Mangroves for sustainable social and economic well-being

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Climate change is a global emergency. All countries must remove 7.6% of atmospheric carbon dioxide (CO_2) per year from 2020 to 2030 so the temperature does not exceed 2°C. If this is not implemented, the impacts will be catastrophic, resulting in major disaster risks, according to the Paris Agreement 2015. In this critical situation, mangroves can provide a nature-based solution for climate change issues as they are a carbon-rich system that efficiently removes atmospheric CO_2, generating higher carbon biomass than any other aquatic systems and also stores far greater carbon than any other ecosystem on the Earth[1,2], making them indispensable for climate change mitigation.

Mangroves are of global significance. The world leaders, including the Indian Prime Minister, planted mangroves during the G20 Summit in Bali, Indonesia, in November 2022. India's budget-2023 has proposed a scheme, namely 'MISHTI' (Mangrove Initiative for Shoreline Habitats and Tangible Incomes), for intensive mangrove planting along the country's coastline and on salt-pan lands. India is now hosting the 2023 G20 Summit, with a crucial role in the present context of a rapidly warming world due to climate change.

Mangrove forests are located between land and sea in tropical and warm temperate coastal areas. Dinosaurs and mangroves originated during the same geological time; the dinosaurs have become extinct, while the mangroves are still thriving. This is due to their remarkable adaptation to harsh environments; no other trees in the entire plant kingdom can survive under fluctuating tides, strong winds, high salinity and oxygen-deficient soil conditions. The mangroves are also known as 'oceanic rainforest', 'coastal woodland', 'tidal forest' and 'root of the sea'.

Mangroves protect coastal communities from the impacts of climate change, such as sea-level rise, storms and coastal erosion. This is possible due to the green 'sea-wall'-like physical structure, elastic roots aboveground and underground cable root system of mangrove vegetation. The value of mangroves in saving human life and property was realized in India after the 1999 supercyclone in Odisha and the 2004 tsunami[3]. Mangroves reduce the flood risk of 15 million people every year and prevent more than US$ 65 billion in property damage across the world[4]. They also protect groundwater aquifers from seepage of seawater, ensuring water security for the coastal populations. The mangroves filter solid waste materials and remove coastal pollution, particularly toxic heavy metals, by burying them as sulphides deep in the sediments.

Mangroves are 'fish factories' providing a critical 'home' for crabs, prawns, molluscs and finfish to live, eat and reproduce. The increasing mangrove cover has been shown to increase fish resources and economic development[5]. Mangroves support wildlife, especially birds, reptiles and mammals, making them attractive to nature lovers and for ecotourism development. They also provide forestry products such as firewood, timber, cattle feed, honey and medicines. Thus, mangroves support biodiversity, food security and livelihoods of coastal communities.

Mangroves of India are globally unique, having the highest record of biodiversity with 5745 plant and animal species[6]. No other country has recorded so many species in mangrove ecosystems. India is the third richest country in the world with respect to mangrove biodiversity, with 46 species, after Indonesia and Australia[7]. The country is gifted with the mangrove 'genetic paradise' at Bhitarkanika, Odisha, similar to another at Baimaru in Papua New Guinea, and the mangrove 'wildlife paradise' in the Sundarbans, West Bengal. The Sundarbans is the only 'mangrove–tiger kingdom', a World Heritage Site of UNESCO and the largest mangrove forest in the Gangetic Delta, which is the largest wetland with the highest sedimentation in the world. It also supports the globally threatened wildlife species such as tigers, fishing cats, Gangetic dolphin, estuarine crocodiles, horse-shoe crabs, water monitor lizards and river terrapins. The Sundarbans were the first in the world to implement management of mangrove forests on a commercial basis with plantations as early as 1759. It is a dense mangrove forest, unique in extending 100 km inland from the seafront. Its flora and fauna are found to adjust well to the rigorously fluctuating tidal conditions. India has the world's largest nesting site for Olive Ridley turtles near the mangroves of Bhitharkanika. Mangroves are extremophilic ecosystems, a vast area of which is distributed on the arid coast of Gujarat with a tidal height of 7 m, as well as on the humid and wet coast of the Sundarbans. Mangroves are worshipped in India, and a mangrove plant (*Excoecaria agallocha*) has been revered as the 'temple tree' (sacred tree) in Chidambaram, Tamil Nadu, for over 1800 years.

Global mangroves are disappearing at the rate of 0.3–0.66% loss annually[8]. The long-term survival of mangroves is at risk, and the ecosystem services offered by them may totally be lost to the world within the next 100 years[9]. On the contrary, in India, mangrove cover has increased at the annual rate of 9 km^2 during 2019–21 (ref. 10). Also, their economic value in terms of carbon storage, fish catch and flood protection is estimated to be nine-fold greater than the amount spent for conservation and restoration[11]. The Government of India has conserved mangroves using three strategies. In the promontory approach, management action plan is implemented in 38 core areas of mangroves. In the regulatory approach, mangroves are legally protected under 'Marine Protected Areas'. In the participatory approach, the local community is involved in mangrove management. However, India has a large track of sparse mangrove stands with less than 40% canopy density and low carbon storage. These sparse stands must be transformed into dense mangroves. In this regard, the canal-bank planting technique in a fish-bone design has been demonstrated with community participation, which has increased the mangrove cover by 90% in the degraded areas in Pichavaram, Tamil Nadu, within 16 years between 1986 and 2002 (ref. 12).

Novel strategies and climate policies are required to ensure the long-term security of mangroves and those who depend on them. In this regard, India has joined hands with the Global Mangrove Alliance (GMA) to implement three goals by 2030. These are: (i) halting the loss of mangrove areas from deforestation to zero, (ii) restoring at least half of all recent loss and (iii) protecting mangroves by two-fold increase of the Marine Protected Areas[13]. In addition to GMA, under the MISHTI programme, India aims at increasing its mangrove cover area of 540 km^2 within five years during 2023–28. These restored sites are estimated to store carbon in the biomass and soil,

equivalent to 92,593 tonnes of atmospheric CO_2, with an economic value of US$ 0.46–1.11 million in the international carbon market. The restored sites are also estimated to generate over 3.3 billion commercially important fish and shellfish species every year. The G20 nations are colonized by 49% of the global mangroves, of which 44% is in Indonesia, Australia, Brazil, Mexico and India. Being the leader of the G20 nations, India has a greater responsibility of being a 'role model' for mangrove management in the race to a net carbon-zero world.

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