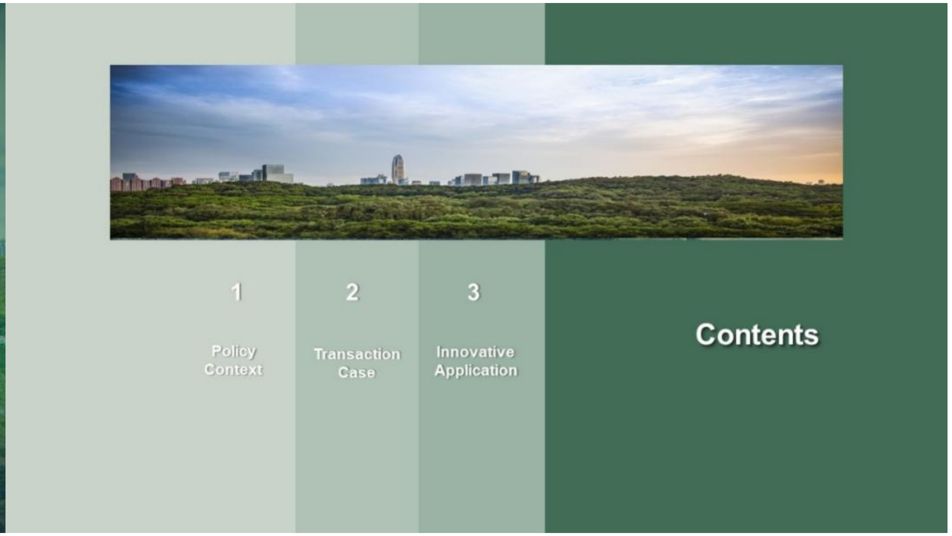
CARBON POTENTIAL OF ARID MANGROVE ZONE

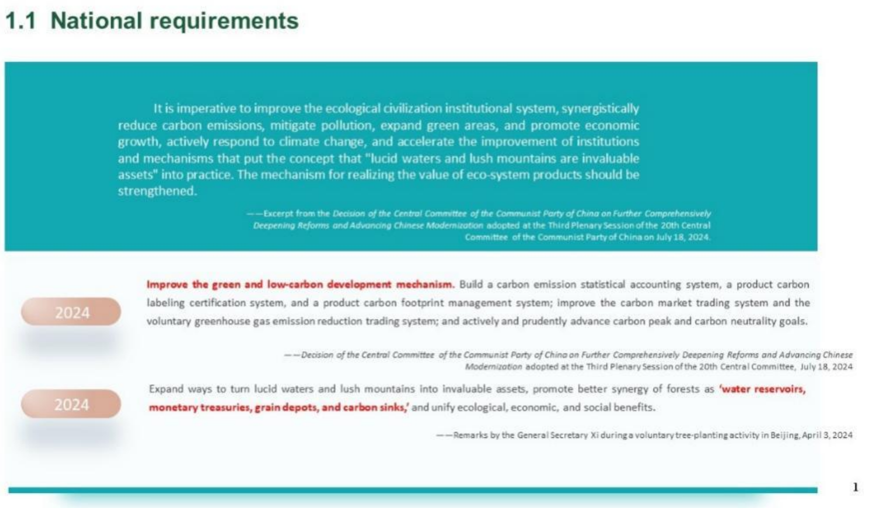
- The expected Carbon removal capacity of DBC-I & DBC-II is 200 million tons and is expected to be sequester in coming 60 years.
- So far till now from the delta blue project-I 40 Million Dollars trading has been done and expected 20 million dollar trading will be carried out this year

- Under the Delta Blue Project's Community Incentive Programme, support is being provided to local communities through initiatives in health, education, and livelihood.


THANK YOU

Annex 3.12: Shenzhen Mangrove Conservation Carbon Sink Project: Development and Trading Practice





1.1 National requirements

Official Guidance on Establishing and Improving the Mechanism for Realizing the Value of Eco-system Products

Improve the carbon emission trading mechanism and explore pilot programs for carbon sink rights trading.

——General Office of the Communist Party of China Central Committee & General Office of the State Council, April 2021

Guidance on Fully, Accurately, and Comprehensively Implementing the New Development Philosophy and Achieving the Carbon Peak and Carbon Neutrality Goals

Advance the development of market-based mechanisms, integrate carbon sink trading into the national carbon emission trading market, and establish a sound ecological conservation compensation mechanism that reflects the value of carbon sinks.

——Communist Party of China Central Committee & State Council, September 2021

Notice on Issuing the Action Plan for Carbon Dioxide Peaking Before 2030

Establish a sound ecological conservation compensation mechanism that reflects the value of carbon sinks, and research and formulate rules for carbon sink projects to participate in the national carbon emission trading market.

——State Council, October 2021

Regulations on Ecological Conservation Compensation

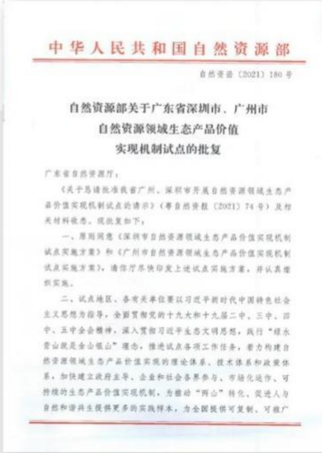
The state shall establish sound trading mechanisms for carbon emission rights, pollution discharge rights, water use rights, carbon sink rights, and other权益 (rights and interests), promote the development of trading markets, and improve trading rules.

——State Council, April 2024

2

1.2 Ministry requirements

In February 2021, the Ministry of Natural Resources initiated the work on realizing the value of eco-system products by issuing the *Letter on Issuing the Guidelines for Pilot Projects on the Mechanism of Realizing the Value of Eco-system Products in the Field of Natural Resources*. **The implementation plan for Shenzhen was approved in July**, with Guangzhou being another pilot city in Guangdong Province.


中华人民共和国自然资源部

自然资函〔2021〕180号

自然资源部关于广东省深圳市、广州市
自然资源领域生态产品价值
实现机制试点的批复

3

02

Transaction Case

- Background
- Transaction Overview

2.1 Background

□ Pilot Program for Realizing the Value of Eco-system Products (EVP)

In April 2021, the General Offices of the CPC Central Committee and the State Council issued the *Official Guidance on Establishing and Improving the Mechanism for Realizing the Value of Eco-system Products*, calling for the exploration of pilot programs for carbon sink rights trading.

In February 2021, the Ministry of Natural Resources issued the *Guidelines for Pilot Projects on the Mechanism of Realizing the Value of Eco-system Products in the Field of Natural Resources*, urging efforts to develop a theoretical framework, a technical system, and a policy system for realizing the value of eco-system products in the domain of natural resources.

In July 2021, the Ministry of Natural Resources approved the *Proposal from Shenzhen on Pilot Projects for the Mechanism of Realizing the Value of Eco-system Products in the Field of Natural Resources*, requiring active advancement of ecosystem carbon sink trading and exploration in establishing an ecological conservation compensation mechanism that reflects the value of carbon sinks.sm that reflects the value of carbon sink.


中华人民共和国自然资源部

自然资函〔2021〕180号

自然资源部关于广东省深圳市、广州市
自然资源领域生态产品价值
实现机制试点的批复

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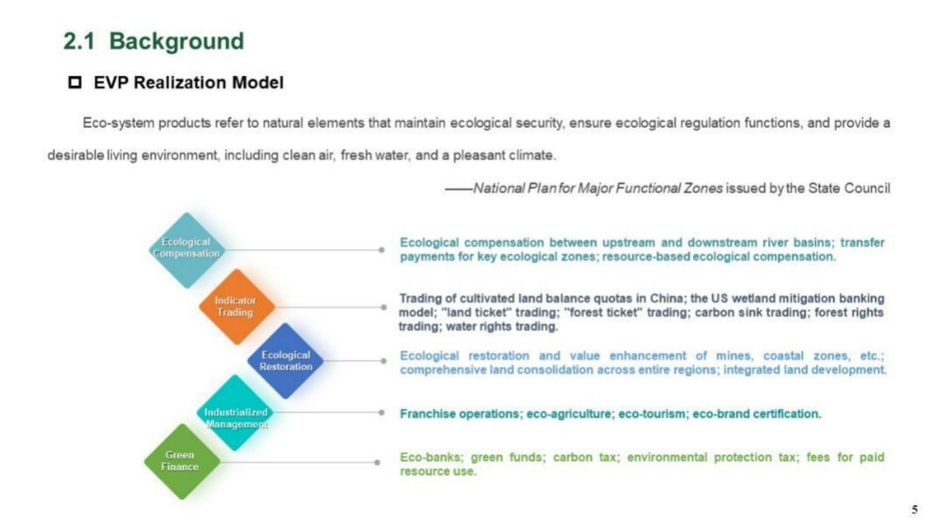
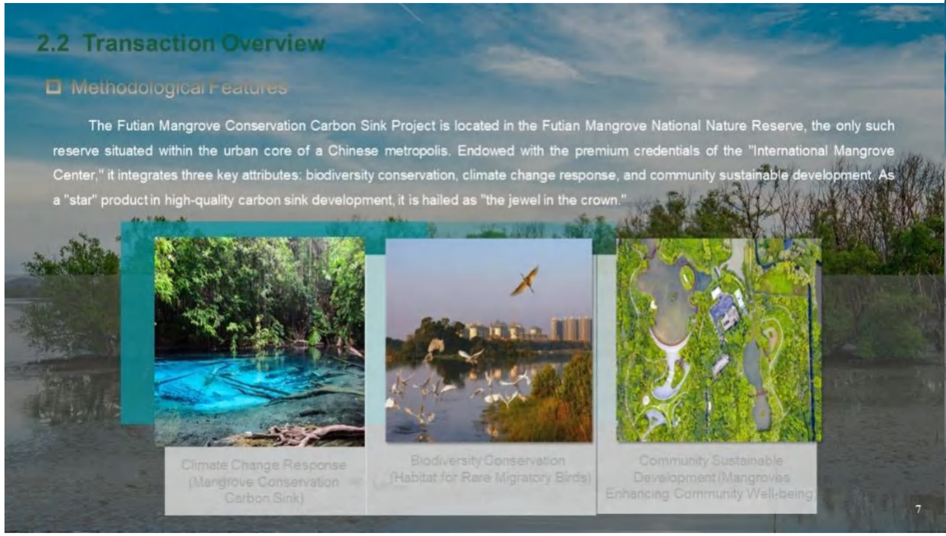

5
2.1 Background
EVP Realization Model
Eco-system products refer to natural elements that maintain ecological security, ensure ecological regulation functions, and provide a desirable living environment, including clean air, fresh water, and a pleasant climate.
——*National Plan for Major Functional Zones* issued by the State Council
Ecological Compensation
Ecological compensation between upstream and downstream river basins; transfer payments for key ecological zones; resource-based ecological compensation.
Indicator Trading
Trading of cultivated land balance quotas in China; the US wetland mitigation banking model; "land ticket" trading; "forest ticket" trading; carbon sink trading; forest rights trading; water rights trading.
Ecological Restoration
Ecological restoration and value enhancement of mines, coastal zones, etc.; comprehensive land consolidation across entire regions; integrated land development.
Industrialized Management
Franchise operations; eco-agriculture; eco-tourism; eco-brand certification.
Green Finance
Eco-banks; green funds; carbon tax; environmental protection tax; fees for paid resource use.


6
2.2 Transaction Overview
Mangrove Conservation Carbon Sink Trading Pilot
Taking the lead, the Futian Mangrove National Nature Reserve, which had completed unified natural resource registration, was selected to pioneer blue carbon trading. This initiative has preliminarily established a comprehensive trading mechanism covering the entire chain, including: ownership registration of mangrove carbon sinks, methodology development, carbon sink verification, reserve price assessment for auctions, formulation of trading organization plans, and carbon trade registration.
Methodology Development
Carbon Sink Verification
Reserve Price Assessment for Auctions
Trading Organization Plan
Mangrove Conservation Carbon Sink Auction
Carbon Sink Certificate and Registration
Carbon Sink Index Insurance
Government "Leveraging" Effect
The first methodology in China targeting biodiversity conservation and climate change response
The methodology underwent review by authoritative experts from the Ministry of Natural Resources, Chinese Academy of Sciences, Tsinghua University, Chinese Academy of Agricultural Sciences, China Green Carbon Foundation, and other institutions. It was unanimously recognized as a pioneering achievement in China, effectively filling the gap in methodologies for carbon sink projects focused on natural ecosystem conservation.
Notice of the Shenzhen Municipal Planning and Natural Resources Bureau on Issuing the *Methodology for Mangrove Conservation Carbon Sink Projects (Trial)*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2.2 Transaction Overview
Methodological Features
The Futian Mangrove Conservation Carbon Sink Project is located in the Futian Mangrove National Nature Reserve, the only such reserve situated within the urban core of a Chinese metropolis. Endowed with the premium credentials of the "International Mangrove Center," it integrates three key attributes: biodiversity conservation, climate change response, and community sustainable development. As a "star" product in high-quality carbon sink development, it is hailed as "the jewel in the crown."
Climate Change Response (Mangrove Conservation Carbon Sink)
Biodiversity Conservation (Habitat for Rare Migratory Birds)
Community Sustainable Development (Mangroves Enhancing Community Well-being)


8
2.2 Transaction Overview
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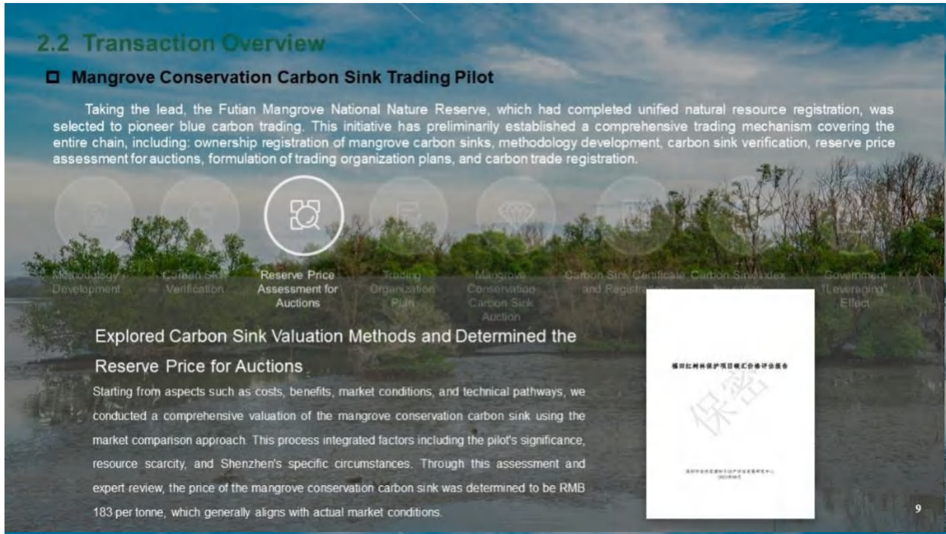
Carbon Sink Verification
Certification of carbon sink for mangrove conservation project
The verification confirms that the mangrove conservation activities across the 126-hectare pilot area generated a total carbon sink of 38,745.44 tonnes during the first monitoring period (January 1, 2010-January 1, 2020), with an annual average of 3,874.544 tonnes.



2.2 Transaction Overview
Mangrove Conservation Carbon Sink Trading Pilot
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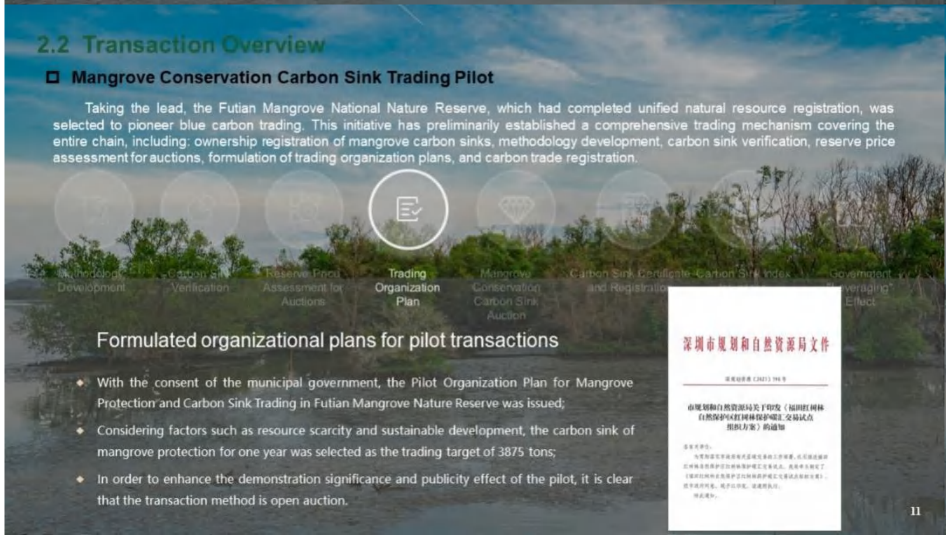
Reserve Price Assessment for Auctions
Explored Carbon Sink Valuation Methods and Determined the Reserve Price for Auctions
Starting from aspects such as costs, benefits, market conditions, and technical pathways, we conducted a comprehensive valuation of the mangrove conservation carbon sink using the market comparison approach. This process integrated factors including the pilot's significance, resource scarcity, and Shenzhen's specific circumstances. Through this assessment and expert review, the price of the mangrove conservation carbon sink was determined to be RMB 183 per tonne, which generally aligns with actual market conditions.
保密
9

2.2 Transaction Overview
Innovative Design of a Valuation Methodology for Mangrove Conservation Carbon Sinks
At present, carbon sink transactions are predominantly conducted through negotiation, as there is no mature carbon sink valuation methodology domestically or internationally. The reserve price for the mangrove carbon sink auction was determined with reference to land asset appraisal methods.
This study explores the development of carbon sink valuation methodologies by analyzing cost-benefit analysis and market dynamics. Utilizing the market comparison approach, we selected blue carbon trading cases with comparable transaction timelines, subject matter, and operational frameworks to establish a modified factor system comprising 3 primary indicators and 16 secondary metrics. The framework quantifies and adjusts the impact of comparative factors—including resource scarcity, mangrove conservation practices, and carbon sink product quality—on valuation. Through this systematic evaluation, we assess the carbon sequestration value of protected mangrove ecosystems.
修正因素体系
时间因素
区域因素
个别因素
碳配额价格指数
交通便捷度
环境质量
基础设施完善度
公共设施完善度
管护方式
交易方式
资源稀缺性
福田红树林保护碳汇价格评估报告
保密
10



2.2 Transaction Overview
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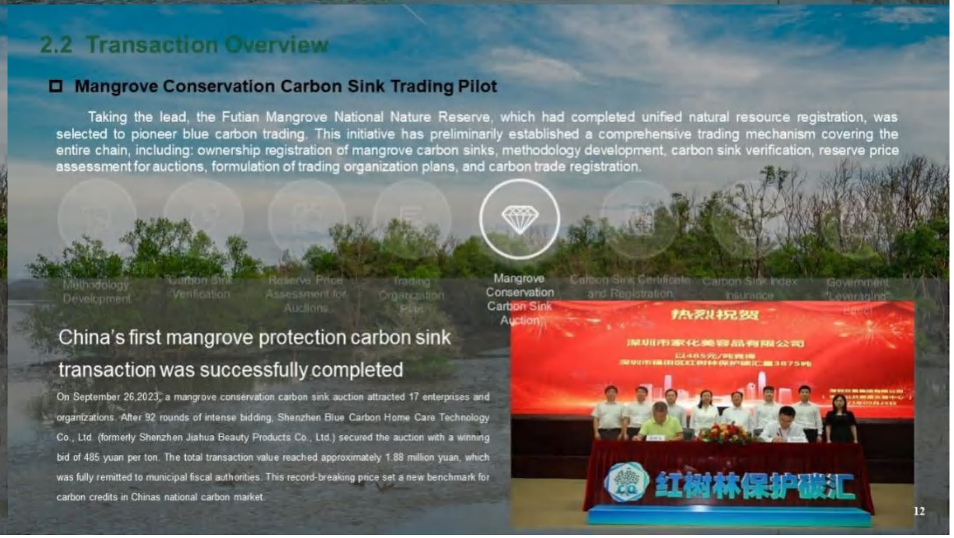
Trading Organization Plan
Formulated organizational plans for pilot transactions
With the consent of the municipal government, the Pilot Organization Plan for Mangrove Protection and Carbon Sink Trading in Futian Mangrove Nature Reserve was issued;
Considering factors such as resource scarcity and sustainable development, the carbon sink of mangrove protection for one year was selected as the trading target of 3875 tons;
In order to enhance the demonstration significance and publicity effect of the pilot, it is clear that the transaction method is open auction.
深圳市规划和自然资源局文件
11



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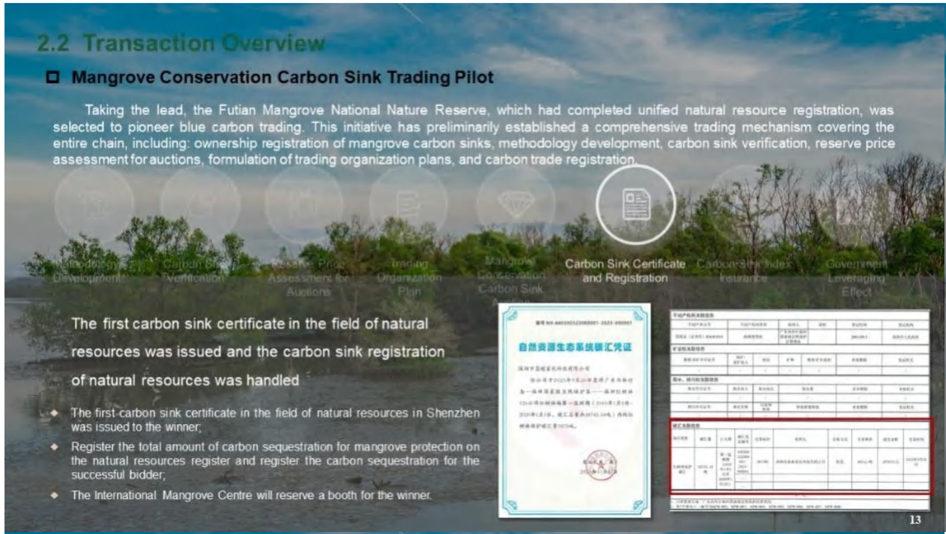
Mangrove Conservation Carbon Sink Auction
China's first mangrove protection carbon sink transaction was successfully completed
On September 26,2023, a mangrove conservation carbon sink auction attracted 17 enterprises and organizations. After 92 rounds of intense bidding, Shenzhen Blue Carbon Home Care Technology Co., Ltd. (formerly Shenzhen Jiahua Beauty Products Co., Ltd.) secured the auction with a winning bid of 485 yuan per ton. The total transaction value reached approximately 1.88 million yuan, which was fully remitted to municipal fiscal authorities. This record-breaking price set a new benchmark for carbon credits in Chinas national carbon market.
热烈祝贺
红树林保护碳汇
12



Innovative Applications

- Carbon Neutrality
- Judicial Carbon Sinks
- Financial Insurance
- Financial Collateralization

3.1 Exploring Application Scenarios for Carbon Neutrality

Selecting events with international influence that promote the concept of green development to achieve carbon neutrality.

