Eastern and Southern Africa

Eastern and Southern Africa is an important, geographically distinct mangrove region that is isolated from the rich flora of South and Southeast Asia by the Indian Ocean and the arid coasts of the Middle East. This region includes mangroves along the eastern coast of continental Africa and the western shores of Madagascar, and the patchy distribution of mangroves on the offshore islands (Figure 5). Ten mangrove species have been recorded in the region, none of them endemic. The most extensive and diverse formations are found on the wetter coasts of Tanzania and Mozambique, notably in the large Rufiji and Zambezi river deltas (Table 5).

Mangroves have suffered fewer losses in this region than elsewhere, with only an 8% decline between 1980 and 2005. Even so, use is heavy and in countries such as Kenya and Madagascar an apparent stability in gross area may mask quite significant levels of degradation, with trees becoming more sparsely distributed and often stunted as a result of over-exploitation. The conversion of mangroves to other uses—e.g. rice paddies, salt pans and shrimp ponds—has occurred in a few areas, although not yet to the extent that it has in Asia.

Mangrove protection is variable, but generally quite good. In both Kenya and Tanzania, a degree of at least theoretical protection is provided by general laws governing use and harvesting that date back to the early 19th century. Some small-scale mangrove restoration efforts have been undertaken in Kenya and Tanzania. Quite large areas are also incorporated within protected areas.

Middle East

The Middle East has some of the most arid coastlines in the world. There are few permanent rivers (none at all in the Red Sea area), and even temporary freshwater influxes are limited to a few days per year in most places. Mangroves are typically fringing or lagoonal formations, and are often associated with large alluvial fans at the mouths of intermittent rivers (*wadis*) or found along narrow tidal creeks or inlets, known as *khors*. Although four mangrove species have been recorded, only *Avicennia marina* is widespread, typically growing as a shrub or low tree in small stands, often backing on to salt-marsh communities or sand flats (*sabkhas*).

Despite the low stature and diversity and intermittent occurrence of mangroves, their presence is of considerable ecological importance. Mangrove species are often the only trees in the arid desert landscapes, attracting birds and offering foraging for livestock. Although coastal areas in the region are sparsely populated, nomadic people such as the Bedouin undertake fishing and their goats and camels browse mangroves; in some places, mangroves are used for timber. Such uses are not always sustainable, but some communities apply traditional rules, restricting mangrove use to the dry season or times of extreme drought. More recently, increasing coastal development has had considerable impacts on mangroves, particularly in the oil-rich nations. In some countries, however, mangroves are being planted for their aesthetic value.

Figure 5 Western Indo-Pacific mangroves

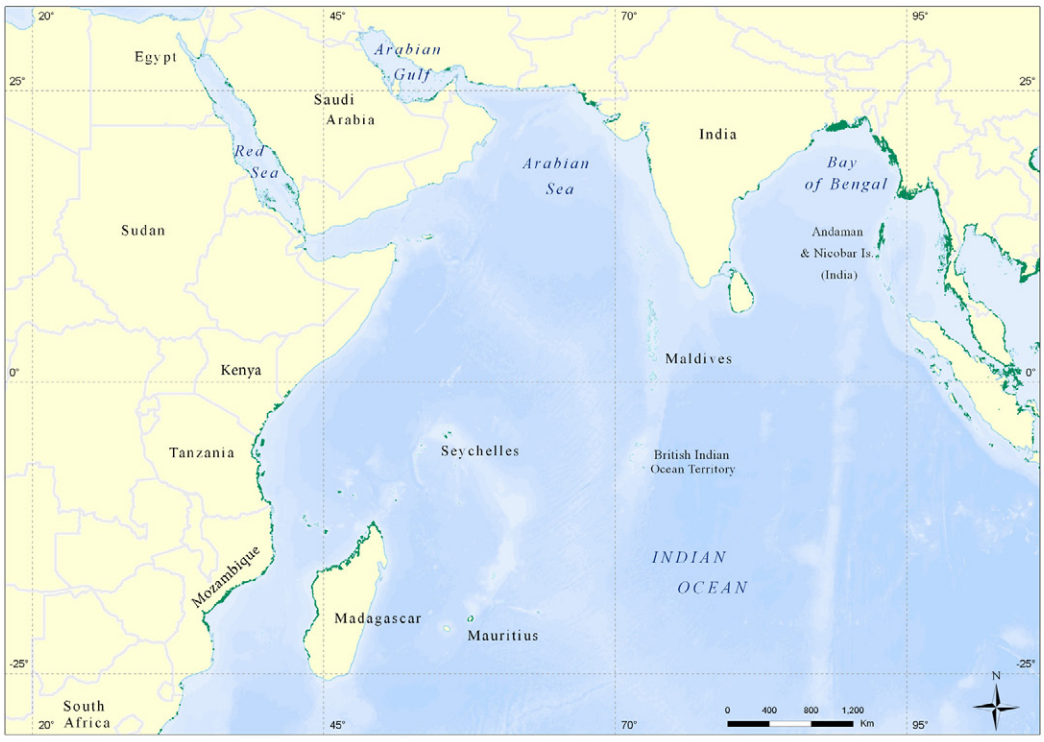


Table 5 Large mangrove extent countries in Eastern and Southern Africa

Country	Mangrove area (km^2)	Number of mangrove species	Number of mangrove protected areas	Number of international protected areas
Madagascar	2990	8	6	1
Mozambique	2910	10	6	1
Tanzania	1290	10	24	1