- Carbon Neutrality for the 2024 China Marine Economy Expo Professional Forum (90 tonnes)
- Carbon Neutrality for the 4th "Shanhai Liancheng · Nature Shenzhen" Lifestyle Festival (10 tonnes)
- Carbon Neutrality for the 2025 "Green Futian, Zero-Carbon Public Welfare" Event (20 tonnes)

3.2 Justicial Carbon Sinks

Actively exploring diversified pathways for realizing the value of eco-system products, the city has promoted the integration of the mechanism for realizing the value of eco-system products in the natural resources sector with the mechanism for restoring ecological and environmental damages. The Municipal Planning and Natural Resources Bureau, in collaboration with the Municipal Qianhai People's Procuratorate and the Municipal Finance Bureau, has jointly **developed a novel model for marine ecological and environmental damage restoration termed "Mangrove Conservation Carbon Sinks + Ecological Justice"**.

On January 21, 2025, the *Implementation Plan for Mangrove Conservation Carbon Sink Subscription as an Alternative to Marine Ecological Restoration* was issued by the Shenzhen Municipal Planning and Natural Resources Bureau and the Shenzhen Municipal Oceanic Development Bureau. In March, the Municipal Qianhai People's Procuratorate subscribed to 520 tonnes of mangrove conservation carbon sinks from the Guangdong Neilingding-Futian National Nature Reserve to be used for alternative marine ecological and environmental damage restoration, **completing Shenzhen's first judicial blue carbon transaction**.

In August 2025, led by the Shenzhen Municipal Intermediate People's Court and jointly issued by multiple departments including the Shenzhen Municipal Planning and Natural Resources Bureau, the *Implementation Opinions on Applying the Subscription of Carbon Sinks as a Fulfillment Method (Trial)* was promulgated. Adhering to the principle of prioritizing ecological restoration, the document outlines regulatory requirements and procedural guidelines for actively directing responsible parties in relevant environmental resource cases to voluntarily subscribe to carbon sinks as an alternative means of fulfilling ecological and environmental restoration responsibilities and compensation liabilities. This initiative aims to enhance the level of law enforcement and judiciary in ecological and environmental resource cases, thereby supporting and securing the achievement of carbon peak and carbon neutrality goals.

3.3 Financial Insurance

Working in partnership with the National Financial Regulatory and Administration Commission's Shenzhen Bureau, we are exploring the establishment of a cooperative mechanism for blue carbon trading and innovative financial formats. By organically integrating "ecological conservation + insurance mechanisms," we are innovatively developing financial insurance products tailored for mangrove and biodiversity protection.

On July 25, 2023, witnessed by the Shenzhen Municipal Planning and Natural Resources Bureau and the National Financial Regulatory and Administration Commission's Shenzhen Bureau, the Administration of Guangdong Neilingding-Futian National Nature Reserve signed the *Futian Mangrove Nature Reserve Mangrove Carbon Sink Insurance Donation Agreement* with Ping An Property & Casualty Insurance Company of China, Ltd. Shenzhen Branch. **This marked the launch of the first mangrove carbon sink index insurance policy in China, implemented in Shenzhen**.

3.4 Financial Collateralization

In October 2024, Shenzhen Branch of Industrial Bank Co., Ltd. and Shenzhen Blue Carbon Home Chemical Technology Co., Ltd. officially signed an agreement on innovative blue carbon finance cooperation, launching **Shenzhen's first mangrove conservation carbon sink pledge financing operation**. By adopting an approach of exchanging "carbon" for "loans," this initiative provides enterprises with new financing channels and focuses on meeting their working capital needs, representing an innovative breakthrough in the field of blue finance.


Thank You!
We welcome your questions and feedback.
Development Research Center for Natural Resource and Real Estate Assessment, Shenzhen
Reporter: Xie Xinli
November 6, 2025

Annex 3.13: Introduction to China and its Culture

Introduction to China and its Culture

WU Xuerui

National Academy of Forestry and Grassland Administration

Nov. 2025

Main contents

Part One Profile of China

Part Two Population and Culture

2

Part One Profile of China

I. Geography
II. History
III. Political system
IV. Economy
V. Diplomacy

3

I. China's geography

The People's Republic of China, commonly referred to as China. China is vast in territory, with beautiful mountains and rivers.

4

1. Location and territory

East Asia and west to the Pacific, with a land area of 9.6 million km^2, the third largest after Russia and Canada.

5

2. Terrain and landscape

Altitude decreases from west to east, resembling a flight of three stairs. Mountains, hills and plateaus account for 67% and basins and plains 33% of China's total area.

First stair: altitude over 4000 meters ---Plateaus and mountains

Second stair: altitude 1000-4000 meters---Plateaus and basins

Third stair: altitude below 1000 meters ---Plains and low hills

6

3. Rivers and water resources

China is one of the countries with the most rivers in the world, with over 1,500 rivers having a drainage area exceeding 1,000 square kilometers. Among them, the Yellow River and the Yangtze River are the mother rivers of the Chinese nation.

Every March 9th is the Mother River Protection Day in China.

7

4. Scenery

China has vast territory, abundant resources, diverse climate, beautiful scenery, and countless fascinating mountains, lakes, canyons, and waterfalls.

This picture are Lushan Mountain in central China, the Yarlung Zangbo River in southwest China, Hainan Island in southern China, and the colorful Danxia landscape in northwest China.

World Natural Heritage Sites from China

As of August 2024, China boasts 19 World Natural Heritage sites, ranking among the top globally. This includes 15 World Natural Heritage sites and 4 World Heritage Mixed sites, covering a total area of over 80,000 square kilometers.

9

The aquatic forest of Huanglong Wucaichi

Sichuan Giant Panda Sanctuaries

Arrow Bamboo Lake in Jiuzhaigou Valley

The pinnacles of Mount Sanqingshan in Jiangxi

"The Roof of Central China" in Shennongjia, Hubei

The sandstone pinnacles of Wulingyuan in Hunan

10

The red cliffs of China Danxia

The stone forests in the South China Karst

Fanjing Mountain Scenic Area in Guizhou

Chengjiang biota in Yunnan

11

Three Parallel Rivers of Yunnan Protected Areas

Snow lotus of the Tianshan Mountains in Xinjiang

The Tibetan antelope (Chiru) of Hoh Xil, Qinghai

The venerable pine trees of Mount Tai in Shandong

Bizarrely-shaped pine trees of Mount Huangshan in Anhui

Leshan Giant Buddha in Sichuan

12

The symbiotic tea-agroforestry system of Mount Wuyi in Fujian

China's Yellow(Bohai) Sea Migratory Bird Habitat

The lakes within the Badain Jaran Desert

II. China's history

China is one of the ancient civilizations in the world, and the only country among the four ancient civilizations (ancient Egypt, ancient India, and ancient Babylon) with uninterrupted civilization. According to the latest achievements of the "Exploration of Civilization" project, the recorded history of China is over 5800 years. In the long process of historical evolution, the Chinese people have created brilliant historical and cultural heritage.

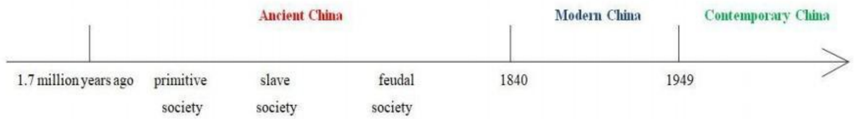
(1) Cradle of civilization

Chinese civilization starts from the Yellow River（5,464km）and the Yangtze River（6,300km）drainage areas.

The Yellow River

The Yangtze River

(2) Historical periods



There are three historical periods in China's history: ancient times, modern times, and contemporary times.

Ancient China

China's ancient history and dynasties oriented from 1.7 million years ago, ended in 1840AD, before the First Opium War.

The ancient history includes: Primitive society, Slavery society, Feudal society.





17

Modern China

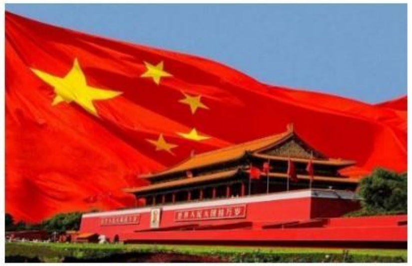
From 1840 （the First Opium War）- 1949（the founding of PRC), the history of the semi-colonial and semi-feudal society.

The first Opium War 1840

18

Contemporary China

From 1949（the founding of PRC) till now, the socialist revolution and construction period

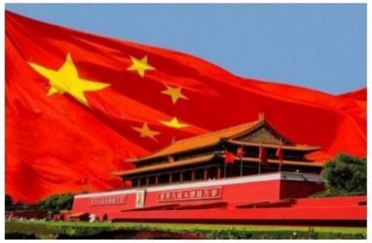


Founding of People's Republic of China 1949

19

IV. China's political system

- The basic political structure: under the leadership of the Communist Party of China, the systems of People's Congress, Multi-party Cooperation and Political Consultation, and Regional Autonomy for Ethnic Minorities are adopted.



20

1. People's congress system

- The people's congress is an important part of the system of socialism with Chinese characteristics and the fundamental political system.

2.Multi-party Cooperation and Political Consultation

- The CPC is the only ruling party in China and the rest 8 democratic parties, led by the CPC, participate in the state affairs.

3.The System of Regional Ethnic Autonomy

- Regional ethnic autonomy means that under the unified leadership of the state, regional autonomy is exercised in areas where ethnic minorities live in compact communities and organs of self-government are established to exercise the power of autonomy. It is a basic element of China's socialist, political system, and a fundamental mechanism to resolve ethnic issues.

4. China's administrative system

China's administrative units are currently based on a three-tier system, dividing the nation into provinces, counties and townships:

- The country is divided into provinces, autonomous regions and municipalities directly under the Central Government;
- A province or an autonomous region is subdivided into autonomous prefectures, counties, autonomous counties and cities;
- A county or an autonomous county is subdivided into townships, ethnic townships and towns.

- The State Council of the People's Republic of China, also known as the Central People's Government
- Municipalities directly under the Central Government and large cities are subdivided into districts and counties;
- Autonomous prefectures are subdivided into counties, autonomous counties and cities.
- Autonomous regions, autonomous prefectures and autonomous counties are all ethnic autonomous areas.
- The Constitution specifically empowers the state to establish special administrative regions when necessary.
- A special administrative region is a local administrative area directly under the Central Government.

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V. China's economy

Reform and opening up

Deng Xiaoping
(1904-1997)

The CPC has steered China to such massive growth and development by introducing its major economic reforms, known as the reform and opening-up policy, in 1978.

Deng Xiaoping led this policy and was hailed as the "chief architect of China's reform and opening up".

By 2024, China's gross domestic product will increase to 134.9 trillion (RMB), consolidating its position as the world's second-largest economy.

26

Shenzhen before and after the policy

27

VI. China's diplomacy

1. Basic tenets

- Maintaining world peace and promoting common development are the purposes of China's foreign policy
- The five principles of peaceful coexistence are the basic norms of China's foreign relations.
- Independence is the basic position of China's foreign policy.
- Strengthening solidarity and cooperation with third world countries is the basic foothold of China's foreign policy.

28

2. Major country diplomacy with Chinese characteristics

- The major country diploma with Chinese characteristics is the inheritance and development of China's consistent foreign policy and ideology in the new era. Its core values embody the traditional Chinese culture of "the world is for all" and are in line with the universal demand for peace and friendship in human civilization.

29

A Community with Shared Future for Humanity

- To build a community with a shared future for humanity calls for concrete actions. China has advocated that the international community promote a common approach to partnership, the security landscape, economic development, cultural exchanges and eco-environmental conservation.

The Belt and Road Initiative

- The initiative was launched by Chinese President Xi Jinping in 2013.
- In September 2013, during an official visit to Kazakhstan, Xi announced the Silk Road Economic Belt, a plan to develop overland infrastructure to connect the region.
- BRI infrastructure projects connect China with different parts of the world.

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Part Two Population and Culture

I. Chinese Humanities

II. Chinese Culture

46

Ⅰ. Chinese Humanities

1. Population

The latest census shows, China’s population reaches 1.41 billion.

The data shows that China's population has continued to maintain a low growth trend for 10 years, and China is accelerating to enter an aging society.

47

2. Ethnic Groups

Ethnic groups China is a unified country with 56 ethnic groups with the han people accounting for 91.11% of the total population

Ⅱ. Chinese Culture

1. Traditional culture

Chinese culture, which originated in the Yellow River basin, has a history of more than five thousand years. From the Yangshao culture and Longshan culture in ancient times, to the ritual and music system of the Xia, Shang, and Zhou dynasties, and then to the contention of hundreds of schools of thought during the Spring and Autumn and Warring States periods, Chinese culture has undergone a long course of development.

The Yellow River

49

Chinese culture is inclusive and develops in a long history. In the process of historical development, not only have numerous local schools of thought emerged, but also foreign cultures have been constantly introduced. Different schools of thought and cultures have absorbed and integrated into each other in contradictions and conflicts, gradually establishing a basic pattern of Confucianism as the main body, with Confucianism, Buddhism, and Taoism each holding its own unique banner, while also working together to complement each other and apply it to society.

Confucius

benevolence, righteousness, courtesy and trustworthiness

Laotzu

non-intervention, follow the nature

Buddha

compassion, karma

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Confucianism emphasizes benevolence and filial piety, requiring humans to hold awe for all things in nature and to maintain the harmonious order of the universe. Taoism focuses on pursuing the realm of natural non-action, integrating with nature, seeking harmony and unity between nature and human, and advocating that human should conform to the way of nature, abandon impatience and utilitarianism, and pursue inner tranquility and self-transcendence. Buddhism emphasizes letting go of desires, pursuing inner peace and transcendence, advocating compassion, paying attention to the suffering of all beings, and promoting coexistence with nature to achieve harmonious coexistence between human and nature.

2.Specific forms of Chinese Culture

2.1 Opera and Quyi arts

Chinese opera is one of the three ancient dramas in the world (including Chinese opera, Greek tragicomedy, and Indian Sanskrit opera), with over 300 genres including Peking Opera, Kunqu Opera, Yue Opera, and Yu Opera. Peking Opera is the most influential. Peking Opera, also known as Peking Opera or National Opera, is divided into four types of characters: male roles, female roles, painted roles and clowns--on stage. It has four skills: singing, speaking, acting and acrobatic fighting.

52

赤壁 The Red Cliffs

53

Quyi arts

Quyi is a general term for various "talking and singing arts". It is a unique art form that has evolved over a long period of development from folk oral literature and singing arts. According to incomplete statistics, there are about 400 different types of quyi performed by various ethnic groups in China.

Quyi, as a performing art, uses "oral talking and singing" to narrate stories, portray characters, express thoughts and emotions, and reflect social life. Just as the essential characteristic of opera art is "performing stories through singing and dancing," the fundamental feature of quyi art can be described as "narrating stories through oral talking and singing."

54

苏州评弹Suzhou Pingdan

55

2.2 Music and dance

Chinese music specifically refers to Chinese instrumental music and Chinese vocal music, with a history that can be traced back to the Yellow Emperor era. From Confucius' transmission of the Six Arts to modern Western music, Chinese music has continued to enrich and develop in the process of absorbing foreign musical elements. China is known as the "land of rites and music," and ancient music played a significant role and held an important position in personality cultivation, cultural life, and national etiquette.

战国时期曾侯乙编钟
Zeng Houyi Chime Bells

56

Music

Guzheng

Pipa

Erhu

57

二泉映月 Moon Reflected in Second Spring

58

Dance

It can be said that China has had a history of dance for as many years as it has had civilization. Chinese traditional dance is rich in variety and form, containing abundant cultural connotations and ethnic characteristics. Classical dance is one of the main forms of Chinese dance, which has formed a unique artistic style through thousands of years of development and inheritance. It mainly includes Han and Tang dances, court dances, and more. Ethnic and folk dances refer to the dances of various ethnic groups in China in aspects such as production labor, living customs, religious beliefs, etc., fully demonstrating the unique customs and cultural traditions of various ethnic groups in China.

59

《霓裳羽衣舞》The Dance of Rainbow Skirt and Feathered Robe

60

2.3Chinese calligraphy

Calligraphy is a unique traditional art in China, mainly composed of writing Chinese characters with a brush, as well as pen calligraphy and finger writing. There are five main styles of Chinese calligraphy: seal script, clerical script, regular script, running script, and cursive script.

61

Calligraphy Practice

62

2.4Poetry and rhymes, as well as classics, histories, philosophical works, and collected works,

Poetry and rhymes are the treasures of ancient Chinese literature. With refined language, profound artistic conception, and rich emotions, they express the unique perceptions of ancient literati on themes such as life, nature, love, friendship, home, and country. Poetry, songs, and rhymes emphasize rhythm, parallelism, and the creation of artistic conception, embodying the essence of ancient Chinese literary art."

From the simplicity and freshness of the "Book of Songs" to the prosperity and splendor of Tang poetry, and further to the graceful delicacy of Song lyrics, poetry and songs have carried the development process of ancient Chinese literature and reflected the social styles and humanistic spirits of different historical periods.

Li Bai, 701—762

63

The collection of classics, histories, philosophical works, and collected works constitutes the core of ancient Chinese academic culture. The classics section includes Confucian classics such as the "Book of Songs", "Book of History", "Book of Rites", "I Ching", and "Spring and Autumn Annals", which are important carriers of mainstream thought and moral norms in ancient Chinese society. The histories section includes various historical works such as "Records of the Grand Historian", "History of the Han Dynasty", and "History of the Later Han Dynasty", which record the social development, changes, and historical events of ancient China, serving as important materials for studying ancient Chinese history. The philosophical works section covers the writings of various schools of thought such as "The Analects of Confucius", "Mencius", "Laozi", "Zhuangzi", etc., representing different ideological schools and academic viewpoints in ancient China.

Sima Qian, 145B.C.--?

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定风波(Calming Wind and Waves)

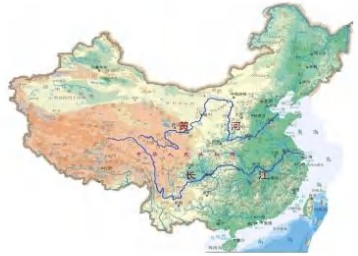
65

2.5Architecture

- The total number of world heritage sites amounts to 1,122, distributed in 167 countries around the world, with 39 dual world cultural and natural heritage sites, 213 world natural heritage sites and 869 world cultural heritage sites. China has 57 world cultural and natural heritage sites on the World Heritage List, including 39 world cultural heritage sites, 4 dual world cultural and natural heritage sites and 14 world natural heritage sites.

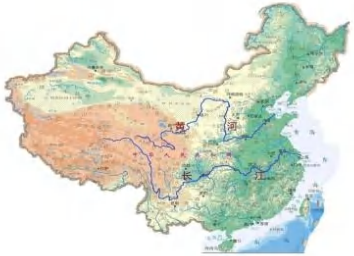
66

The Great Wall, also known as the Ten Thousand Li Great Wall, has a total length of over 21000 kilometers and is mainly distributed in 15 provinces, autonomous regions, and municipalities, including Hebei, Beijing, Tianjin, Shanxi, Shaanxi, Gansu, Inner Mongolia, Heilongjiang, Jilin, Liaoning, Shandong, Henan, Qinghai, Ningxia, and Xinjiang. It is listed as a world cultural heritage site. It is an ancient military defense fortification in China, a tall, sturdy, and continuous long wall used to limit the movement of enemy cavalry.



67

The Palace Museum was a royal palace of the Ming and Qing dynasties in China. It's also known as the Forbidden City, located at the center of the central axis of Beijing. The Forbidden City is centered around three major halls, covering an area of approximately 720000 square meters with a building area of approximately 150000 square meters. There are over 70 palaces of various sizes and 8707 rooms. The Forbidden City is one of the largest and most well preserved wooden structure ancient architectural complexes in the world, and is a world cultural heritage site.



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III. Chinese martial arts

Chinese martial arts is a rich and full cultural carrier, reflecting Chinese wisdom in every move, embodying Chinese spirit in every fist and every movement, and concealing Chinese civilization in every skill and theory. Chinese martial arts emphasizes the balance of strength and softness, with both internal and external cultivation. It has a robust and beautiful appearance, as well as an elegant and profound connotation.

69

Video: Three Section Cudgel

70

Ⅳ.Festivals and customs

4.1 Etiquettes

Chinese traditional culture is renowned for its long history, profound connotations, and diverse artistic forms. One of its core characteristics is the high emphasis on ceremonies and etiquette. Ceremonies and etiquette permeate every aspect of Chinese traditional culture, from family to society, from religion to politics, omnipresent. They are not only seen as a code of conduct but also carry moral values, social order, and the maintenance of interpersonal relationships. Through the study and inheritance of ceremonies and etiquette, we can gain a deep understanding of the essence of Chinese traditional culture and experience the respect and care between people.

71

In the excellent traditional Chinese culture, rituals and etiquette play an important role. Ritual is a sacred activity that expresses respect for significant events and traditional customs through standardized procedures and unique symbols. Etiquette emphasizes the norms and respect of personal behavior, reflecting the unique expression of culture.

In traditional Chinese culture, etiquette is regarded as a necessary social way and behavioral norm. It involves interpersonal communication, social interaction, and rituals in various fields. Etiquette occupies an important position in traditional Chinese culture and runs through all aspects of people's lives.

72

Tiananmen Square Flag Raising Ceremony

73

4.2 Important festivals

Chinese traditional festivals are an important part of the long history and culture of the Chinese nation, with diverse forms and rich content. The formation of traditional festivals is a process of long-term accumulation and cohesion of the historical and cultural heritage of a nation or country.

74

China is a nation of ceremonies. Rituals express Chinese people's recognition of the importance and value of things. Without a sense of ritual can hardly make people psychologically identify and comply with festivals. Rituals themselves are an important way for people to participate. Below is a brief introduction to some of the main traditional Chinese festivals.