Arid conditions in the Middle East create hyper-saline salt pans (*sabkhas*). *Photo: R. Spalding*

South Asia

Mangroves are widely distributed, though discontiguous, in South Asia; the largest areas are in India and Bangladesh (Table 6). In Pakistan and northwest India, arid conditions create a harsh environment, and mangroves there have low species diversity and trees are typically stunted. The large Indus Delta once stood out for its large expanses of mangroves, but today this great river has been so heavily used upstream that it only flows to the sea for two months of the year and much of its remaining mangrove resource is degraded. Further south, conditions become more humid and there is more reliable riverine input, although for the most part mangroves are restricted to protected lagoons. Deltaic mangroves become important along the east coast of India and in the Bay of Bengal, where the Sundarbans is one of the world's largest contiguous mangrove forests. Overall, 38 mangrove species have been recorded in the region, with diversity increasing towards the east. The northern Bay of Bengal and Sundarbans (Figure 6) form an important part of the Indo–Andaman biogeographic province, with several regional endemic species.

Almost all mangroves in the region have been influenced by humans, and large areas have been lost through over-exploitation or conversion to aquaculture and agriculture. Concern about mangrove loss is stimulating reforestation: Bangladesh has the world's largest areas of new mangrove plantations, and significant areas have also been planted in Pakistan and India. Many remaining mangrove areas are in protected areas.

Southeast Asia

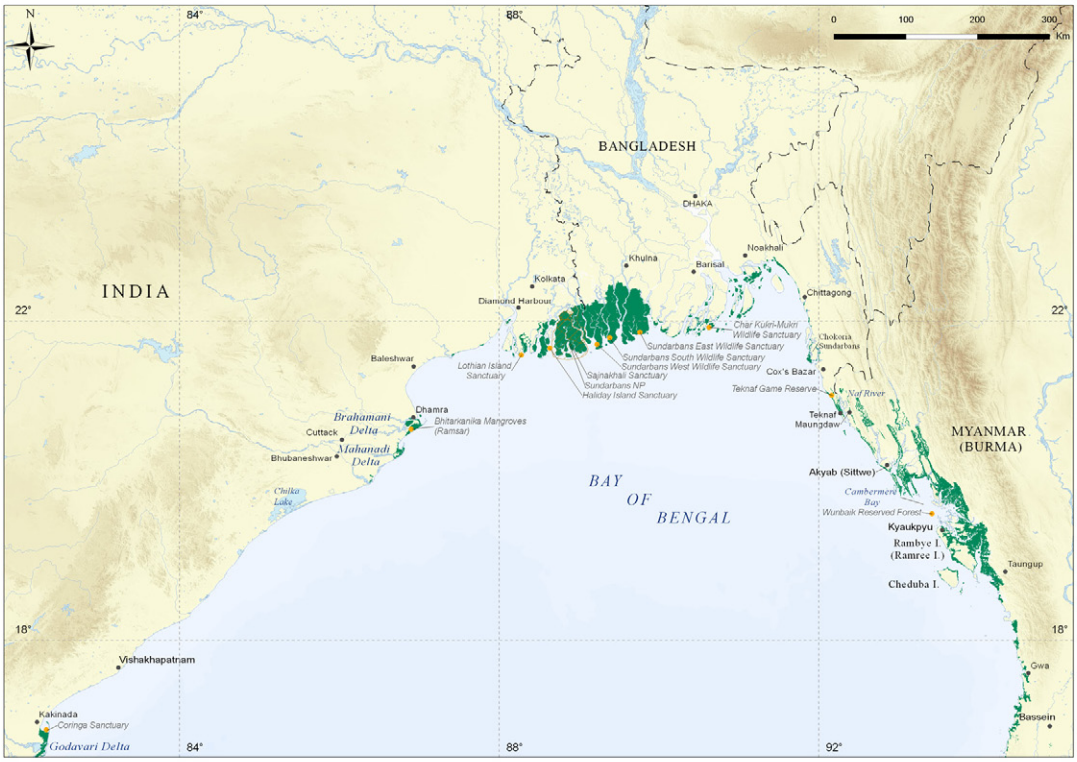
Southeast Asia hosts one-third of the world's mangroves—more than any other region (Table 7, Figure 7). The region is highly conducive to mangrove formation: much of it is humid, with high rainfall, and numerous rivers supply large deltas with freshwater and sediments. These include the Ayeyarwady in Myanmar, the Mekong in Viet Nam, and the extensive deltaic coastline along southern Papua in Indonesia. The region is also the global centre of mangrove diversity, with 51 species, which is 71% of the global total.