75

Spring Festival

also known as the Lunar New Year or the Chinese New Year. The Spring Festival has a long history and evolved from the ancient era of praying for the beginning of the year and offering sacrifices. In traditional agricultural societies, the beginning of the Spring Festival is of great significance. Starting with a hundred festivals, the Spring Festival is the most solemn traditional festival of the Chinese nation. It not only embodies the ideological beliefs, ideal wishes, life entertainment, and cultural psychology of the Chinese nation, but also serves as a display of blessings, food, and entertainment activities.

Yuanxiao Festival

also known as the Lantern Festivalalls on the 15th day of the first lunar month every year and is one of the traditional festivals in China. The first month is the first month of the lunar calendar. The 15th day of the first month is the first full moon night of the year, so the 15th day of the first month is called "Yuanxiao (Filled round balls made of glutinous rice-flour for Lantern Festival) Festival". Since ancient times, the custom of Yuanxiaoas been dominated by the warm and festive custom of watching lanterns.

Qingming Festival

also known as Qingqing Festival, Xingqing Festival, March Festival, Ancestral Worship Festival, etc., is celebrated at the turn of mid spring and late spring. The Qingming Festival originated from the ancestral beliefs and spring festival customs of ancient times, and has both natural and cultural connotations. It is not only a natural solar term, but also a traditional festival.

Loong Boat Festival

The ancients have always advocated the path of righteousness and righteousness. The Dragon Boat Festival, also known as Zhongzheng, refers to the noon hour on this day, which is the highest point in the middle. The Loong Boat Festival originated from the worship of celestial phenomena and evolved from dragon worship in ancient times. The Dragon Boat Festival is an auspicious day of "flying dragons in the sky". People hold some celebration activities at the Dragon Boat Festival, especially the activity elements corresponding to the dragon, such as offering sacrifices to the dragon and ancestors, picking up the Loong Boat, etc., or do some activities to pray for good fortune and ward off evil spirits on this auspicious day.

Mid-Autumn Festival

also known as the Reunion Festival, originates from the worship of celestial phenomena and evolved from the ancient autumn moon sacrifice. Since ancient times, the Mid-Autumn Festival has been associated with customs such as moon worship, moon gazing, eating mooncakes, playing with lanterns, admiring osmanthus flowers, and drinking osmanthus wine, which have persisted and spread for a long time. Eating mooncakes has become an essential custom for celebrating the Mid-Autumn Festival across China. On this day, people eat mooncakes to symbolize "reunion".

80

New Year's Eve

marks the final night of the year, signifying the end of the old year and the beginning of a new one. It is a day for removing the old and welcoming the new, for family reunion, and for sacrificing to ancestors. Together with the Qingming Festival, the Zhongyuan Festival (July 15th), and the Double Ninth Festival, New Year's Eve is one of the major traditional Chinese festivals for ancestral worship.

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V. Food culture

5.1 Chinese food

Chinese cuisine is famous worldwide and is one of China's business cards. Color, aroma, taste, and shape are the four major standards of Chinese cuisine. Traditional Chinese cuisine uses chopsticks as a tool for eating. For thousands of years, people have continuously summarized and formed the eight major cuisines of Chinese cuisine, namely the Shandong, Sichuan, Guangdong, Fujian, Jiangsu, Zhejiang, Hunan, and Anhui schools.

82

5.2 Chinese tea

China is the homeland of tea and the birthplace of tea culture. Chinese tea culture has a long and profound history, with a discovery and utilization spanning over 4,700 years. It has remained vibrant and widespread globally. Chinese tea culture encompasses not only the material cultural aspect but also a profound spiritual dimension. The "Tea Classic" by Lu Yu, the Tea Sage of the Tang Dynasty, sounded the clarion call of Chinese tea culture in history. Since then, the spirit of tea has permeated the imperial court and society, deeply influencing Chinese poetry, painting, calligraphy, religion, and medicine. Over thousands of years, China has accumulated not only a substantial material culture related to tea planting and production but also a rich spiritual culture associated with tea, which is the unique tea culture of China.

83

In 2022, traditional Chinese tea making techniques and related customs were included in the UNESCO Intangible Cultural Heritage List. Chinese tea art is renowned worldwide and was introduced to Japan during the Tang Dynasty, forming the Japanese tea ceremony.

China's tea varieties are also diverse, classified into green tea, black tea, oolong tea, white tea, yellow tea, dark tea, and so on.

84

VI. Technological innovations

In addition to historical relics, ancient China also had countless technological inventions. There were the Four Great Inventions in ancient China, namely paper, Movable type, gunpowder and compass, which greatly promoted the development of politics, economy and culture in ancient China. They spread to the West through various channels, and exerted great influence on the development of world civilization.

85

Paper

Paper was invented by Cai Lun in 105 AD (during the Eastern Han Dynasty). It was made from bark, hemp, rags, and old fishing nets, which is convenient for people to write and promoted cultural dissemination.

86

Movable type printing

Printing in ancient China can be traced back to the 6th century AD. Engraving printing was invented in the Tang Dynasty. Bi Sheng invented movable type printing, marking the birth of movable type printing. He was the world's first inventor, about 400 years ahead of Western lead movable type printing.

87

Gunpowder

The invention and use of gunpowder can be traced back to 2000 years ago. In the Spring and Autumn period, China had already used gunpowder for civilian and people's livelihood applications. China's gunpowder has advanced the process of world history. Gunpowder shook the feudal rule of Western Europe and was one of the important impetus to the European Renaissance and Religious Reform.

Compass

The invention of the compass can be traced back to the Warring States period (2500 years ago), greatly promoting the development of navigation and writing a glorious page in the history of world navigation.

VII.Traditional Chinese Medicine

Traditional Chinese Medicine (TCM). TCM emphasizes "observation, listening, inquiry, and palpation," viewing the human body as a unity of qi (vital energy), form, and spirit. It is also a great invention in Chinese tradition and has made significant contributions to humanity throughout history. In addition to TCM, there are also ethnic medical systems in China such as Tibetan medicine, Zhuang medicine, Miao medicine, Mongolian medicine, Uyghur medicine, Korean medicine, and Dai medicine.

On November 16, 2010, the application for Chinese acupuncture to be included in the World Intangible Cultural Heritage succeeded.

Thank you for your attention!

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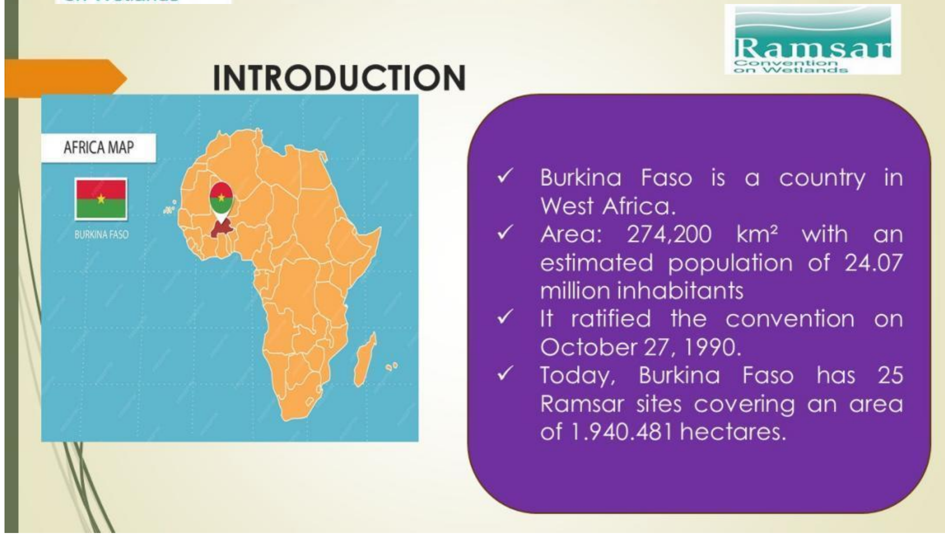
Annex 4: Country Presentations

Annex 4.1: Burkina Faso



BURKINA FASO WETLANDS PICTURES

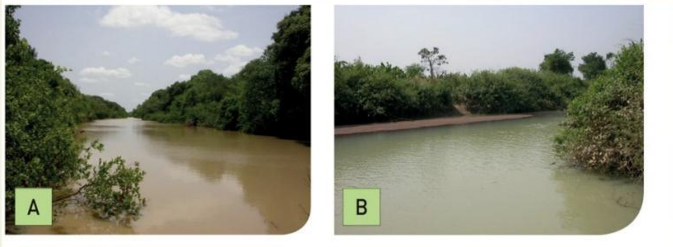


Photo 6: (A) : Galerie forestière le long de la rivière Pendjari ; (B) : Cordon ripicole à Pama

BURKINA FASO WETLANDS PICTURES

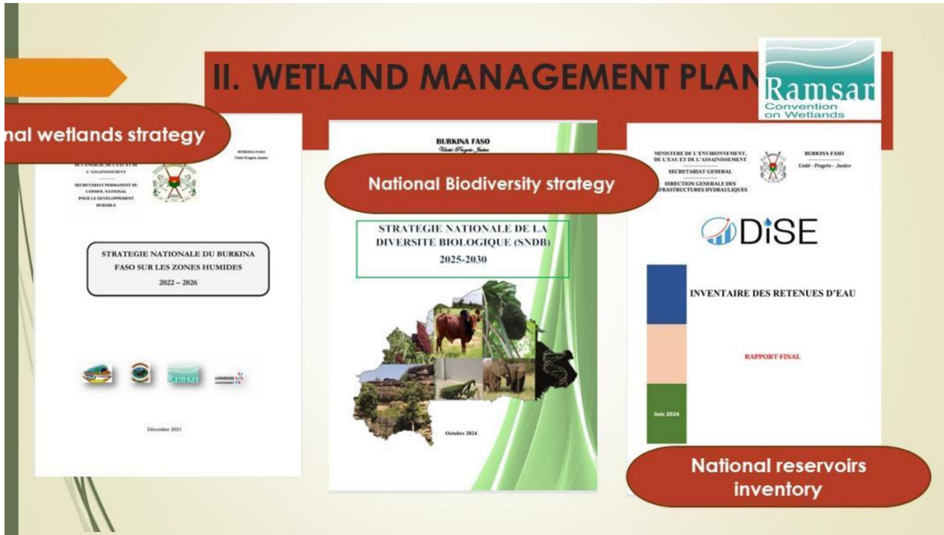
- Ramsar Site of the Samendéni Dam

BURKINA FASO WETLANDS PICTURES

Ramsar Site of «Mare d'Oursi »

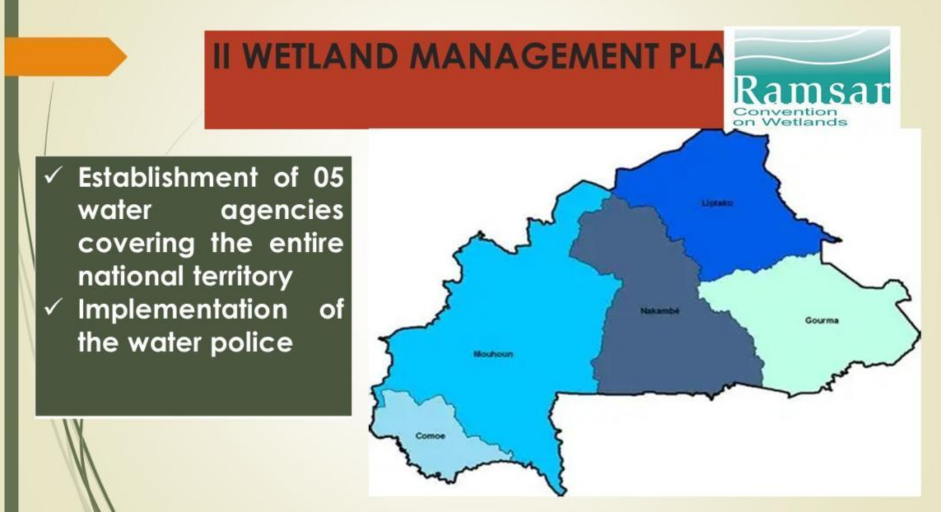
BURKINA FASO WETLANDS PICTURES

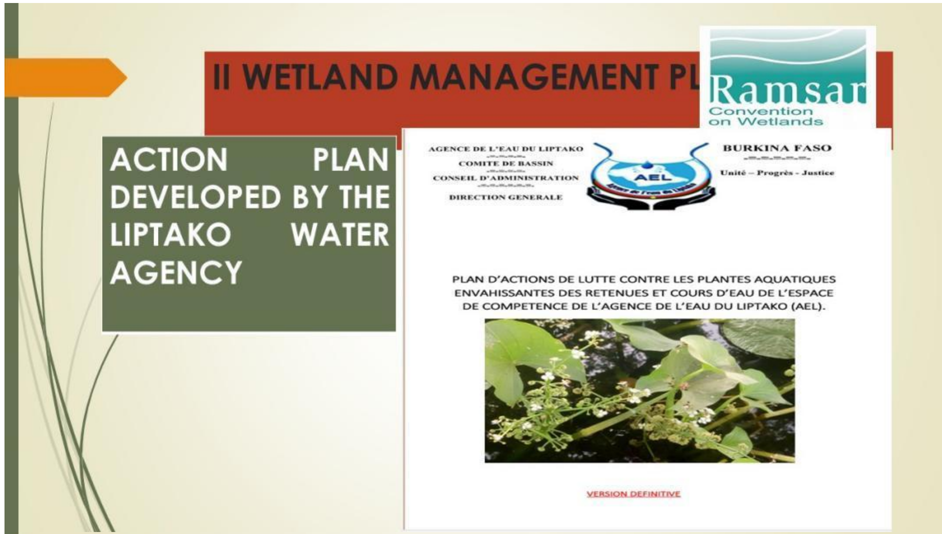
Ramsar site of « Mare aux Hippopotames de Bala »


II. WETLAND MANAGEMENT PLAN
Ramsar
Convention on Wetlands
nal wetlands strategy
STRATEGIE NATIONALE DU BURKINA FASO SUR LES ZONES HUMIDES
2022 – 2026
National Biodiversity strategy
BURKINA FASO
STRATEGIE NATIONALE DE LA DIVERSITE BIOLOGIQUE (SNDB)
2025-2030
Octobre 2024
DiSE
INVENTAIRE DES RETENUES D'EAU
RAPPORT FINAL
Juin 2024
National reservoirs inventory


II. WETLAND MANAGEMENT PLANNING
NDC
BURKINA FASO
CONTRIBUTION DETERMINEE AU NIVEAU NATIONAL (CDN) DU BURKINA FASO
2021-2025
Version finale
Octobre 2021
NAP
BURKINA FASO
Unité-Progrès-Justice
PLAN NATIONAL D'ADAPTATION AUX CHANGEMENTS CLIMATIQUES (PNA) DU BURKINA FASO
(2024-2028)


II. WETLAND MANAGEMENT PLANNING
National monograph on biological diversity
MONOGRAPHIE NATIONALE SUR LA DIVERSITE BIOLOGIQUE DU BURKINA FASO
GMES
Union Africaine


II WETLAND MANAGEMENT PLA
Ramsar
Convention on Wetlands
✓ Establishment of 05 water agencies covering the entire national territory
✓ Implementation of the water police
Liptako
Nakambé
Gourma
Mouhoun
Comoe


II WETLAND MANAGEMENT PL
Ramsar
Convention
on Wetlands
ACTION PLAN DEVELOPED BY THE LIPTAKO WATER AGENCY
AGENCE DE L'EAU DU LIPTAKO
COMITE DE BASSIN
CONSEIL D'ADMINISTRATION
DIRECTION GENERALE
AEL
BURKINA FASO
Unité – Progrès – Justice
PLAN D'ACTIONS DE LUTTE CONTRE LES PLANTES AQUATIQUES ENVAHISSANTES DES RETENUES ET COURS D'EAU DE L'ESPACE DE COMPETENCE DE L'AGENCE DE L'EAU DU LIPTAKO (AEL).
VERSION DEFINITIVE

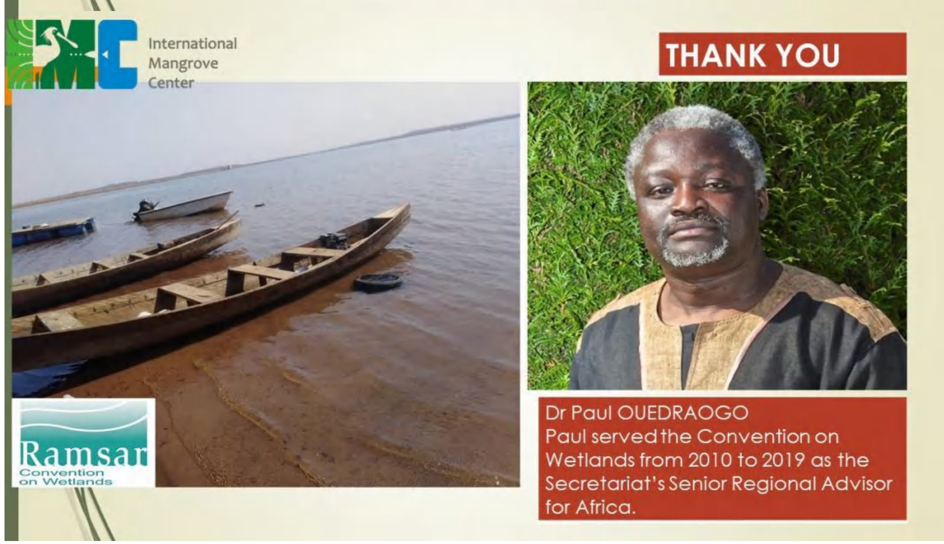

III. RESTORATION AND CONSERVATI
ACTIONS
Ramsar
Convention
on Wetlands
WORLD WETLAND DAY
NATIONAL TREE DAY


III. RESTORATION AND CONSERVATIO
Ramsar
Convention
on Wetlands
Between 2020 and 2023: 970 hectares were reforested on the Samendéni Ramsar site

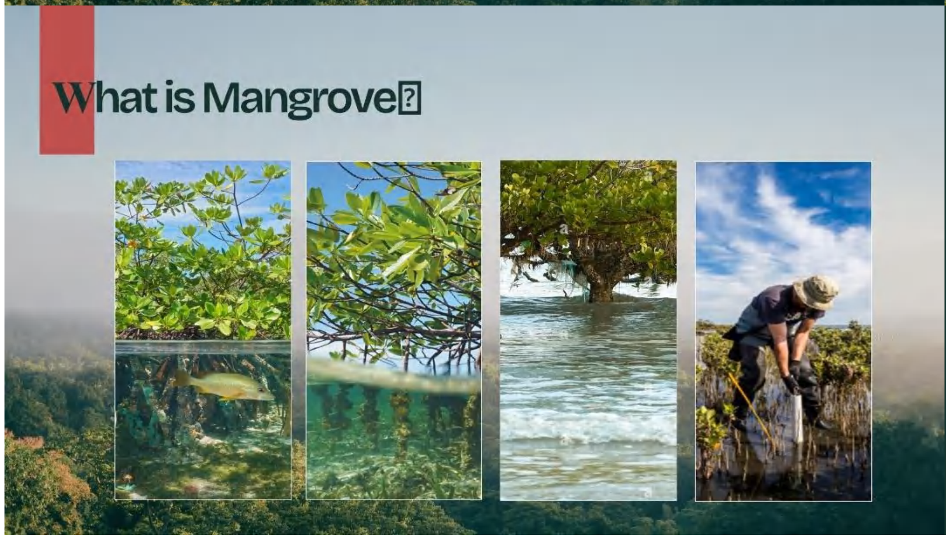

III. RESTORATION AND CONSERV
ACTIONS
Ramsar
Convention
on Wetlands
Mechanical control of invasive plants (*Eichhornia crassipes*) practiced by the Nakanbé Water Agency
WaterAid, the Nakanbé Water Agency, and the local communities are reforesting the banks of the Bougré Dam


III. RESTORATION AND CONSERV
ACTIONS
Ramsar
Convention on Wetlands
IMPLEMENTATION OF WETLAND PROJECTS AND PROGRAMS
✓ Ecosystem-based adaptation (EBA/FEM): 7 000 000 $
✓ Project for the restoration, protection, and enhancement of Bam Lake phase 1 (PRPVL/LB1) : 28 039 761,82 $
✓ Project 'Sustainable Management of Wetlands & Floods for Strengthening Food Security and Ecosystem Resilience in West Africa : 2 363 636,36 $


IV. THE CHALLENGES
Ramsar
Convention on Wetlands
✓ The Financial resources mobilization
✓ The national wetlands inventory


International
Mangrove
Center
THANK YOU
Ramsar
Convention on Wetlands
Dr Paul OUEDRAOGO
Paul served the Convention on Wetlands from 2010 to 2019 as the Secretariat's Senior Regional Advisor for Africa.

Annex 4.2: China



Replantation

Province	Target (ha)	Completion (ha)	Completion rate
Zhejiang	200	147.68	73.84%
Fujian	350	1563.38	446.68%
Guangdong	5500	2778.00	50.50%
Guangxi	1000	795.18	79.51%
Hainan	2000	1919.68	95.98%
Total	**9050**	**7194.92**	**79.50%**

Restoration

Province	Target (ha)	Completion (ha)	Completion rate
Zhejiang	—	44.28	—
Fujian	550	874.28	158.96%
Guangdong	2500	2093.87	83.75%
Guangxi	3500	2232.72	63.79%
Hainan	3200	564.48	17.64%
Total	**9750**	**5809.63**	**59.58%**

Smart Monitoring for Mangrove Conservation in China 天空地"一体化监控网络

•In recent years, China has built integrated "sky–space–ground" monitoring network to strengthen mangrove conservation.

•The South China Sea Bureau of the Ministry of Natural Resources developed a comprehensive system using satellite remote sensing and drone patrols to track mangrove distribution and monitor invasive species.

•On-site surveys are conducted to collect first-hand data.

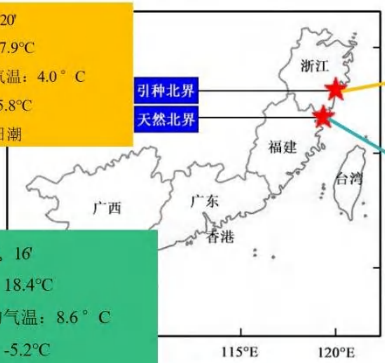
•Regular monitoring in key coastal mangrove areas helps assess community types, habitat features, and ecosystem health, identifying major ecological challenges.

近年，中国各地通过引入智慧化监管技术，搭建起"天空地"一体化监控网络，实现了对红树林的有效保护。例如我了解到，中国自然资源部的南海局为了保护红树林，开发了一整套监控网络。他们会用卫星遥感、无人机巡逻，来观察红树林的分布、监控外来物种的入侵，同时也会派专人走访红树林的生长地区，获取第一手资料。针对红树林海区重点分布区实施常态化监测，动态评估其群落类型、生境特征及健康状况，系统握了面临的主要生态问题，从而实现对红树林的有效监管

Integrated Sky–Space–Ground–Sea Intelligent Monitoring and Early Warning System

地理与气候条件 Geographical and Climatic Conditions in Zhejiang Province

地理位置：28。20′
年平均气温：17.9°C
最低温月平均气温：4.0° C
历史最低温：-5.8°C
潮汐：规则半日潮



Geographical and Climatic Conditions
Location: 28°20′ N
Average annual temperature: 17.9 °C
Average temperature of the coldest month: 4.0 °C
Historical minimum temperature: –5.8 °C
Tides: Regular semidiurnal tide

地理位置：27。16′
年平均气温：18.4°C
最低温月平均气温：8.6° C
历史最低温：-5.2°C
潮汐：规则半日潮

Location: 27°16′ N
Average annual temperature: 18.4 °C
Average temperature of the coldest month: 8.6 °C
Historical minimum temperature: –5.2 °C
Tides: Regular semidiurnal tide

Historical Development of Mangrove Planting in Zhejiang 发展历程

01 Late 1950s – Early 1960s 20 世纪 50 年代末到 60 年代初

- 浙江省进行红树林引种
- 造林，**形成早期浙江省人工栽培红树林**的高潮，此间浙江省总造林面积约 800 hm^2
- Zhejiang initiated mangrove introduction and afforestation, marking the first peak of artificial mangrove planting in the province.
- Total mangrove afforestation area reached approximately 800 hectares.

02 Mid–Late 1980s 20 世纪 80 年代中后期

- 浙江省**强调海岸防护林**建
- 设，掀起了秋茄红树林引种造林的第二个高潮。
- Zhejiang emphasized coastal shelterbelt construction, triggering a second wave of Kandelia obovata (mangrove) planting.

03 1990s – Early 2000s 20 世纪 90 年代至 21 世纪初

- **新一轮的秋茄红树林的引种造林**，累计种植秋茄红树林约 460 hm^2，此间造林保留至今的面积约 30 hm^2。
- A new phase of Kandelia obovata introduction and afforestation began.
- Around 460 hectares were planted, with about 30 hectares remaining today.

04 2013 – Present 2013 年~至今

- 开启了由**海洋部门应用海洋生态补偿和生态修复专项资金**开展的红树林造林，造林面积约 300 hm^2。
- Coastal authorities launched mangrove planting using marine ecological compensation and restoration funds.
- Newly afforested area: approximately 300 hectares.

秋茄 Kandelia obovata

红树科Rhizophoraceae秋茄属，叶片对生，花两两生长在一起。秋茄树层通常高1.5-6米，最高可达10米。果实形状似笔，成熟后跟茄子相似。是红树植物中最能够耐寒的种类，常见分布在福建、浙江、海南、广西、广东等地。

——**温州湾以南**（含温州湾）区域可选择秋茄、桐花树、苦槛蓝、海滨木槿等；——**乐清湾以南**（含乐清湾）区域宜选择秋茄、苦槛蓝和海滨木槿；——**乐清湾以北区域**宜选择苦槛蓝和海滨木槿。

桐花树*Aegiceras corniculatum*

紫金牛科Myrsinaceae桐花树属灌木或小乔木；叶革质；花两性，5数，具柄，排成腋生或顶生的伞形花序。蒴果圆柱形，锐尖，弯如牛角，革质，隐胎生。在广东、广西、福建有大片的大范围分布。

苦槛蓝 *Myoporum bontioides*

苦槛蓝科Myoporaceae苦槛蓝属常绿灌木；叶互生，软革质，无毛；聚伞花序具2-4朵花，或为单花，腋生，无总梗。核果卵球形内含5-8种子；花期4-6月，果期5-7月。分布于日本、琉球、越南北部沿海地区和中国。

海滨木槿 *Hibiscus hamabo*

锦葵科Malvaceae木槿属落叶灌木或小乔木；厚纸质单叶互生，扁圆形、倒卵形或宽倒卵形。花两性，单生于近枝端叶腋。蒴果呈三角状卵形，密生褐色硬毛。花期7-10月；果熟期10-11月。自然分布于日本、朝鲜、浙江舟山群岛和福建沿海岛屿。

Species Selection by Region(in Zhejiang)

·South of Wenzhou Bay (including the bay):
Kandelia obovata, Thespesia populnea, Clerodendrum inerme, Hibiscus tiliaceus

·South of Yueqing Bay (including the bay):
Kandelia obovata, Clerodendrum inerme, Hibiscus tiliaceus

·North of Yueqing Bay:
Clerodendrum inerme, Hibiscus tiliaceus

浙江省红树林营建关键技术--抗寒良种选育
Key Techniques for Mangrove Development in Zhejiang--Selection and Breeding of Cold-Resistant Varieties

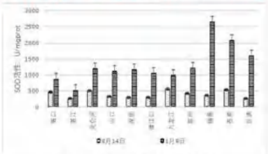


图 4.2 低温胁迫对不同种源秋茄 SOD 活性的影响

Figure 4.2 Effects of SOD in the leaf of *Kandelia obovata* under low temperature stress

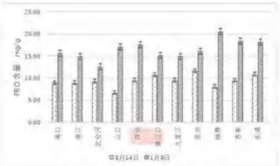


图 4.4 田间试验不同种源秋茄脯氨酸含量影响

Figure 4.4 Effects on PRO content of *Kandelia obovata* in different provenances

种源	回归方程	半致死温度 (LT50)/ °C	拟合度（R^2）
海口	$y=17.669/(1+3.37e^{0.118x})$	-10.3	0.964
湛江	$y=22.249/(1+4.149e0.082^x)$	-14.4	0.982
北仑河口	$y=33.651/(1+6.988e0.169^x)$	-11.5	0.968
山口	$y=35.627/(1+3.197e^{0.117x})$	-9.9	0.969
深圳	$y=47.395/(1+8.755e^{0.148x})$	-14.6	0.977
漳江口	$y=49.219/(1+7.279e^{0.159x})$	-12.5	0.976
九龙江口	$y=32.767/(1+4.487e^{0.168x})$	-9.0	0.948
泉州	$y=43.568/(1+8.037e^{0.169x})$	-12.3	0.972
福鼎	$y=80.165/(1+22.001e^{0.221x})$	-14	0.974
龙港	$y=90.959/(1+16.570e^{0.185x})$	-15.2	0.978
乐清	$y=69.256/(1+25.039e^{0.264x})$	-12.2	0.963

浙江龙港种源秋茄耐寒能力高于其他种源。
The Longgang provenance of Kandelia obovata shows stronger cold tolerance than other provenances.

邓瑞娟，2021

浙江省红树林营建关键技术--宜林地选择 Site Selection for Mangrove Afforestation

高程 (m)	研究区域	成活率(%)	株高(cm)	地径(mm)	叶片数(片/株)	冠幅(cm²)	总生物量(g/株)
2.4	CN	75.20±5.00 a	69.66±1.79 a	29.12±0.97 a	316.69±28.81 a	61.56±2.63 a	309.52±78.60 a
	DT	89.87±3.94 a	58.76±1.24 b	28.05±1.00 a	168.49±10.10 b	45.23±1.45 b	154.91±10.60 b
	YQ	/	/	/	/	/	/
2.2 a	CN	71.20±6.05 a	50.87±1.98 b	21.53±1.08 b	138.43±18.20 a	36.46±2.30 ab	80.66±15.54 b
	DT	54.53±16.21 a	60.22±1.78 a	30.09±0.79 a	131.87±11.67 a	42.22±1.47 a	145.92±13.16
	YQ	64.50±1.76 a	57.47±2.05 a	29.44±1.36 a	60.69±5.81 b	34.13±2.21 b	74.48±16.46 b
2.0 a	CN	45.60±0.69 a	38.89±1.26 b	15.75±0.72 b	46.44±2.92 b	20.33±0.97 b	44.87±10.29 b
	DT	27.07±4.52 b	56.42±1.67 a	26.57±0.86 a	69.42±7.12 a	31.76±1.28 a	128.55±9.46
	YQ	/	/	/	/	/	/
1.8	CN	/	/	/	/	/	/
	DT	9.20±0.80 b	55.38±1.76 b	23.89±1.19 a	45.48±4.33 b	26.18±1.35 b	98.19±6.42 a
	YQ	16.83±8.58 a	44.51±1.47 a	29.54±1.33 a	26.69±5.12 a	27.62±1.67 a	43.73±10.35 b

在浙南地区，红树林应优先选择在85高程2.2 m以上的滩涂，不能低于1.9 m。
In southern Zhejiang, mangroves should be planted on tidal flats above 2.2 m elevation, and not lower than 1.9 m.

红树林生态修复效果Ecological Restoration Effect of Mangroves

树排沙岛Shupaisha Island

2016年

2019年

2018年

2019年

2020年

树排沙岛人工秋茄林群落监测Monitoring of Artificial Kandelia obovata Forest Community on Shupaisha Island

年份	株数（丛）	覆盖率（%）	株高（cm）	草本物种数（种）	草本盖度（%）
2018	94.33±7.08b	65.33±4.58a	52.89±3.03a	4	1.33±0.55a
2019	76.67±5.25a	76.78±3.12b	70.62±3.70b	5	9.83±2.54a
2020	68.78±5.14a	90.56±2.56c	79.81±4.21b	6	24.83±6.63b

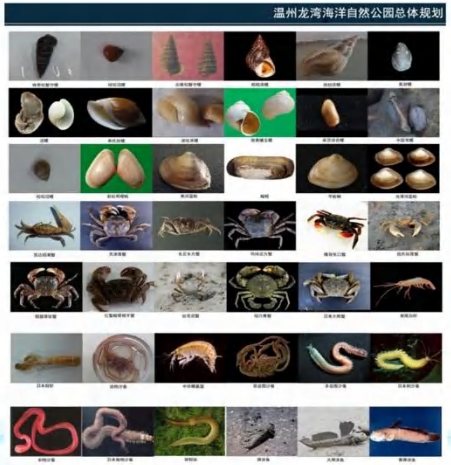
人工秋茄林群落中草本物种数量和盖度逐年增加，到2020年达到显著水平，盖度达90.65%，乡土草本植物回归，盖度达 24.83%，草本植物包括：盐地碱蓬、糙叶薹草、海三棱藨草、芦苇等。

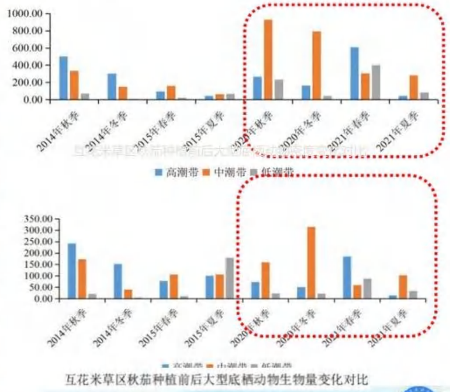
In artificial Kandelia obovata forests, both the number and coverage of herbaceous species have increased annually. By 2020, total vegetation coverage reached 90.65%, with native herbaceous plants such as Suaeda salsa, Carex kobomugi, Scirpus mariqueter, and Phragmites australis returning and reaching 24.83% coverage.

数据暂未发表

在护花米草区种植秋茄后，底栖生物显著增长。

After planting mangroves in former Spartina alterniflora zones, benthic organisms increased significantly.





累计记录到鸟类 12 目 35 科 71 属 121 种，2021年记录到国家重点保护野生动物 17 种（国家 I 级3 种；国家 II 级14 种）；浙江省重点保护陆生野生动物 10 种。

黑脸琵鹭

大滨鹬

黄嘴白鹭

苍南沿浦湾红树林，2016年~2018年，累计种植约84公顷。

Cangnan Yanpu Bay Mangrove Area
Planted about 84 hectares (2016–2018).

龙港新美洲红树林湿地公园Longgang Xinmeizhou Mangrove Wetland Park

2019年列入省级湿地公园，面积约150亩，覆盖度95%，平均株高3.22 m。2021年，审定为省级良种“龙港秋茄母树林种子” Listed as a provincial wetland park in 2019 (95% coverage, avg. height 3.22 m). In 2021, approved as the provincial superior provenance “Longgang Kandelia obovata Mother Tree Seed Source.”

2019 年 3 月，浙江省人民政府批复同意建立温州龙湾海洋特别保护区；
2020年调整为温州龙湾海洋自然公园

Wenzhou Longwan Marine Nature Park

Approved in March 2019 as a Marine Special Protection Area; adjusted to a Marine Nature Park in 2020.

乐清市西门岛海洋特别保护区

1957年便开始红树林引种栽培，是浙江省最早人工红树林引种点。

Yueqing Ximen Island Marine Special Protection Area In 1957 — the earliest artificial mangrove cultivation site in Zhejiang.

洞头霓屿岛红树林

2018年栽植400余亩，造林树种为秋茄，
经过多年培育，贝类、鱼、虾、蟹等海洋生物在区域滩涂重新繁衍，丰富了鸟 类
食物资源，吸引了很多候鸟筑巢栖息。

Dongtou Niyu Island Mangrove Site

Over 400 mu of Kandelia obovata planted in 2018.
After several years, shellfish, fish, shrimp, and crabs recolonized the tidal flats, enriching bird food resources and attracting many migratory species.

Thank You

Annex 4.3: Comoros

Workshop on Mangrove Conservation and Restoration

2 nd to 16 th November 2025

COMOROS,
RAHAMATA AHAMADA,
DGEF/ Karthala National Park

05 NOVEMBRE 2025

PLAN

- INTRODUCTION
- ▶PRESENTATION OF COMOROS ISLANDS
- ACTORS AND THEIR ACTIONS
- CONCLUSION AND OUTLOOK

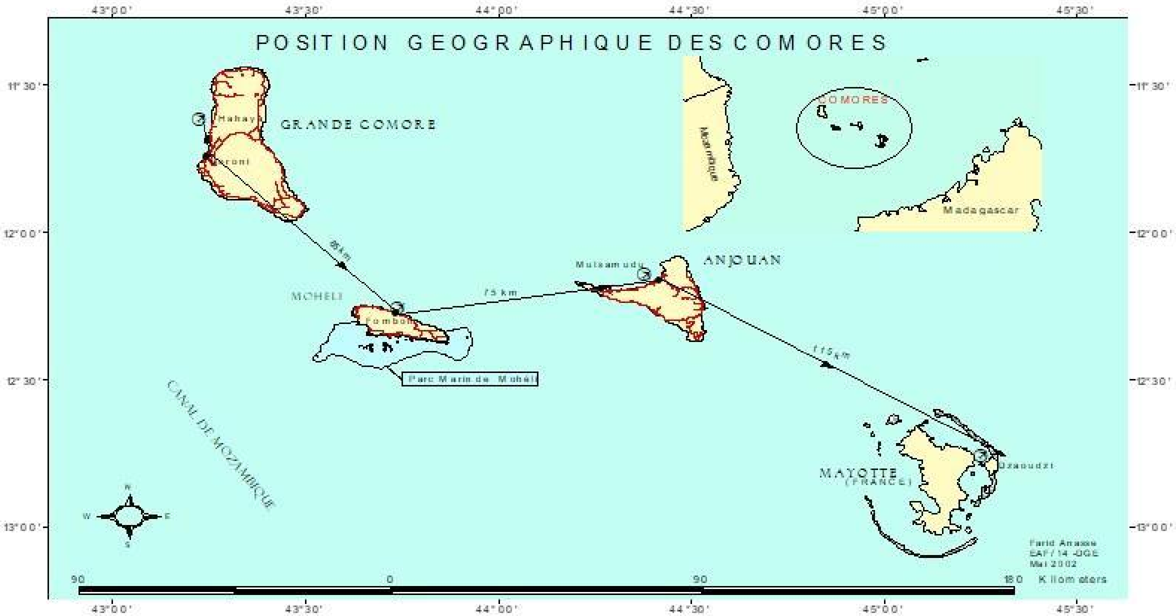
INTRODUCTION

In Comoros, as on many coasts of the western Indian Ocean, the protection and restoration of mangroves are both a conservation priority and an essential climate action, contributing to a more resilient and sustainable future for people and nature.

The conservation of mangroves in the Comoros relies on sustainable projects.
A strong involvement of local communities and awareness initiatives are led by young people. These efforts aim to fight against deforestation, pollution, and the effects of climate change, while strengthening coastal ecosystems.

Presentations of the Comoros Islands

Comoros are 4 islands:

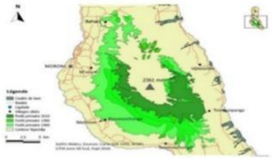


Area: 2 236 km^2

Populations: 867 605 hab

RAMSAR SITES

KARTHALA: 13'000 ha , Ngazidja
Inscription: 12-11-2006
Site N : 1649
Since : 17 year(s)



Le Mont Ntringui: 3'000 ha, Ndzwani
Inscription: 12-11-2006
Site N: 1650
Since: 17 year(s)

RAMSAR SITES

LAKE DZIANI BOUNDOUNI: 30 ha, Mwali
Inscription: 09-02-1995
Site N: 717
Since: 29 year(s)

Official list of Comoros mangrove species

N°	Espèce	Famille APG	Distribution
1	*Avicennia marina* (Forssk.) Vierh.	ACANTHACEAE	Ndz, Nga et Moi
2	*Rhizophora mucronata* Lam.	RHIZOPHORACEAE	Ndz, Nga et Moi
3	*Sonneratia alba* Sm.	LYTHRACEAE	Ndz, Nga et Moi
4	*Lumnitzera racemosa* Willd.	COMBRETACEAE	Ndz, Nga et Moi
5	*Heritiera littoralis* Aiton	MALVACEAE	Ndz, Nga et Moi
6	*Xylocarpus granatum* J.Koenig	MELIACEAE	Nga
7	*Xylocarpus moluccensis* M.Roem.	MELIACEAE	Ndz, Nga et Moi
8	*Ceriops tagal* C.B.Rob.	RHIZOPHORACEAE	Nga et Moi
9	*Bruguiera gymnorhiza* (L.) Savigny	RHIZOPHORACEAE	Ndz, Nga et Moi

Mangrove species of the Comoros

Faunal diversity of mangroves

Threats related to mangroves

The mangroves are affected by diffuse pollution from agriculture and inadequate rainwater and urban wastewater management, as well as by non-biodegradable household waste (plastics, tires), sand accumulation ,urban plannig.plant pests)

Anthropogenic pressures

Natural pressures

Actors and their actions

1. National parks of the Comoros,(GEF/ UNDP):

Pioneer in the protection of marine and terrestrial ecosystems, including mangroves

2. ReSea Project and Inclusion Mission(IUCN):

aims to restore, protect, and enhance mangroves by drawing on local knowledge. It trains and involves young people as guardians of nature and integrates them into the blue economy.

3. NGO:

4. Comoros university:

Mangrove restoration

Conclusion and Prospects

Mangroves; productive biomass and highly threatened. Ecological, socio-economic role, climate change **mitigation.**

- Risk of disappearance if no action is taken.
- Deepen studies on mangroves (vulnerability of mangroves to the climate change)
- dentify sites to be restored, operated and conserved
- mprove the waste management system
- Propose a follow-up of the dynamics and spatio-temporal evolution of Involve local communities in all types of mangrove management Mangroves


AGIR POUR PROTÉGER LES
MANGROVES DE GRANDE COMORE
CEMENTIS
Thank you

Annex 4.4: Cuba

Title: Conservation of Mangroves in Cuba. Experiences to Share

MSc. Yosviel González Rodríguez.

Contents

Location and configuration of the Cuban archipelago as the basis for the mangrove management model

North: Florida Strait
East: Windward Passage.
South: Caribbean Sea
West: Gulf of Mexico

- Total área: 109 886,19 km^2
- 4,195 cays, islets, and adjacent islands.

Main ocean currents:
-Caribbean Current
-Gulf Stream
-Against the Current of Cuba

Location and configuration of the Cuban archipelago as the basis for the mangrove management model

Characteristics of the insular platform:

- **Northern platform:** Wide, shallow, and with numerous cays that form protected lagoon and estuarine systems, ideal for mangroves.
- **Southern platform:** Narrower and with steep slopes in some areas.

Drainage network and river basins:
Short rivers with low flow

Latitudinal position and climate:
- Tropical zone: humid tropical climate, marked by a dry season (November–April) and a rainy season (May–October).

These physical and oceanographic characteristics determine:
- The spatial distribution of mangroves: greater development in protected areas (north and south)

-Vulnerability or resilience to extreme events and climate change.

-The interaction between terrestrial and marine systems is key for the design of coastal ecological corridors and buffer zones.

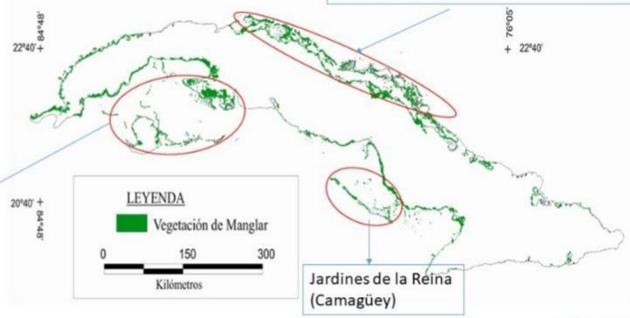
Characteristics of Cuban mangroves

450,000 hectares of mangroves

Good position among the top countries in the world

5% of the country's forested area and 70% of the archipelago's coasts.

Northern coast: it is home to the country's largest mangrove complex (over 3,000 km²).



Ciénaga de Zapata National Park (Matanzas), those of the Los Canarreos archipelago (including the Isle of Youth)

Jardines de la Reina (Camagüey)

Distribution map of the mangrove ecosystem in Cuba

Characteristics of Cuban mangroves

Cuba has the four typical mangrove species of the Caribbean

When they receive considerable amounts of freshwater, they can reach heights of 20 to 25 meters

Types of formations:

- Riverside mangroves
- Fringe mangroves
- Basin mangroves
- Cay Mangroves

Policies implemented in Cuba to conserve mangroves.

Policies created by the Cuban State to protect and conserve ecosystems

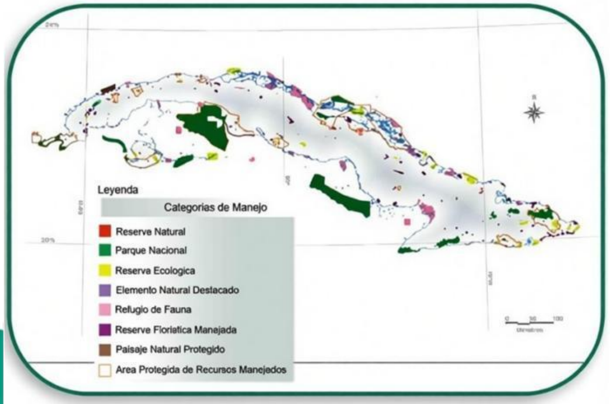
Year/Year of Approval	Policy / Key Project	Main Objective
2021-2029	"My Coast" Project	Massive scaling up of mangrove and wetland restoration along 1,300 km of coastline.
2014-2019	"Living Mangrove" Project	Mangrove restoration pilot laboratory for climate adaptation.
2017	Cuban State Plan 'Life Task'	National strategy for climate change adaptation, prioritizing coastal ecosystems.
2000	Decree-Law No. 212 (Coastal Zone Management)	Spatial planning and delineation of protected coastal areas.
1998	Law No. 85 (Forest Law)	Classification and legal protection of the "Coastal Protective Forests".
1997	Law No. 81 (Environmental Law)	Creation of the general environmental legal framework and basic principles.

Both Manglar Vivo and Mi Costa have placed strong emphasis on community participation as a core principle.

Paradigm shift

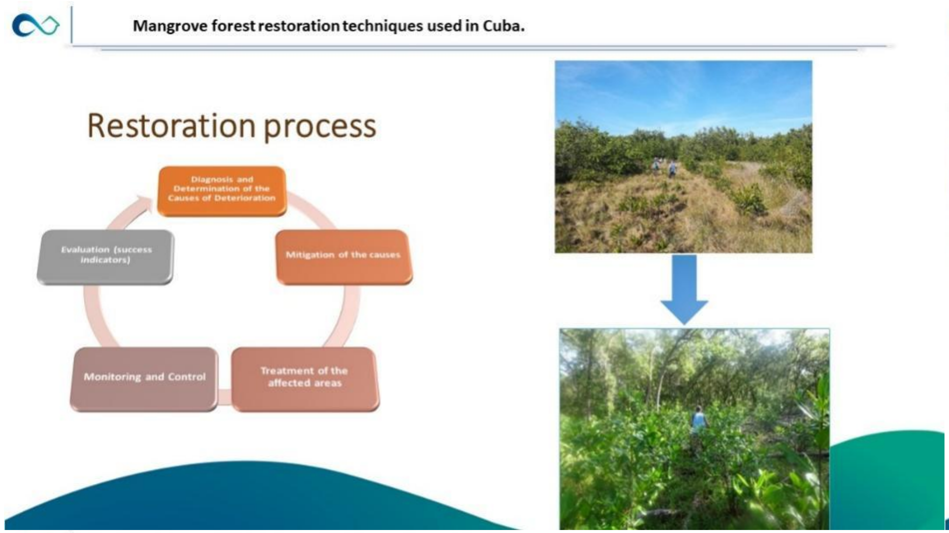
Policies implemented in Cuba to conserve mangroves.

Distribution of areas with different management categories

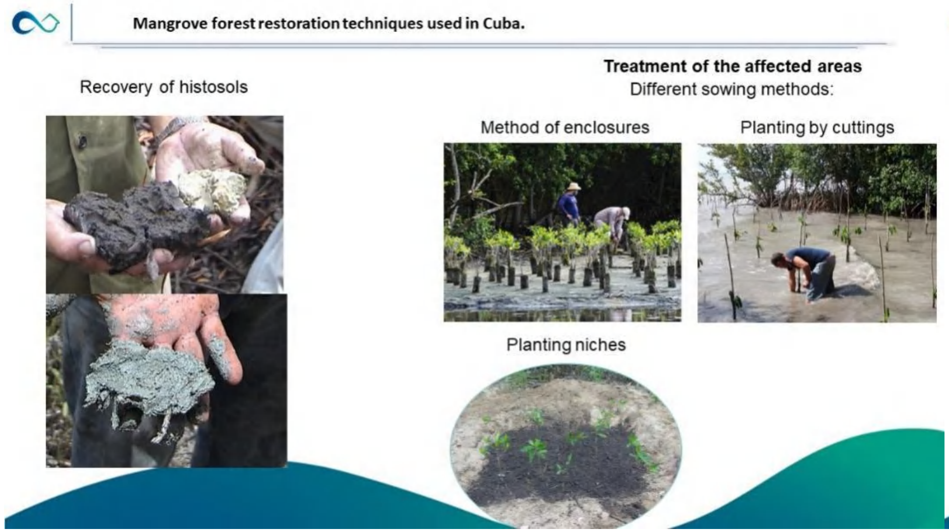


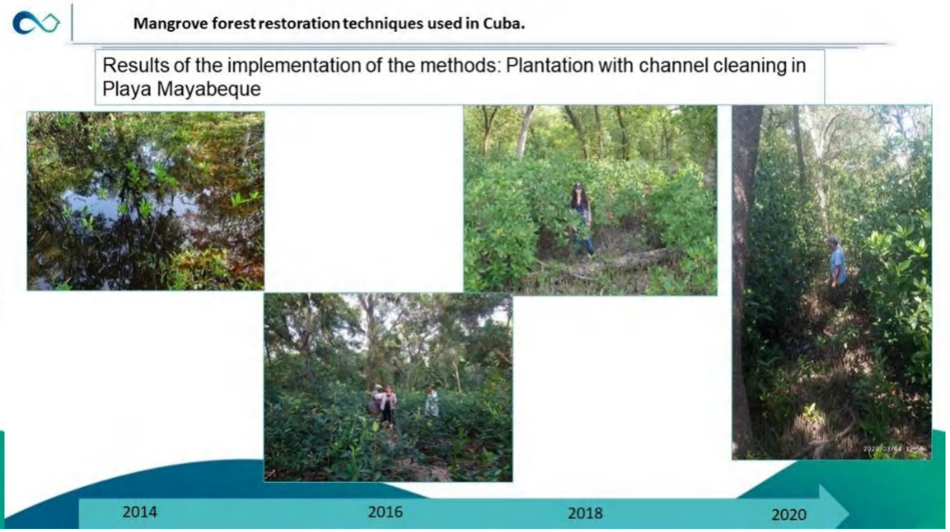
More than 70% of Cuban mangroves are under some category of protected area

Despite local pressures (urbanization, tourism, agriculture), the net loss rate of mangroves has been very low in recent decades, in contrast to other Caribbean countries.


Mangrove forest restoration techniques used in Cuba.
Restoration process
Diagnosis and Determination of the Causes of Deterioration
Mitigation of the causes
Treatment of the affected areas
Monitoring and Control
Evaluation (success indicators)


Mangrove forest restoration techniques used in Cuba.
Diagnosis and Determination of the Causes of Deterioration
Mitigation of the causes
Construction of main and secondary trenches.
- Clogging of channels and ditches
- High salinity levels
- Disruption of hydrological flow


Mangrove forest restoration techniques used in Cuba.
Recovery of histosols
Treatment of the affected areas
Different sowing methods:
Method of enclosures
Planting by cuttings
Planting niches

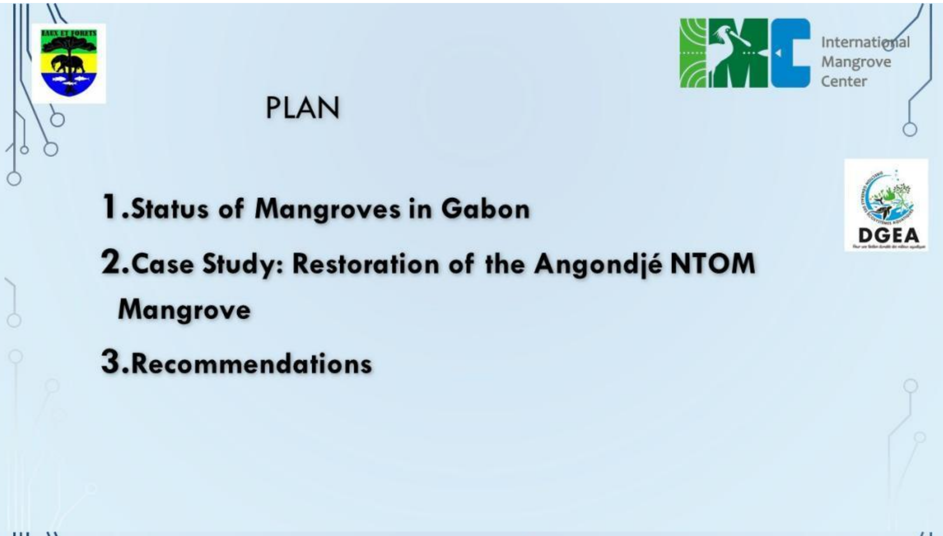

Mangrove forest restoration techniques used in Cuba.
Results of the implementation of the methods: Plantation with channel cleaning in Playa Mayabeque
2014
2016
2018
2020

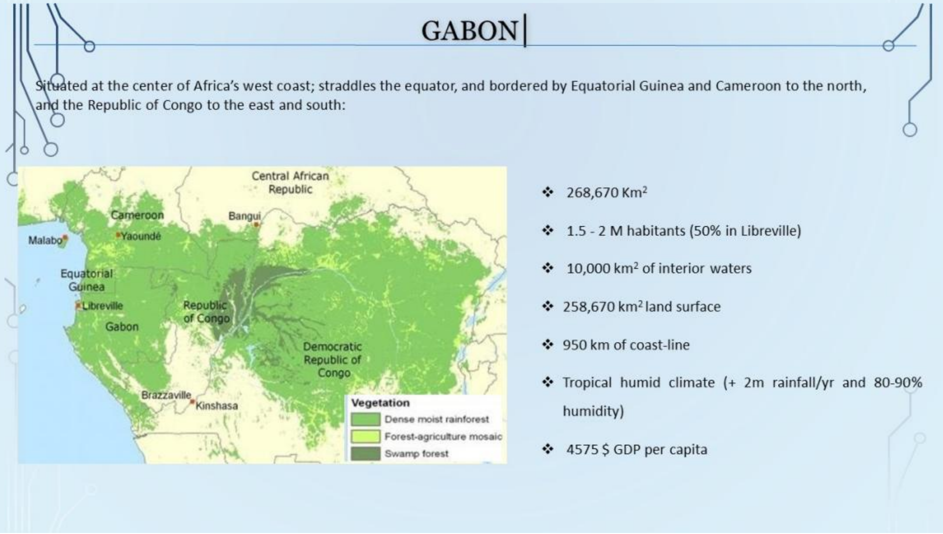
Conclusions.

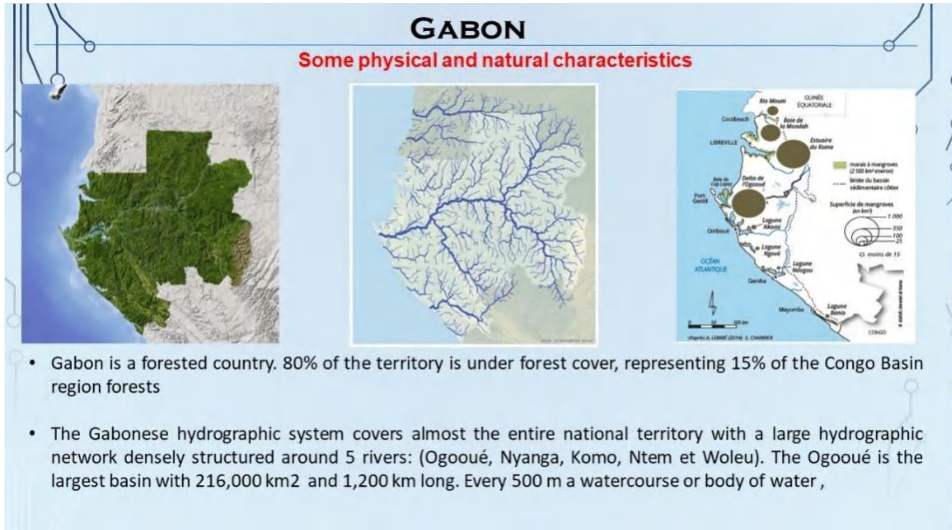
Cuba has established a mangrove management model that is dynamic, strategic, and increasingly based on science and community involvement. The combination of a strong legal framework, a long-term political vision driven by climate change, and the implementation of large-scale restoration projects funded by the international community positions Cuba as a leading actor in mangrove protection in the Caribbean

Thank you so much...!!!

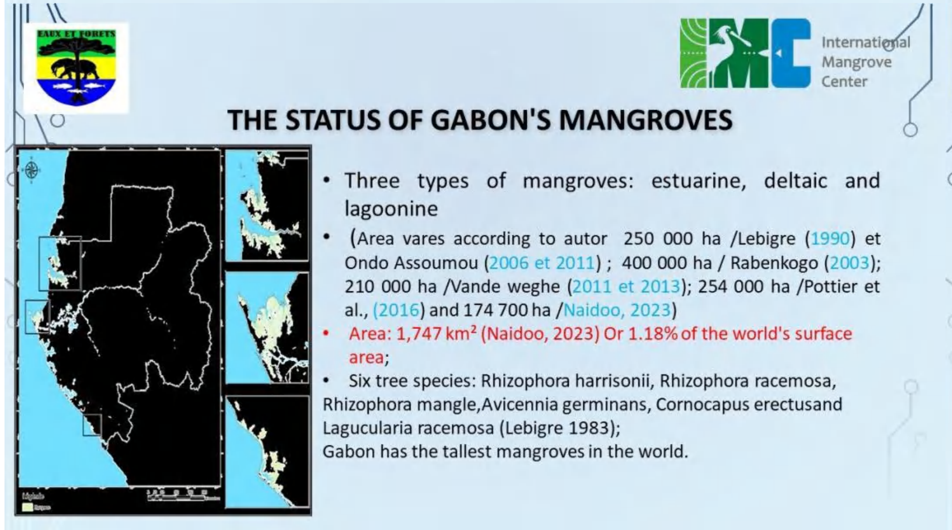
Annex 4.5: Gabon






GABON
Some physical and natural characteristics
• Gabon is a forested country. 80% of the territory is under forest cover, representing 15% of the Congo Basin region forests
• The Gabonese hydrographic system covers almost the entire national territory with a large hydrographic network densely structured around 5 rivers: (Ogooué, Nyanga, Komo, Ntem et Woleu). The Ogooué is the largest basin with 216,000 km2 and 1,200 km long. Every 500 m a watercourse or body of water ,


Gabon| Hotspot de biodiversité
GABON
THE LAST EDEN
NATIONAL GEOGRAPHIC


EAUX ET FORETS
International Mangrove Center
THE STATUS OF GABON'S MANGROVES
• Three types of mangroves: estuarine, deltaic and lagoonine
• (Area vares according to autor 250 000 ha /Lebigre (1990) et Ondo Assoumou (2006 et 2011) ; 400 000 ha / Rabenkogo (2003); 210 000 ha /Vande weghe (2011 et 2013); 254 000 ha /Pottier et al., (2016) and 174 700 ha /Naidoo, 2023)
• Area: 1,747 km² (Naidoo, 2023) Or 1.18% of the world's surface area;
• Six tree species: Rhizophora harrisonii, Rhizophora racemosa, Rhizophora mangle,Avicennia germinans, Cornocapus erectusand Laguncularia racemosa (Lebigre 1983);
Gabon has the tallest mangroves in the world.


EAUX ET FORETS
VARIOUS THREATS TO MANGROVES
International Mangrove Center
• Aquaculture
•Pollution from domestic and industrial discharges
•Urban development
•Uncontrolled construction
•Loss of scientific knowledge on biodiversity
•Industrial and semi-industrial facilities
•Smoking of fish using mangrove wood
•Climate change
•Sedimentation
DIRECTION GÉNÉRALE DES ECOSYSTÈMES AQUATIQUE
Orthophoto mangrove dégradée d'Alénakiri

MEASURES FOR THE CONSERVATION AND RESTORATION OF MANGROVES

International Mangrove Center

General Directorate of Aquatic Ecosystems

- Created by Decree No. 0291/PR/MEF of 18 February 2011 on the allocation and organisation of the Ministry of Water and Forests,

mission:

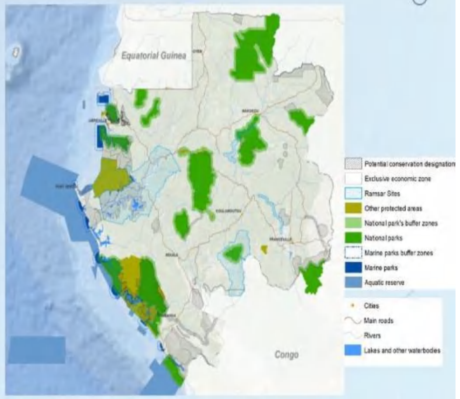
- **To know**
- To preserve
- To restore
- And to enhance knowledge aquatic ecosystems

Conservation measures

International Mangrove Center

- 20 Marine Protected Areas:(27% of EEZ)
- 13 National Parks (Five 11% of the lands surface) throughout the territory;)
- 2 UNESCO World Heritage Sites (Lopé and Akanda, and Ivindo National Park)
- 9 Ramsar Sites (4 of which are in national parks)

An Arboretum (Raponda Walker) 2,000 hectares created in the Mondah Forest (near Libreville);



LES MESURES DE CONSERVATIONS ET DE RESTAURATION MANGROVES

DGEA

At the international level: Conventions

- Convention on Wetlands of International Importance (Ramsar, 1971)
- The Abidjan Convention (1982)
- Convention on Biological Diversity (Rio de Janeiro, 1992)
- United Nations Framework Convention on Climate Change (Rio de Janeiro, 1992)

At the national level: Law

- Law No. 007/2014 on Environmental Protection in the Gabonese Republic
- Law No. 002 on Guidelines for Sustainable Development in the Gabonese Republic
- Law No. 016/2001 establishing the Forest Code in the Gabonese Republic
- Law No. 3/2007 of May 27, 2007, on National Parks
- Law No. 14/63 of 1963 on State Property and the Public Maritime Domain (PMD)
- Law No. 006/2020 of June 30, 2020, establishing the Penal Code

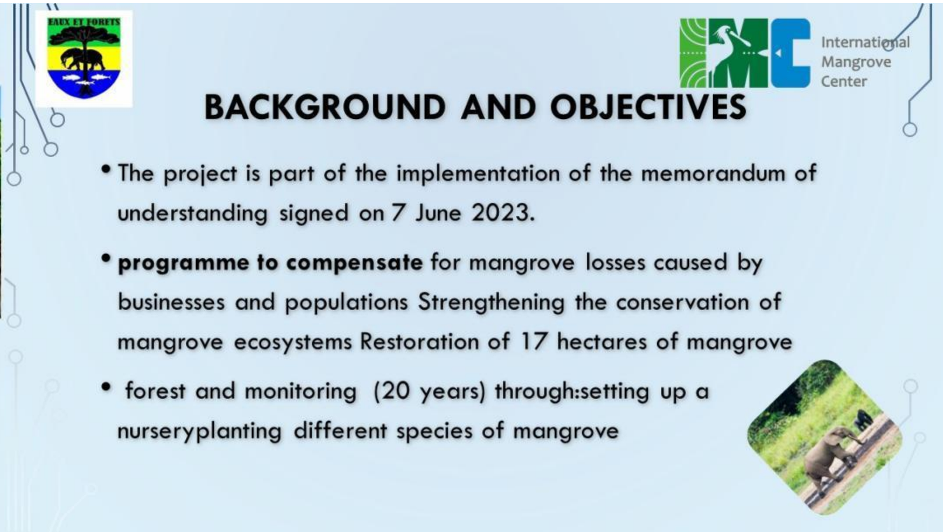
International Mangrove Center

RESTORATION AND CONSERVATION

CASE OF ANGONDJE NTOM MANGROVE

ARISE INTEGRATED INDUSTRIAL PLATFORMS


EAUX ET FORETS
DESCRIPTION
International Mangrove Center
The Angondjé-Ntom mangrove restoration and conservation project, launched in July 2024,aims to restore 17 hectares of degraded mangrove forest and protect an additional 1,000 hectares over 20 years. This project, led by the Ministry of Water and Forests, the ARISE IIP group and other partners, is a joint initiative to offset industrial impacts, combat erosion and climate change, and preserve biodiversity. Concrete actions such as reforestation have already taken place, mobilising various civil society actors.
REPUBLIQUE GABONAISE


EAUX ET FORETS
International Mangrove Center
BACKGROUND AND OBJECTIVES
The project is part of the implementation of the memorandum of understanding signed on 7 June 2023.
programme to compensate for mangrove losses caused by businesses and populations Strengthening the conservation of mangrove ecosystems Restoration of 17 hectares of mangrove
forest and monitoring (20 years) through:setting up a nurseryplanting different species of mangrove


EAUX ET FORETS
ARISE
INTEGRATED INDUSTRIAL PLATFORMS
DGEA
RESTORATION MEASURES
Main activitiesPreliminary site studies (by scientists);
Consultation and awareness raising;
Securing restored sites;
Reforestation and maintenance operations (by NGOs)
Post-restoration monitoring;
Programme coordination and monitoring-evaluation


EAUX ET FORETS
International Mangrove Center
SITE LOCATION
Akanda municipality in Greater Libreville;partly
in the buffer zone of Akanda Park.
Runs along a tributary of the Tsini River which flows into Mondah Bay;
latitudes 0.547400°N and 0.556260°N and longitudes 9.421597°E and 9.431385°E.

AGONDJE NTOM MANGROVE CONSERVATION

STAKEHOLDERS

- **Supervisor**: Directorate-General for Aquatic Ecosystems (DGEA)
- **Institutions**:Directorate-General for the Environment and Nature Protection (DGEPN) Akanda Town
- **HallScientific partners**: Laboratory of Geomatics, Applied Research and Consulting (LAGRAC)IRAF Hydrology and Ichthyology Laboratory
- **Technical partners**: National Agency for National Parks (ANPN) National Agency for Urban Planning, Topographical Works and Cadastre (ANUTTC) Kéva Initiative NGO.
- **Surrounding populations**

DIFFERENT STAGES OF THE PROJECT

- Identification and selection of the site
- Initial assessment of the site (LAGRAC)
- Conducting the socio-economic study
- Public consultation (all stakeholders)
- Technical meetings with DGEA, ANUTT, ANPN;
- Recruitment of the NGO responsible for reforestation;
- Site demarcation;
- Production and installation of information and awareness-raising signs;
- Construction of the nursery;
- Launch of reforestation operations by the Minister of Water and Forests

RESULTS

- 2 nurseries with over 5,000 seedlings established;
- 3 reforestation campaigns
- Avicenia: 3 ha
- Languncularia: 1 ha
- Rhizophora: 9 ha
- 3.5 ha of Avicenia and Languncularia regenerating naturally thanks to cleaning and monitoring

CHALLENGES ENCOUNTERED

The bad weather that slowed down the process;
The collapse of the greenhouse followed by the loss of seedlings;
The availability of propagules and seeds.
The destruction of seedlings by crabs;
The underestimation of costs, which led to a slowdown in field activities.

OUTLOOK

- Appoint individuals to regularly monitor the site, based on jointly defined indicators.
- Education and Awareness: Implement educational programmes for local communities on the importance of mangroves and sustainable practices.
- Strengthen the nursery in order to continue reforestation.
- Strengthened partnerships:
- Collaboration with environmental and local institutions

RECOMMANDATIONS

- **Recommendations:**
- Support for the conduct of a mangrove inventory
- Strengthening scientific and technological capacities
- Support for the development of a mangrove restoration standard
- Creation of a network of research stations (reference sites)
- Support for the centralized data management, storage, and system
- Enhance the value of restored sites
- Material support: drones, satellites, sensors, boats, camera traps, etc

Annex 4.6: Guinea

THE REPUBLIC OF GUINEA

Geographical location

- The Republic of Guinea is a coastal country located in West Africa. It is limited to:
- In the north, by Senegal and the Republic of Mali;
- To the south, by Sierra Leone and Liberia;
- To the east, by Côte d'Ivoire and the Republic of Mali;
- To the west by the Atlantic Ocean and Guinea Bissau.

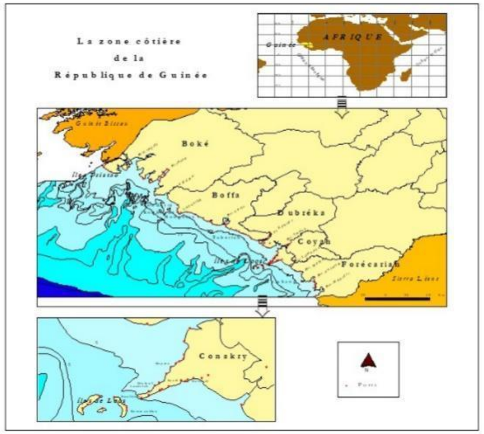
- **Population: the population is around 13,000,000 inhabitants (population census 2024) composed of several ethnic groups**
- **Languages: there are several languages spoken; but there are three that are main: the Soussou, the Fulani, and the Malinke.**
- **The official language is French**
- **Socio-economic activities: the main activities carried out by the population are: agriculture, livestock, fishing, handicrafts, and trade.**

Surface

The country covers an area of 245780 km2.

The country has 300 km of coastline covering six prefectures corresponding to six distinct mangrove areas

The mangrove area in Guinea is estimated at 182,472 ha, which represents 25% of the mangrove cover in West Africa (West Africa Blue 2023).



Faunal diversity of mangroves

Guinea's mangroves are home to biologically rich life forms and are among the most important biodiversity hotspots in West Africa. Faunal groups encountered include: 11 species of reptiles, 5 species of mammals (e.g., hippos), 38 species of birds (e.g., pelicans), 16 species of fish (A variety of commercial fish species, including

snappers, emperors, groupers, catfish, tilapia, milkfish, crabs, molluscs and mullets), several insects (such as bees). In addition, there are 4 species of seagrass beds.

Photos of the Guinean mangrove

Floristic diversity

The Republic of Guinea has five (5) main mangrove plant species. See Table

Family	Scientific name	Local name	IUCN Status
Acanthaceae	Avicennia germinans	Woofiri	NT
Combretaceae	Laguncularia racemosa	Mapeka/Totoni	LC
Rhizophoraceae	Rhizophora harrisoni	Kinsi gbeli	LC
Rhizophoraceae	Rhizophora mangle	Kinsi gbeli	LC
Rhizophoreceae	Rhizophora racemosa	Kinsi gbeli	LC

Socio-economic activities in mangroves

The communities bordering the mangroves practice the following activities:

Fishing

Salt extraction

Rice Farming

Exploitation of wood for service and energy

Possible solutions

To mitigate the anthropogenic pressure on the mangroves, there have been development projects in certain mangrove areas such as the Bay of Sangarea in Dubreka, the West Africa Blue Project in Boffa and Forécariah. These activities included:

- For the extraction of salt, there was training and popularization of the use of solar tarpaulin.

Mise enplace des bâches écoles

Récolte de sel

Sel recolté

For rice cultivation, we have considered building protective dikes to block the seawater in the crops; for it is the seawater that acidifies the soil and renders it unproductive, and the populations are forced to go elsewhere to clear new land.

See photos;

For fish smoking, it has been envisaged to train and popularize improved stoves which greatly reduce the amount of wood to be used for fish smoking.

See photo

To mitigate the exploitation of mangrove wood, it is envisaged to create community plantations with fast-growing species chosen in common agreement with the communities that will serve them over the long term of the timber exploitation sites.

In addition, communities are involved in the restoration of mangroves.

See photos

Perspectives

In order to sustain the activities of the projects carried out and to extend these mangrove mitigation activities to all stands, we intend to establish mangrove restoration and conservation programs as follows:

Develop and implement mangrove restoration and conservation projects;

Delimitation and securing of mangroves;

Development of surveillance posts and inspection trails in the mangroves.

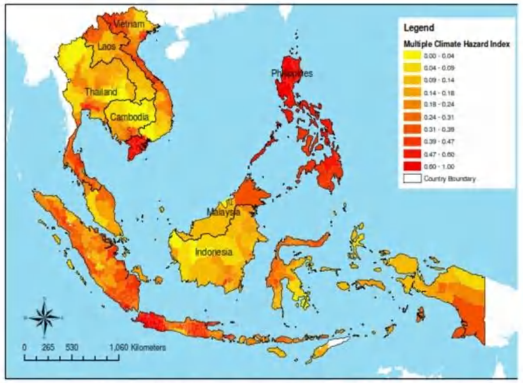
Installation of research and seed quality improvement centres.

THANK YOU FOR YOUR KIND ATTENTION

Annex 4.7: Lao PDR

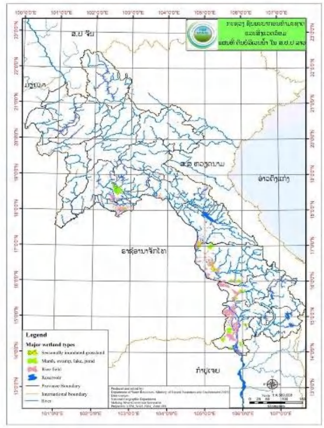
Outlines

- Overview of Wetlands in Lao PDR
- Legal and Policy Framework
- Institutional Framework
- Ramsar Governance
- Threats and Challenges
- Way Forwards



Overview of Wetland Management in Lao PDR

- A total area of the wetlands in Laos has been estimated 1,082,600 ha (5% of total area of the country)
- Major wetland types:
  - Seasonally inundated grassland
  - Marshes, swamps, lakes, ponds
  - Rivers / Streams / Reservoirs
  - Rice fields



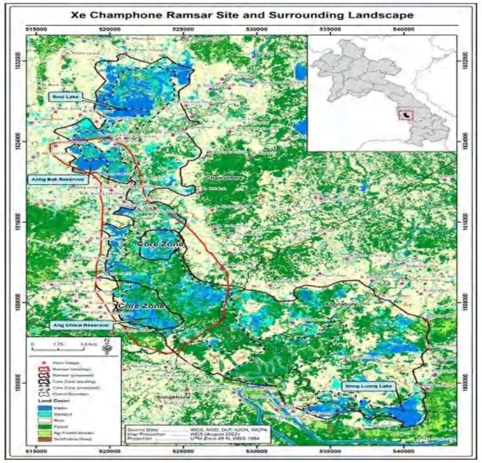
Legal and Institutional Framework

- **Ministry of Agriculture and Environment (MAE)** supervises overall responsibility for national wetland management
- **Department of Water Resources (DWR)** is technically responsible for all wetlands, peatland including Ramsar sites, in coordination with line agencies and communities
- Water and Water Resources Law, (Amended 2017, 2020)
- National Water and Water Resources Management Strategy 2030
- Land law (Amended 2019),
- National Land Allocation Master Plan (2018)
- River Basin Management Plans (2022)
- Environment Protection Law (2012)
- Forestry law (2019), Agricultural law (1998)
- Xe Cham Phone Ramsar management plans (2023)
- Beung Khet Ngong Ramsar management plans (2023)
- Wetland regulations for some specific sites
- Decree on Wetland Management (2024)
- Report on State of Wetland in Lao PDR (2024)
- Vision 2040, Plan on Wetland Management and Utilization 2026 – 2030 (2025)

Ramsar Governance

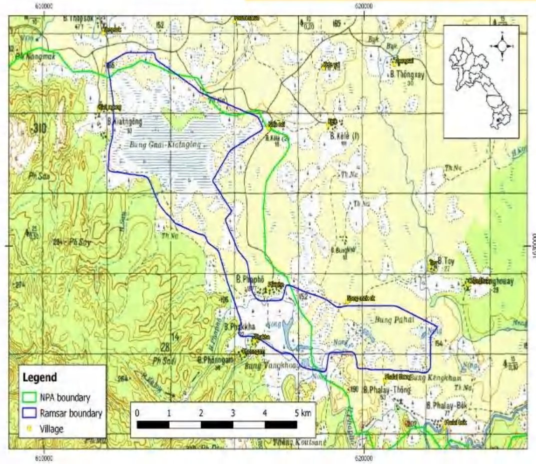
- The convention entered into force in Lao PDR on September 2010 (2 sites)
- 1 Ramsar National Committee (2011)
  - Chaired by the Vice Prime Minister
  - Involvement of Minister of former MoNRE and fromer MAF and 5 other ministries (Now we combine as Ministry of Agriculture and Environment – MAE)
  - Secretariat under DWR
  - 2 Committees in Savannakhet and Champasak provinces, coordinated by Provincial DAE
  - Ramsar implementation teams at provincial & district levels

Xe Cham Phon Ramsar Site



- Location: Champhone district, Savannakhet province
- Ramsar site: 12,400 ha
- 16 Villages in Ramsar area
- Population estimated: 21,579 people and 3,526 household (2022)
- Livelihoods: farming, fish farming, livestock rising, other cultivations, handicraft, labor, trading, NTFP harvest, etc.,
- Management plan approved 2023

Buang Kiat Ngong Ramsar Site

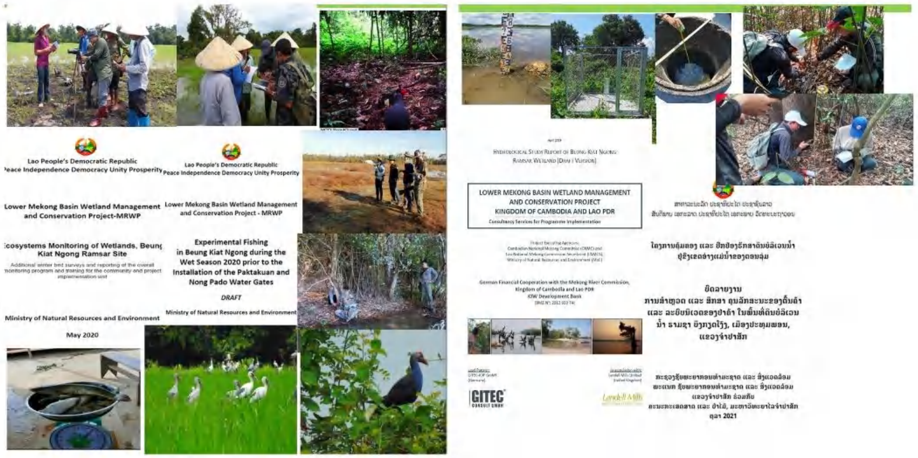


- Location: Phathomphone district, Champasack province
- Ramsar site: 2,360 ha
- 8 Villages in Ramsar area
- Population estimated: 9,397 people and 2,185 household (2022)
- Livelihoods: farming, fish farming, livestock rising, other cultivations, handicraft, labor, trading, NTFP harvest, etc.,
- Management plan approved 2023

Threats and Management

- Encroachment
- Hunting and over harvesting
- Invasive species
- Habitat degradation
- Hydrological modification
- Climate change
- Pollution

Some activities



Some activities

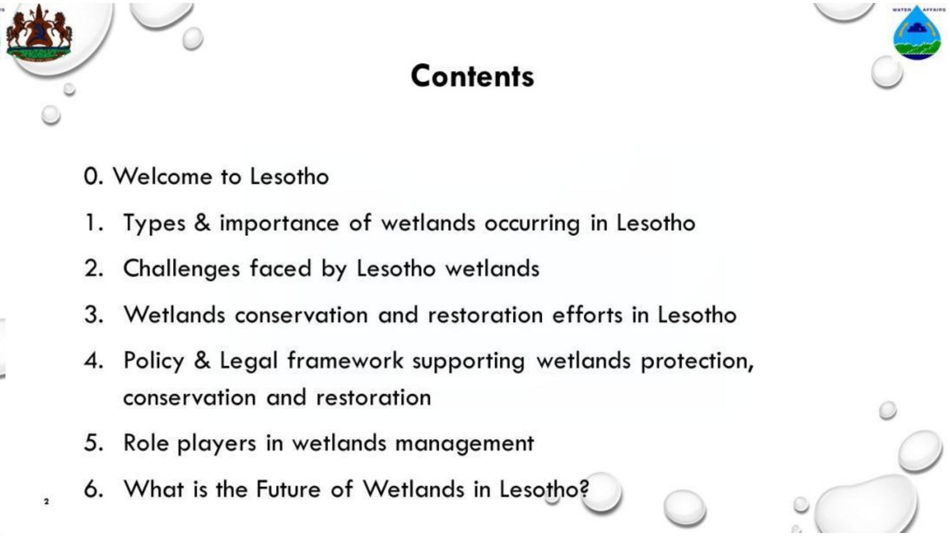
Some activities

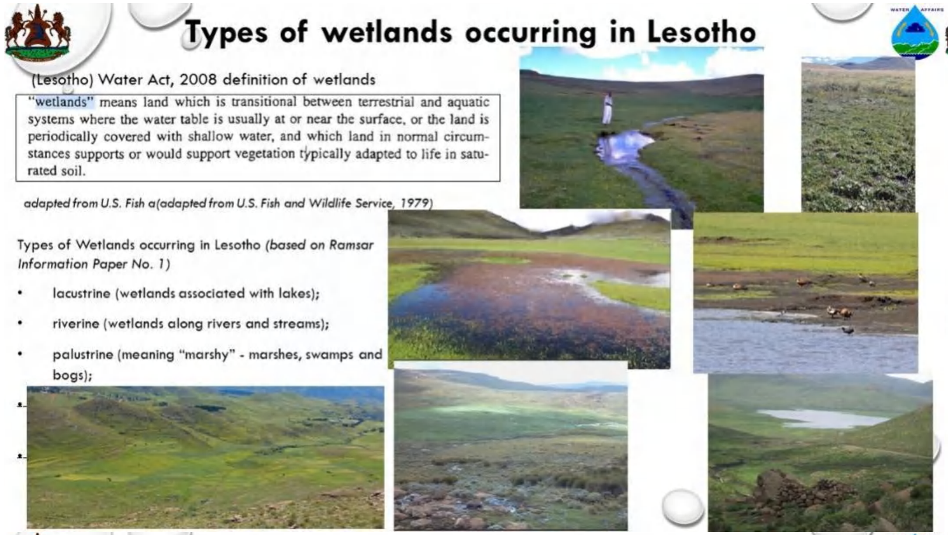
Some activities

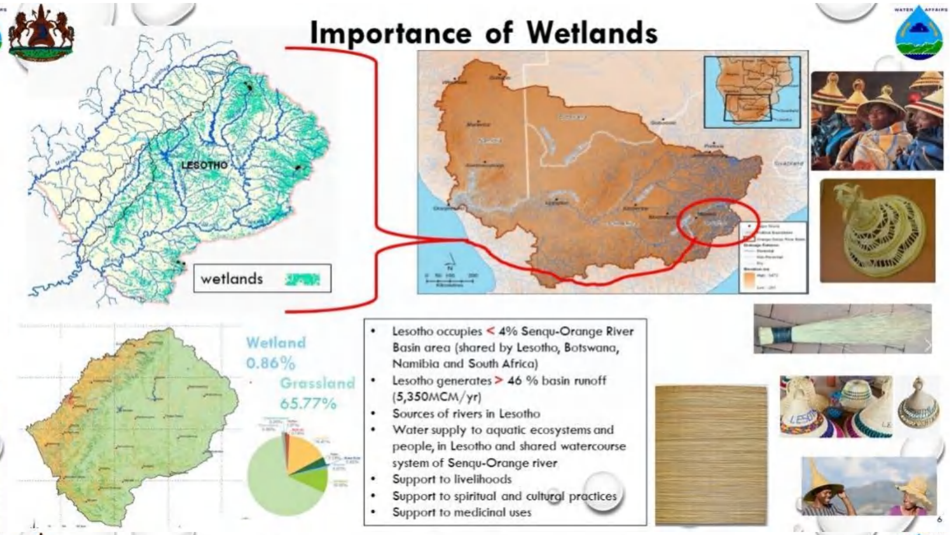
Way forward

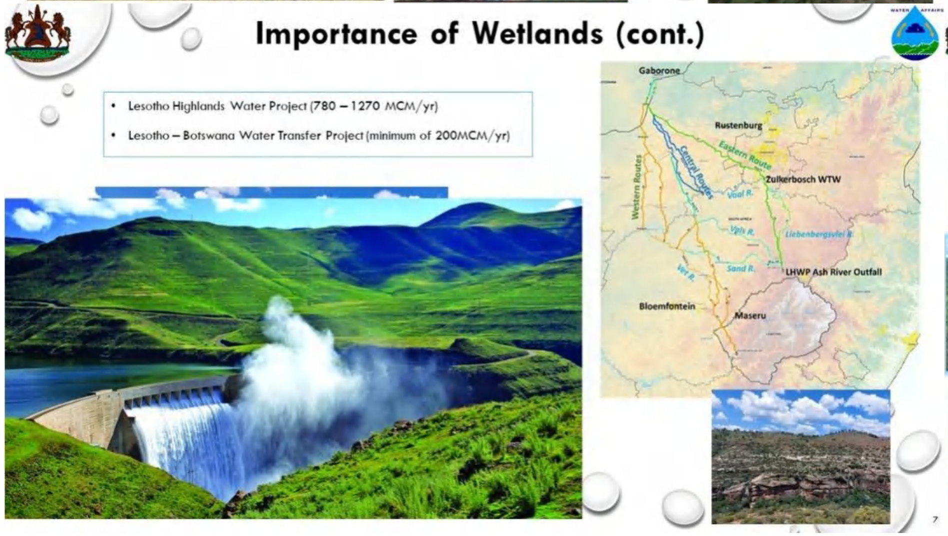
- Awareness raising and capacity building
- Wetland demarcation
- Regulation formulation and enforcement
- Livelihood improvement
- Integrated management of Ramsar sites and other wetlands
- Propose for additional Ramsar sites: Siphandone, Nongkhamsen, Beungsanan, etc.

Annex 4.8: Lesotho




Types of wetlands occurring in Lesotho
(Lesotho) Water Act, 2008 definition of wetlands
"wetlands" means land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.
adapted from U.S. Fish a(adapted from U.S. Fish and Wildlife Service, 1979)
Types of Wetlands occurring in Lesotho (based on Ramsar Information Paper No. 1)
lacustrine (wetlands associated with lakes);
riverine (wetlands along rivers and streams);
palustrine (meaning "marshy" - marshes, swamps and bogs);


Importance of Wetlands
LESOTHO
wetlands
Wetland
0.86%
Grassland
65.77%
Lesotho occupies < 4% Senqu-Orange River Basin area (shared by Lesotho, Botswana, Namibia and South Africa)
Lesotho generates > 46 % basin runoff (5,350MCM/yr)
Sources of rivers in Lesotho
Water supply to aquatic ecosystems and people, in Lesotho and shared watercourse system of Senqu-Orange river
Support to livelihoods
Support to spiritual and cultural practices
Support to medicinal uses

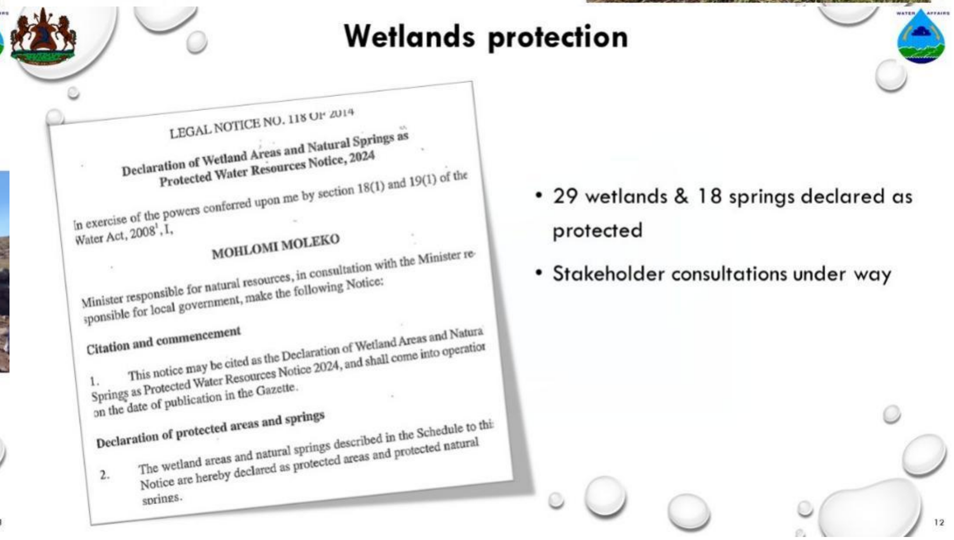

Importance of Wetlands (cont.)
Lesotho Highlands Water Project (780 – 1270 MCM/yr)
Lesotho – Botswana Water Transfer Project (minimum of 200MCM/yr)
Gaborone
Rustenburg
Eastern Route
Central Routes
Western Routes
Zuikerbosch WTW
Vaal R.
Liebenbergsvlei R.
LHWP Ash River Outfall
Bloemfontein
Maseru


Challenges faced by wetlands
Degradation
Encroachment by settlements, agriculture
Overgrazing
Burning
Land use planning


Wetlands conservation, rehabilitation & monitoring

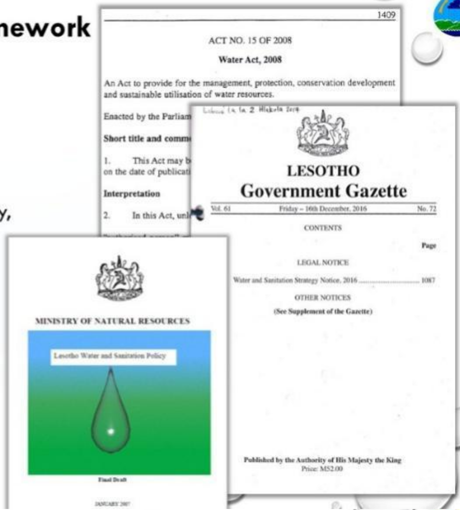

Wetlands rehabilitation
2024
2025
renoka.org
Community engagement
2023


Poor landuse planning
• Stakeholder consultation & engagement
• Coordination & collaboration


Wetlands protection
LEGAL NOTICE NO. 118 OF 2024
Declaration of Wetland Areas and Natural Springs as Protected Water Resources Notice, 2024
In exercise of the powers conferred upon me by section 18(1) and 19(1) of the Water Act, 2008, I,
MOHLOMI MOLEKO
Minister responsible for natural resources, in consultation with the Minister responsible for local government, make the following Notice:
Citation and commencement
1. This notice may be cited as the Declaration of Wetland Areas and Natural Springs as Protected Water Resources Notice 2024, and shall come into operation on the date of publication in the Gazette.
Declaration of protected areas and springs
2. The wetland areas and natural springs described in the Schedule to this Notice are hereby declared as protected areas and protected natural springs.
• 29 wetlands & 18 springs declared as protected
• Stakeholder consultations under way

Wetlands Policy & Legal Framework

- Lesotho Water and Sanitation Policy, 2007
- Water Act, 2008 & (Water Resources Management Bill, 2025)
    - Provide for wetlands identification, inventory, protection, rehabilitation, conservation, including declaring wetlands as protected areas
- National Wetlands Conservation Strategy
- SADC Protocol on Shared Watercourses
- RAMSAR Convention on Wetlands
- …..



13

Who are the players in wetlands management?

- Government
- Communities
- Non-Governmental Organisations and Community Based Organisations
- Academic and research institutions
- The private sector
- Development Partners and Agencies

14

What is the Future of Wetlands in Lesotho?

- Improved coordination & collaboration
- More science based, systematic approaches in planning and implementing wetlands management efforts
- Improved communication, visibility and awareness raising strategies and plans

15

谢谢
Kea leboha

Annex 4.9: Liberia

Why wetlands Matter

Cover ~30% of Liberia's coastline and urban landscapes

Provide flood protection, biodiversity habitats, and fish nurseries

Natural defenses against climate change(erosion, storm surge, flooding)

Critical for public health & urban resilience

Existing legal instruments

- Environmental Protection and Management Law of Liberia 2003 Sections 74 and 75
- The Environment Protection Agency Act of 2002
- The Wetland Policy Document of 2014

Ensuring Sustainable Environmental Management

The National Wetlands Taskforce

- **Executive Mandate**
- Established by Executive Order No. 143 (Feb 24, 2025)
- Direct mandate from President Joseph Nyuma Boakai
- **Purpose:** Halt degradation of wetlands, waterways & beachfronts
- National Taskforce chaired by the Environmental Protection Agency of Liberia

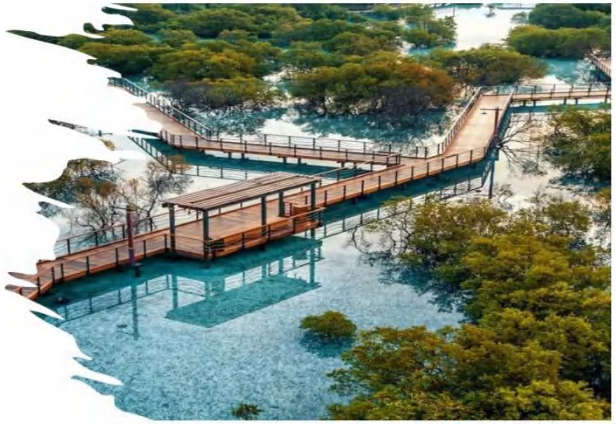
Ensuring Sustainable Environmental Management

Objectives of the Taskforce

- Preservation: Protect wetlands as national ecological assets
- Economic growth: Unlock eco-tourism & job opportunities
- Climate resilience: Saves billions in disaster costs
- Governance: Enforce laws & clarify land tenure
- Community benefits: Healthier spaces, cleaner water, fisheries

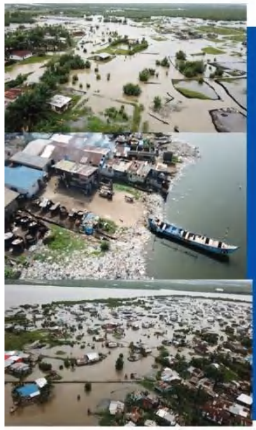
Ensuring Sustainable Environmental Management

Vision for Ecotourism



Ensuring Sustainable Environmental Management

Current Challenges



- Plastic waste pollution choking waterways
- Backfilling & illegal construction destroying mangroves
- Soil degradation & erosion threatening livelihoods
- Loss of huge hectares of mangroves each year
- Declining fish catches linked to wetland destruction

Strategy: Align Mangrove Conservation to national development agenda

Ensuring Sustainable Environmental Management

Alignment with national priorities

- Supports the national development agenda referred to as the ARREST Agenda for inclusive development (Resilience, Environment, Jobs)
- Supports livelihood activities
- Strengthens compliance with Ramsar, Paris Agreement, CBD
- Enhances urban resilience in in all coastal regions
- Enhancing protection effectiveness of blue carbon landscapes (mangrove) critical for **carbon market projects**.

Ensuring Sustainable Environmental Management

National Mangrove Inventory (NMI)

- The National Mangrove Inventory has been conducted and just concluded in October 2025
- This inventory was conducted under a project called the Blue Oceans Program by the University of Liberia
- This is the first time to collect nationwide real time data on the country's mangrove ecosystems
- The NMI was able to identify, discover and highlight new information on Liberia's mangrove ecosystems
- The NMI also provided information on social economic activities of mangrove community dwellers

Ensuring Sustainable Environmental Management

List of identified mangroves species vegetation and associates

True Mangrove Species	Mangrove Associates	Faunal Species	Non-mangrove terrestrial/fresh water plants
Rhizophora racemose	Annona glabra	Tympanotonos fuscatus	Machaerium lunatum
Rhizophora mangle	Cyrsobalanus icaso	Creassostrea tulipa	Pterocarpus santalinoides
Avicennia germinans	Canocarpus erectus		Pandanus candelabrum
Avicennia Africana	Acrostichum aureum		Ixora nimbana
Avicennia officinalis	Dalbergia ecastaphyllum		Eichornia crassipes
Lagucularia racemose			Pycnanthus spp

Ensuring Sustainable Environmental Management

Liberia's Sinoe County Mangrove Ecosystem

Ensuring Sustainable Environmental Management

Liberia's Sinoe County Mangrove

Ensuring Sustainable Environmental Management

Assessing Liberia Mangrove in hard to reach terrain

Ensuring Sustainable Environmental Management

Mangrove assessment, Sinoe County, Liberia

Ensuring Sustainable Environmental Management

IMC Focal Point, Joseph F. Charles and colleagues in the field

Ensuring Sustainable Environmental Management

RECOMMENDAIONS FROM NMI

- Strengthen Mangrove Conservation Policies and Enforcement
- Conservation and Restoration: - Promote Species Diversity Through Restoration
- Develop Alternative Livelihoods: - Address Drivers of Deforestation
- Implement Pollution Control and Hydrological Management: - Improve Water Quality and Reduce Land-based Pollution
- Enhance Community Engagement, Awareness and Participation
- Monitoring and Further Research: - Strengthen Data, Monitoring and Future Research

Ensuring Sustainable Environmental Management

Mzou, Mbadeka

Ensuring Sustainable Environmental Management

Annex 4.10: Madagascar

1. OVERVIEW: Advantages and opportunities

> 8,000 Ha
of **restoration potential area**

82.6M USD/Year
to the **country's economy**

303Mt CO2e
stored

41-74%
of **annual CO2 emissions** from **fossil fuels** stored

> 2 million (6%)
people whose **livelihoods sustained** (including **women & youth**)

2. OVERVIEW: Key driver of mangrove degradation

Mangrove deforestation: overall loss between 3,000 Ha and 7,000 Ha per year from 1995 to 2018, totalling about 74,050 Ha during this period

Climate change and sea-level rise

Human factors:

- Overharvesting of wood
- Conversion to agriculture and aquaculture
- Urbanization and infrastructure development
- Pollution and sedimentation
- Unsustainable fishing practices

1. OVERVIEW: Key challenges

- Lack of infrastructures: Access, signs (boundary, prohibition)
- Lack of adapted CEPA tools
- Data collection and management
- Land conflict
- Weak governance and lack of law enforcement
- Limited capacities of key stakeholders
- Lack of financial resources

2. MAIN INITIATIVES WITH GOOD PRACTICES AND LESSON LEARNED

- Forest and Landscape Restoration strategy&mapping of potential areas
- National strategy for integrated management of mangrove (2022-2032)
- Restoration comittee (2016), Mangrove thematic group (2024)
- More mangroves in protected areas & community-based mangrove management areas
- Empowering women & youth

- Various researches
- Social & local medias
- Adapted tool kits
- Periodic follow-up & surveillance
- Drone
- Remote sensing & GIS

- Hydrological restoration (drainage canal)
- Local nursery
- Drone seed dropping
- Improved crab farming & artisanal fisheries

- Sustainable mangrove value chains (crab, shrimp, honey, ecotourism, blue carbon, etc.)
- Business incubation & acceleration
- Recipes with improved nutritional value by using mangrove products

2. MAIN INITIATIVES WITH GOOD PRACTICES AND LESSON LEARNED

Drone Seed Dropping for Mangrove restoration

Species: *Avicennia marina*
Seed dropping: 1 ha in 10 minutes
Load capacity : 15 to 20 kg seeds/flight
Type of seeding drone: GAIA 90, Hexacopter

Success rate: 60 to 70%

Very practical for hard-to access areas, results 10 times higher with less person mobilized

Source: Ministry of Environment and Sustainable Development in Madagascar 2024

2. MAIN INITIATIVES WITH GOOD PRACTICES AND LESSON LEARNED

MANGROVE NATIONAL STRATEGY and ACTION PLAN

The strategy is based on five orientations:

- Restoration of mangrove multifunctionality;
- Development of research and improvement of knowledge management on mangroves;
- Valorization of natural resources in mangroves as natural capital;
- Increased funding and development of the partnership for the implementation of the action plan;
- Improving institutional and local governance.

3. INTERNATIONAL COOPERATION: International Mangrove Center (IMC)

International Mangrove Center

Platform for research and expertise, bringing together scientific knowledge & traditional wisdom to design and implement real world solution

Promoting dialogues

Improving international cooperation

Incubating pilot projects

Scaling up best practices

Strengthening & valuing knowledge and capacity

3. INTERNATIONAL COOPERATION: Mangrove Conservation Foundation (MCF) 2024-2026

The first environmental conservation foundation with public fundraising certificate launched by civil society in China dedicated to protecting wetlands and their biodiversity

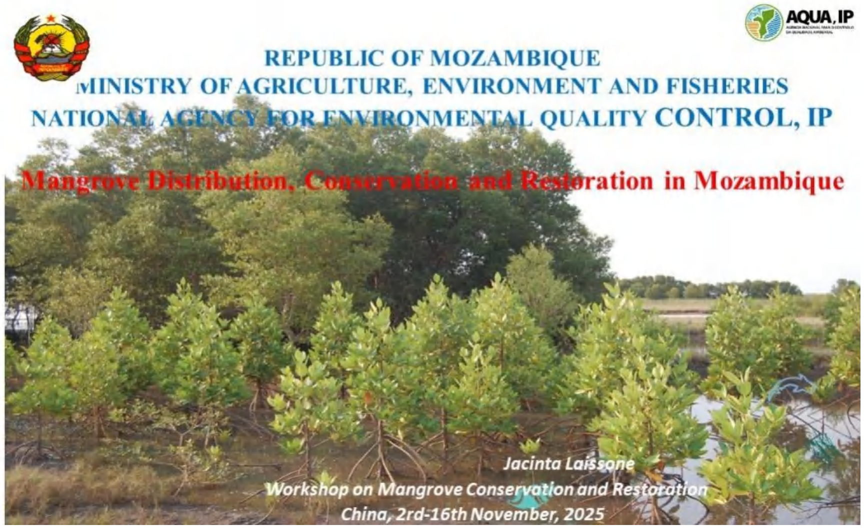
The cooperation aims to enhance collaboration between the Parties in mangrove restoration, management and wise use, through technical support, capacity building, CEPA

3. INTERNATIONAL COOPERATION: Hainan international Blue Carbon Research Center (HiBC) June – October 2025

Hainan International Blue Carbon Research Center has the main responsibilities in Science and policy research, pilot and demonstration, exchanges and collaborations

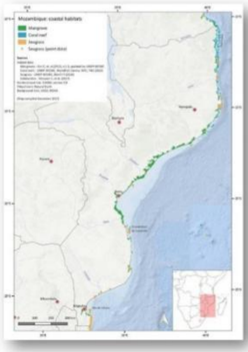
The collaboration is centered around a joint research project designed to assess the current state of BCE conservation and management in Madagascar, to document and analyze community-based approaches to mangrove protection, promote knowledge exchange and academic cooperation between Madagascar and China and identify pathways to integrate mangrove conservation with local livelihood development

Annex 4.11: Mozambique



CONTENTS

I. INTRODUCTION



In Mozambique, mangroves ocorre in all 07 coastal zones provinces with approximately 396,080 hectares and more than 50% of mangroves are concentred on Zambeze river Delta and around Quelimane city with aproximately 200km in the coastal area and about 50km in interland.

Mozambique has 9 sps: *Avicennia marina, Bruguiera gymnorrhiza, Ceriops tagal, Heritiera littoralis, Lumnitzera racemosa, Rhizophora mucronata, Sonetaria alba, Xylocarpus granatum* e *Xylocarpus moluccensis.*

THE IMPORTANCE OF MANGROVES

WETLANDS (Ramsar)

In parallel, Mozambique possesses a vast area of wetlands, approximately 36% of which is equal to or greater than 500 hectares (MITADER, 2019), and has two areas of international importance:

1. **The Marromeu Complex- declared in 2004** (due to its large number of African buffalo, hippopotamus, zebra, lion, and a rich avifauna, including about 20% of the world's population of cock-of-war cranes and various species of pelicans, herons, and cormorants and its role as a breeding ground for various species of aquatic birds).

2. The Lake Niassa Partial Reserve -declared a Ramsar site in 2011.

The first wetland of international importance in Mozambique-Marromeu National Reserve

Water birds fly on the floodplains

Autor: Daniel Rosengren, 24 October, 2024

Buffaloes in the floodplains

Autor: Daniel Rosengren, 24 October, 2024

II. LEGISLATION

Mozambique's environmental legislation is a pillar for the protection of coastal ecosystems, through laws such as:

✓The Environmental Law (Lei 20/1997); is being revised to grantee the inclusion actualy dinamics of impacts of climate changes and human dinamics.

✓The Forest Law (Lei 17/2023);

✓The Biodiversity Conservation Law (Lei 5/2017); and

✓Strategic and National Action Plan of Mangrove Management (2020-2024) in revision.

- The Governer implementing mangroves restoration in all coastal provinces in partnership wich ONGs and OCB manily those that are working in coastal zones.

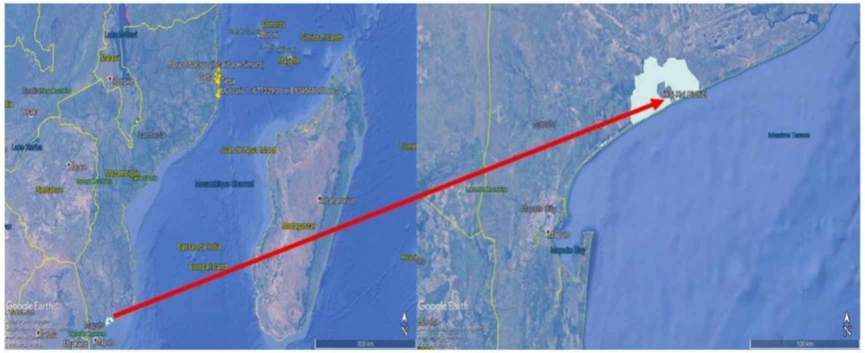
III. MANGROVE DEGRADACTION

In Mozambique the estimated total area of mangrove losted is aproximately 15.910ha in the last 24 years (1996-2020):

Causes:

1. Extraction of wood for charcool prodution, urbanization, among olhers.
2. Impacts of ciclones and floods. The anual lose is estimated in 17 há (Saket e Matusse, 1994), while olher autors estimated in 88ha (Fatoynbo et al., 2013).

IV. CASE STUDY: LIMPOPO RIVER ESTUARY



Tecnics Used for Mangrove Restoration

- ➢Topographic survey;
- ➢Hydrological channels restoration;
- ➢Establishment of Nursery for Mangrove Seed and seedling production;
- ➢Planting (Mangrove restoration);
- ➢Monitory; and
- ➢Research

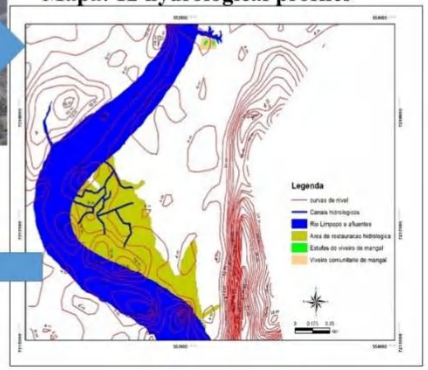
Description of the Study Area

Mangal degradado After floods (2000)

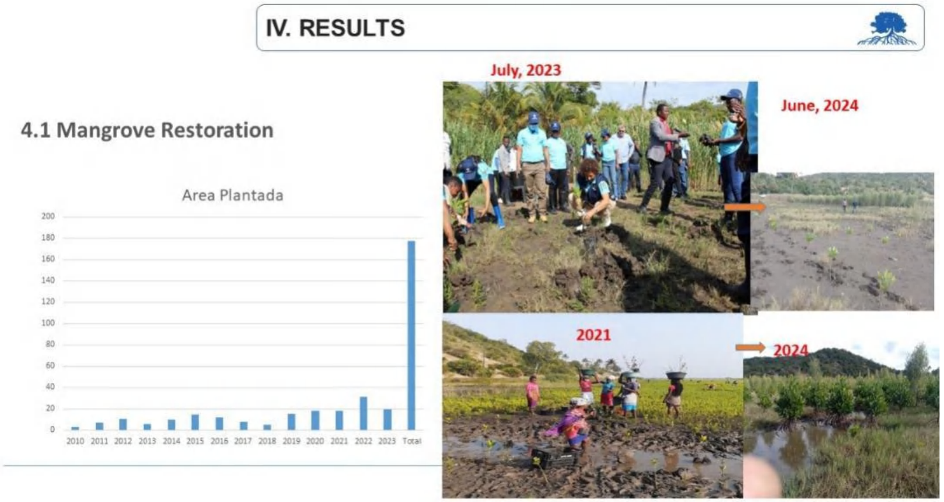
1. **Population: 35.000 Hb**
2. **Total Mangrove Area- 932 Ha**
3. **2000- Floods**
4. **More than half of the mangrove area was submerged in fresh water for 45 days**
5. **About 382 hectare losted.**

- **Mangrove restoration - Data collecting for topographic survey was carried out in an area of 15 ha**

Mapa: 12 hydrological profiles




Capacity: 60.000 seedlings
Mangrove protection from crabs


IV. RESULTS
4.1 Mangrove Restoration
Area Plantada
0
20
40
60
80
100
120
140
160
180
200
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 Total
July, 2023
June, 2024
2021
2024


Local Community Engagement
• More than 2000 community members and schools are envolved Training and Environmental Education, those about 80% were women;
• Public instituitions and civil society are so envolved in diferent activities


Alternative Liverhoods
Pig criaction started in 2022: 10 pigs and benefit community members. Now are 53 new beneficiary. Many of them they had all red sold e buy same domestic materials.
Fish trade
Raising chickens for egg production: total of: Chickens: 1440 Beneficiaries: 226 Nr of chickens p/person: 6
Beekeeping: 216 hives –100 lts – the money supports conservation activities: Nursery maintenance, forest monitory, ...

V. CHALLENGES AND PRESPECTIVES

- ✓ Ensuring long-term mangrove sustainability;
- ✓ Establish partnership with Institute of research in Blue carbon to study the stocks of Blue Carbon in mangrove forest;
- ✓ Create forests of native and exotic species where local communities can obtain firewood and construction materials;
- ✓ Ensure the integration of the mangrove ecosystem into local primary schools;
- ✓ Inforce of financial resources

VI. PARTINERS AND AKNOLEGMENTS

- ✓ UNEP/Nairobi Convention,
- ✓ GEF
- ✓ USAID (RESLIM and AWARD)
- ✓ University Eduardo Mondlane/Dpto of Biological Ciency
- ✓ Local Structures and Authorities, Local communities, including NRMC
- ✓ IMC

Annex 4.12: Samoa

Mangroves of Samoa

Status, Importance, Threats & Conservation

Prepared by:
Marine Conservation Section
Division of Environment & Conservation (DEC)
Ministry of Natural Resources & Environment (MNRE)

Contents

- Background
- What are Mangroves?
- Adaptations
- Mangroves of Samoa
- Distribution of mangroves species
- Characteristics of mangrove species
- Mangrove zonation
- Importance of mangroves
- Threats and Impacts
- Conservation Initiatives
- Case study: Vaiusu Bay Mangroves
- Case study: Saanapu-Sataoa Conservation

Background:

- MNRE is primarily responsible for the sustainable development and management of Samoa's natural resources and environment. The work is mandated under various legislations, regulations, policies and multilateral environmental agreements.
- The overall objective of the Marine Conservation Section (MCS) is *Sustainable development and management of marine biological resources and the environment.*
- 5 Main Components of the MCS:
  - Ecosystem conservation & management eg. mangroves & coral reefs
  - Species conservation & management eg. turtles, whales, sharks, dolphins
  - Establishment of Marine protected areas/sanctuary eg. Palolo deep
  - Implementation of Conventions eg. CBD, CITES, RAMSAR
  - Awareness and Information Programs

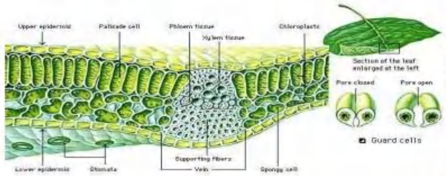
What are Mangroves?

- Mangroves are trees or shrubs, growing more than 0.5meters in height that live between the land and sea.
- Mangrove ecosystems are commonly found along the sheltered coastlines where sediments are deposited, such as estuaries.
- They have the ability to adapt to the environmental conditions such as high salinity, low oxygen, poor nutrient availability and substrate mobility.


Adaptations:

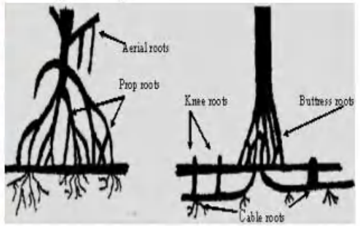
Mangroves are able to adapt to the different environmental stresses through:

- **Preventing water loss:** leaves have a thick-walled epidermis covered by a waxy cuticle which acts like a waterproof skin. Leaves have a fleshy structure containing layers of water storing cells called **spongy cells**.



Adaptations:

- **Specialized root structures:** lack of oxygen and the constant changing of tide means that mangroves to have to adapt to these situation.
  - Breathing roots called "pneumatophores" which help with the air exchange when roots are exposed above the water and mud.
  - Intertwining masses of the roots help anchor the tree from being eroded by the changing tides and waves eg. *Rhizophora sp.*

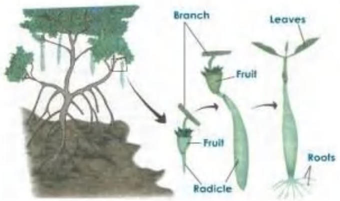


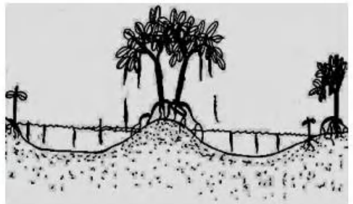
Adaptations:

- **Ability to excrete and exclude salt:**
  1. **Exclusion:** roots take up only water but exclude the bulk of the salt.
  2. **Extrusion:** excess salt is excreted through special glands on their leaves which gets washed away when it rains.
  3. **Accumulation:** excess salt is accumulated in older leaves and bark which fall off getting rid of the salt.
- Different species remove salt using the above mechanisms.

Adaptations:

- **Specialized reproduction:** embryo germinates while still attached to the parent tree into a seedling, afterwards the seedling either drops and takes root or floats until it takes root in a favorable muddy shore. This reproduction method is called **viviparity**.





Mangroves of Samoa

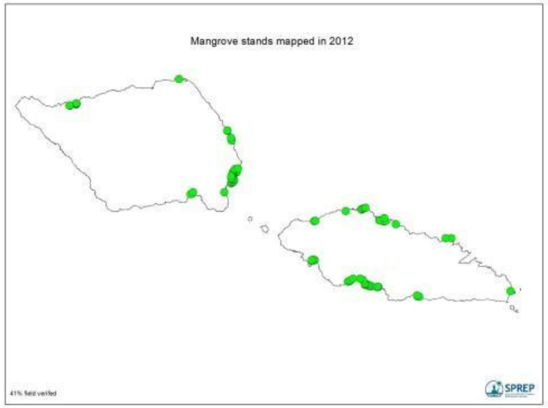
- Over 80 mangrove species are found worldwide, only 3 are found in Samoa. However, recent surveys conducted by DEC under the Mangrove Ecosystems for Climate Change Adaptation and Livelihood (MESCAL) confirmed 2 additional Species. Total mangroves species found in Samoa is now 5.
- The largest mangrove area in Samoa is the Vaiusu Bay mangrove area, extending from the Mulinu'u Peninsula to Fugalei, Vaitoloa, Vaiusu and part of Vaitele .

Species Name	Common Name	Status
Rhizophora samoensis	Red/Female mangrove	Common
Bruguiera gymnorhiza	Oriental/Male mangrove	Common
Xylocarpus granatum	White mangrove/Puzzle-nut	Rare
Acrostichum speciosum (new)	Swamp fern	Common
Pemphis acidula (new)	Reef mangrove	Rare

Map of Vaiusu Mangrove Bay

Distribution of Mangroves:

- Total area of mangroves = 217.85 hectares & found on Upolu & Savaii. However, there are more mangrove sites that are yet to be included.



Characteristics of mangrove species of Samoa

1. *Rhizophora samoensis* (Red mangrove)

- Stilt roots which allows the mangroves to survive from the changing tides.
- Flowers are whitish yellow in colour
- Tips of leaves are blunt
- Seedlings are usually longer & thinner

Stilt roots

2. *Bruguiera gymnnorrhiza* (Oriental/Male mangrove)

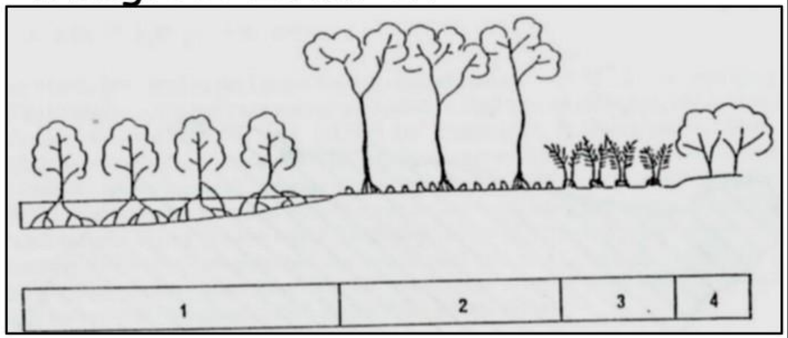
- Thick vertical buttress roots growing around the trunk and knee-like roots that grow up above the mud surface.
- Flowers are reddish, pale yellow, white or green in colour
- Tips of the leaves are pointed
- Seedlings are shorter and fatter

Knee-like roots

3. *Xylocapus spp* (White mangrove)

- Rare mangrove with biggest stand found in Salailua, Savaii
- Leaves are oval shaped
- Flowers are creamy white in colour
- Seeds are round

Mangrove Zonation

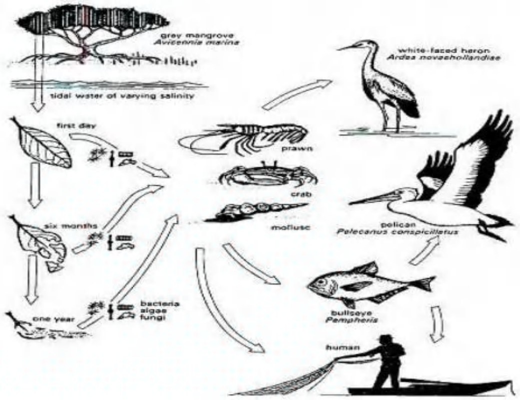


1. *Rhizophora Zone*
2. *Bruguiera Zone*
3. *Fern Zone*
4. *Beach Hibiscus & Coastal Forest Zone*

Importance of Mangroves:

Ecological Values:

- Mangroves are one of the starting points of the food chain of marine & seashore life.



Importance of Mangroves:

Ecological Values:

- Provides shelter & nursery grounds for a vast range of marine & terrestrial wildlife.

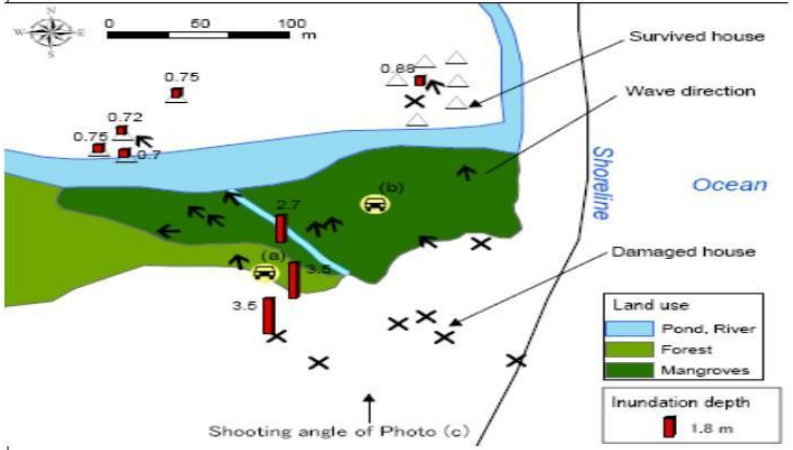
Importance of Mangroves:

Ecological Values:

- Shoreline & lagoon protection – filter water & trap debris (sediments/nutrients/rubbish) before reaching the coral reef and seagrass beds.
- Stabilizes coastal areas from erosion especially during storms, hurricanes and tsunami.

Example of shoreline protection: Malaela Mangroves Before & After Tsunami in 2009

Post tsunami assessment of Malaela



Importance of Mangroves:

Community Values:

- Provide food source for surrounding communities.
- Oysters, prawns, mud crabs and various species of fish are caught or collected for everyday subsistence.

Importance of Mangroves:

Community Values:

- Marine resources associated with mangroves also have commercial value.
- Crabs, prawns, clams and fish are caught/collected and sold at the local fish market or along the side of the roads.
- In developed countries, commercial fishing industries place a high value on mangrove resources such as prawns.

Importance of Mangroves:

Community Values:

- Support eco-tourism providing income for local communities
- Firewood as fuel for cooking
- Timber for building houses and canoes
- Medicines for various illnesses eg. sores
- Colouring dyes

Threats & Impacts:

Human Activities:

- Rubbish disposal in and around mangrove areas especially by industries and companies
- Pollution of area leads to poisoned ecosystems and the spread of diseases


Threats & Impacts:

Human Activities:

- Large areas of mangrove swamps and forests have been reclaimed to create more land for the increasing population and developments.


Threats & Impacts:

Human Activities:

- Excessive clearing and cutting of mangroves for various uses eg. Firewood and construction materials.


Threats & Impacts:

Natural Phenomenon:

- Cyclones and strong storms can generate strong winds and wave action that can topple and uproot mangrove trees.
- Heavy rainfall can lead to high discharge of rivers and streams leading to flooding.
- Tsunami can also uproot and destroy large areas of mangroves.


Threats & Impacts:

Natural Phenomenon:

- Pigs can also cause damage to mangrove areas especially when they dig up the seedlings that are starting to establish into mangrove plants.

Conservation Initiatives:

Establish mangrove reserves or protected areas:

- As reserves or protected areas mangroves would be fully protected by law
- Allows for easy governance and management of mangrove resources

Conservation Initiatives:

- Mangrove Ecosystems for Climate Change Adaptation and Livelihoods (MESCAL)
- 4 years project which also involves Fiji, Tonga, Solomon Island and Vanuatu
- **Aim:** increase the resilience to climate change for the people of the Pacific Island Countries.

MESCAL
SAMOA

- Research
- Mapping of mangroves
- Development of a specific law for the protection and sustainable management of mangroves in Samoa.

Conservation Initiatives:

Re-habilitation Programs:

- Promote the re-planting of mangrove seedlings or juvenilles in areas that have been degraded.

Conservation Initiatives (cont)

Stop habitat destruction:

- Stop the disposal of rubbish into mangrove areas
- Stop the reclamation of mangrove areas
- Stop the excessive cutting and clearing of mangroves

Establish legislations:

- Develop specific laws regarding the use and management of mangrove resources
- Enforce legislations for the effective management of mangroves

THANK YOU
Any Questions?

Conservation Initiatives:

Public Awareness:

- It is important to inform and educate the public on the important values of mangroves and the harmful impacts of our actions.

Annex 4.13: Sierra Leone

Sierra Leone Country Report on Mangrove Conservation and Restoration Effort

By Yatta H. Kamara
National Protected Area Authority

Second IMC Workshop, November 2025

Outline

2

Brief Introduction on Sierra Leone Mangroves

Cross Section Map of Sierra Leone Showing the 4 MPAs with mangroves within

- Sierra Leone with a coastline of 560 km needs to be effectively managed as a source of revenue generation for the country
- A total of 7 species of mangroves are found along our coast. Rhizophora mangrove species dominant across the MPAs (R. racemosa, R. harrisonii and R. mangle); Other species include Avicennia germinans; A. africana, Laguncularia racemosa, and Conocarpus erectus
- A new species of mangrove has been discovered but yet to be announced
- 60,000ha of mangrove lost sine 1990-2020
- 150,000ha of mangroves along the coastline need to be protected
- These mangroves are found within Marine Protected Areas (MPAs) but inadequate resources to monitor and enforce their protection

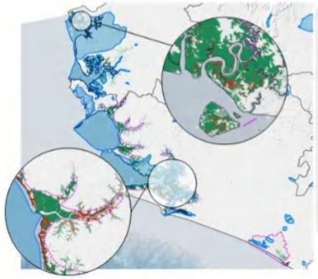
3

Brief Intro Continues

Map Showing Description of Mangroves Status

Our Aspiration

Intact | Degraded | Protected | To be protected



~Plan to Protect 150,000 ha of mangroves and 270,000 ha of coastal areas effectively

To restore 20,000 ha of degraded mangrove areas by 2030

This will be achieved through…

- **Demarcation of additional mangrove and wetland areas** through partnerships between NPAA, local stakeholders and other ministries
- **Feasibility study** to determine ecosystem suitability
- **Continuous mangrove tracking and maintenance** through innovative model
- **Income generated** from carbon sequestration credits sold on voluntary carbon credits market
- **Equitable benefit sharing** arrangement with local communities and district councils
- **Establishment of a Coastal Coalition for Mangroves** which will centralize data, coordinate support to alternative livelihood programs
- **Development of a restoration playbook** that will include guidance on how to achieve successes in mangroves restoration and management

4

Threats to Sierra Leone's Mangroves Protection and Restoration

(*High Coastal Communities Dependence on Mangroves*)

- Firewood extraction (e.g. fish smoking, bakery, diesel making etc)
- Rice farming and other agricultural deforestation
- Raw oyster harvesting, Crab and local fishing
- Mining (sand, stone, zircon)
- House construction from urbanization

5

Restoration Effort in 2024-2025

200 ha of degraded mangrove forest have been restored through direct propagules (R. racemose) planting into the soil using spacing of 0.5m and 1m in different locations

- 80 ha in 2024 with 75% survival rate; some heights are 3m and 4m
- 120 ha in 2025, started in June to date; all propagules have germinated but we are now observing the growth rate.
- 100 community workers (more of women and youths) were hired and trained in planting and tracking of mangrove within a period of one year as a form of green job; being paid incentives to boost their livelihood

6

Restoration Effort

An innovative method of tracking number of planted mangroves and growth progress using simple android phone with an App being installed

7

Challenges Encountered in Mangrove restoration

In 2024

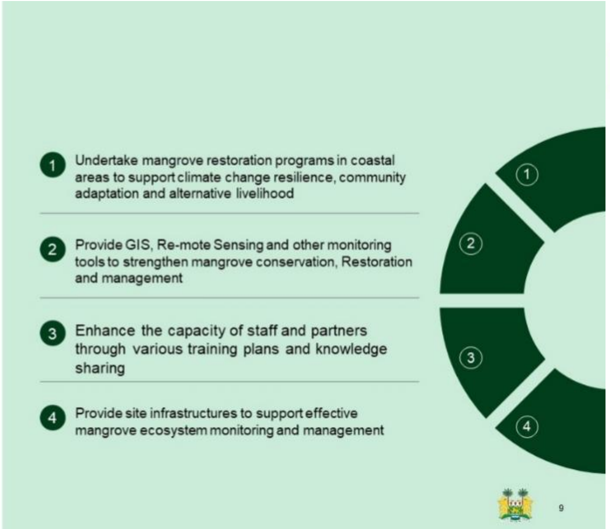
- **Debris from tidal flow**
- **Crabs eating planted propagules**
- **Fishing of crabs by community people**
- **Riding of canoe at high tides for fishing by community people**
- **Soil**
- **Leaves being withered**

In 2025

- **Monkeys root out planted propagules, bite and throw away**
- **Crabs eating planted propagules**
- **Fishing of crabs by community people**
- **Riding of canoe at high tides for fishing by community people**

8

What we will need to be successful in Mangrove conservation and management



THANK YOU

Annex 4.14: Zimbabwe

WETLANDS: THEIR THREATS AND COMMUNITY BENEFITS IN ZIMBABWE

PRESENTED BY ROBERT RWAFA, PROVINCIAL MANAGER

MINISTRY OF ENVIRONMENT,CLIMATE AND WILDLIFE

ENVIRONMENTAL MANAGEMENT AGENCY,

ZIMBABWE

BACKGROUND AND INTRODUCTION

- Zimbabwe is a landlocked country surrounded by South Africa, Zambia, Mozambique and Botswana.
- Zimbabwe has a population of 14 million people (2022 census)
- No mangroves but inland wetlands only
- No shores no costs and beaches
- About 11 700 square kilometres are covered by wetlands
- Seven of the wetlands sites are RAMSAR sites which include the Victoria Falls which was the venue for the COP 15 in July.
- Zimbabwe is a signatory to the RAMSAR Convention (2013)

MAP OF ZIMBABWE

continued

- Zimbabwe's wetlands are often overlooked and degraded by the intended beneficiary communities yet they are incredibly rich in biodiversity.
- From the majestic wetlands of Victoria Falls to the serene waterways of the Zambezi Delta, these ecosystems provide numerous benefits to both the environment and local communities.
- Despite that, they face numerous threats that jeopardize their very existence and potential.
- This discussion will shed some light into the importance of wetlands in Zimbabwe, examine the pressing threats they face, and highlight the benefits that these ecosystems bring to local communities.

KASIBO WETLAND, HWANGE DISTRICT, Matabeleland North

- Located in the heart of Hwange, Zimbabwe the Kasibo wetlands are a vital ecosystem that supports a diverse range of flora and fauna.
- The wetland plays a crucial role in maintaining the region's biodiversity, providing habitat for numerous bird species and supporting the livelihoods of local communities.
- The Kasibo wetlands are an important site for waterbirds and other wildlife, and their conservation is essential for sustaining the ecological balance and promoting sustainable development in the area.

- It's a stark contrast to the devastating drought gripping most of the district thanks to the community's sustainable use and protection of a local wetland.
- The wetland has been an oasis enabling the village to establish irrigation, gardens, beekeeping and fish farming
- These projects have helped families put food on the table and earn income despite the climate crisis.
- Children in the community are healthy and families can pay school fees.
- The wetland has really turned things around for communities
- Kasibo wetland was restored after years of degradation from overuse, and is now mitigating climate change effects and providing climate-resilient livelihoods

PROJECTS IN KASIBO WETLANDS

Irrigation garden established in Kasibo wetland

The wetland has also provided bees hives for honey production due to the availability of diverse vegetation

DRIEFONTEIN WETLANDS

- The Driefontein grasslands is located in the Zambezi river basin about 200 km south-west of Harare
- It is located in the Chirumanzu district in the Midlands province of Zimbabwe
- The Driefontein wetland is the head water for five rivers (Mutirikwi, Pokotekwe, Deure, Chivake and Shashe), originating from the central watershed of Zimbabwe

Pictures of the Driefontein wetland showing pastures thriving and clean flowing water

SOCIAL AND ECONOMIC VALUES

- Vegetable cropping within the wetland is the main source of livelihood for the local communities
- Several types of vegetables are grown in communal gardens within the wetland. These include beans, tomatoes, potato, rape and other cash crops which fetch high market prices in nearby towns and cities, such as in Gweru.
- Due to the wet conditions throughout the year, the wetland supports the growing of maize crop during the dry season.
- Communities around the wetland sometimes exchange the maize for horticultural crops.
- The wetland also provides grazing pasture and water for livestock and provides cultural services as there are many traditional beliefs and myths attached to it. (IKS helping its conservation)
- Tourism

ENVIRONMENTAL VALUE

- The Driefontein wetland is rich in birds and other biodiversity, Three globally threatened bird species namely the Wattled Crane (Bugeranus carunculatus), Grey Crowned Crane (Balearica regulorum) and Secretary bird (Sagittarius serpentarius) are found in the wetland.
- Driefontein wetland is the key breeding and foraging area for cranes, supporting more than half of the total crane population found in the country.
- The Grey Crowned Crane, which is quite common in Driefontein, is an endangered bird species

- The Wattled and Grey Crowned Cranes were reported to damage maize crops in Driefontein wetland resulting in conflict with subsistence farmers
- Many other protected bird species which include Kori Bustard, Black-bellied Korhan, Saddle Billed tork, White-backed and Lappet-faced Vulture, and Batelaur Eagle are found in this area.
- Mammals which include waterbuck, zebra, vervet monkeys, baboons, warthog, spring hares, impalas, squirrels and jackals are also found in the wetland.
- The wetland also supports species of amphibians such as Frogs

Risks and Threats to wetlands

- Major threats to wetland include veldt fires and cultivation in the wetland fringes
- Farmers with gardens along the wetland have been expanding them into the wetland, Therefore, farming encroachment has been affecting water distribution and retention and siltation
- Uncontrolled veldt fires destroy nesting sites, eggs and chicks, crane foraging habitats, thus disturbing the hydrology of the wetlands.
- Overgrazing in some parts of the wetland is another key threat to the area. Illegal collection of crane eggs is also a threat to the key bird species in the area.
- Human activities on the crane breeding sites disturb the birds which require calm places for breeding
- This, coupled with other naturally induced threats like climate change, has resulted in a limited number of conducive breeding sites available for the threatened Grey Crowned Crane and the Wattled Crane

- The wetland area used to be fenced when it was under private ownership, before resettlement areas were established in year 2000. Grazing was controlled and no cultivation was carried out
- Change of land tenure has resulted in land use change, resulting in wetland ecological conditions modification.
- Due to uncontrolled human activities on the wetlands site, the fence was removed and uncontrolled grazing and cultivation contributed towards the degradation of the wetland. (Tragedy of the Commons)
- Increased presence of water hyacinth due to eutrophication
- Little buy in from locals

What Government is doing

- Annual commemoration of World Wetlands Day with high profile offices as Guests
- Continuous training and environmental awareness campaigns to communities
- Law enforcement (S.I. 7 of 2007, the EMA Act Cap 20:27 and the Water Act)
- Environment Courts creation
- Enactment of the National Wetlands Policy
- Engaging community members as Environmental Monitors
- The Catch them young policy in schools
- Signatory to many Multi-lateral Environmental Agreements

CONCLUSION

- Zimbabwe's wetlands are invaluable ecosystems that support biodiversity, provide essential ecosystems services, and contribute to the livelihoods of local communities
- They also help mitigate the impacts of climate change
- However they face significant threats from unsustainable human activities
- It is crucial that collective action be taken to conserve and protect these vital ecosystems for future generations
- For this to succeed, local communities must be part of the matrix

THANK YOU