Mangroves have long been a source of timber and fisheries in the region; many areas have transitioned to commercial use. Matang Forest in Malaysia has been sustainably managed for timber for over 100 years, while supporting rich fishing industries in channels and adjacent coastal waters. There is a stark contrast between such places and the widespread pattern of mangrove degradation and loss elsewhere in the region. Since the 1970s, aquacultural development has decimated vast areas in the Gulf of Thailand, Viet Nam, Java, Kalimantan and the Philippines. Too often, the benefits of this industry have been short-lived,

Table 6 Large mangrove extent countries in South Asia

Country	Mangrove area (km^2)	Number of mangrove species	Number of mangrove protected areas	Number of international protected areas
Bangladesh	4950	22	5	2
India	4330	37	33	5

Figure 6 The Sundarbans, one of the world's largest contiguous mangrove forests



with ponds abandoned when they become polluted or diseased, leaving behind unproductive saline pools and depleted coastal fisheries.

Large areas of mangrove forest in Manila Bay in the Philippines have been converted to aquaculture and agriculture. *Photo: M. Spalding*

While mangrove deforestation has been high for 25 years, there is growing awareness of the importance of mangroves. Both government-led and community-led efforts are under way to restore and replant mangroves, and to improve legal systems to regulate use. These efforts, combined with a large and growing network of mangrove protected areas in many countries, make it likely that the rate of loss will diminish in the near future.

Table 7 Large mangrove extent countries in Southeast Asia

Country	Mangrove area (km^2)	Number of mangrove species	Number of mangrove protected areas	Number of international protected areas
Indonesia	31 890	45	91	8
Malaysia	7100	40	88	4
Myanmar	5030	32	4	-
Philippines	2570	42	52	5
Thailand	2480	35	23	7
Viet Nam	1060	30	17	5

East Asia

The coasts of southern China, Taiwan Province of China and the southern islands of Japan encompass a transition from tropical to temperate waters. Mangroves in the region are discontiguous in their distribution and are marked by a latitudinal decline in diversity, from 26 species in Hainan Island to a single species (*Kandelia obovata*) on Kyushu Island in Japan.

Figure 7 Central Indo-Pacific mangroves

With the exception of Japan's mangroves, which are well protected, the mangroves of East Asia are among the most altered mangrove ecosystems in the world, due mainly to coastal development. Only a few natural areas remain, although there are growing efforts to protect some of those and to restore mangroves elsewhere.

Australasia

Australia is one of the world's major mangrove nations, with 6.6% (9910 km²) of the total global area, mostly in the wetter north and northeast. Some 40 mangrove species have been recorded, with a rapid diminution in diversity away from the tropics. *Avicennia marina* extends into temperate areas as far south as the state of Victoria. Aborigines and Torres Strait Islanders traditionally use mangroves for food, timber and other products. Mangroves are critically important in sustaining non-traditional fisheries, including offshore prawn fisheries and widespread recreational fishing. Overall, mangrove deforestation has been minimal and localized, usually linked to urban expansion and port and marina development. Increasing efforts are being made to protect mangroves through broad policy and regulatory frameworks and the designation of protected areas.

New Zealand lies close to the southern limit of mangroves and has only one species, *Avicennia marina*. Despite this, mangrove forests are widespread in estuaries and sheltered bays in the north of the North Island, even within the Auckland urban area. Mangroves in northern estuaries can form canopies over 4 m tall; the southernmost mangroves reach only 2 m. The Maori people traditionally fish in mangrove areas for oysters and mullet. Recreational and small-scale commercial fisheries operate in and adjacent to mangrove areas. Overall, New Zealand still maintains a thriving mangrove biota. There is community interest in mangroves, and hiking trails, boardwalks and kayaking offer opportunities to explore these habitats in a number of locations. Significant areas of mangroves are in protected areas.

Figure 8 The Americas

Pacific Islands

The Pacific Islands encompass a great variety of mangrove flora. Papua New Guinea, in the west, has high mangrove diversity, with 43 recorded species and extensive mangrove forests (4270 km²), particularly along the deltaic Gulf of Papua. Diversity declines rapidly eastwards into the Pacific. The larger mangrove areas occur on the larger islands, such as Solomon Islands, Vanuatu, Fiji and New Caledonia, but mangroves are also found on smaller islands, particularly those with mountainous interiors where rainfall and sediment supply are good. The Pacific's numerous low-lying limestone islands present mangroves with a much more challenging environment, with no surface freshwater and generally poor soils. Even so, they do host mangroves if they have protected lagoons or inland brackish ponds.

In many areas in the Pacific people still make extensive use of mangroves. Fishing is a mainstay, both for subsistence and as a commercial enterprise. Dyes extracted from mangrove bark are still used to color the traditional tapa bark-cloth, which is made across the region. The value of mangroves was not lost to the seafaring peoples who first colonized these islands, and it seems likely that some brought mangroves with them. For example, it is generally accepted that *Rhizophora stylosa* was introduced by early arrivals to French Polynesia and *Bruguiera gymnorhiza* to the Marshall Islands, and *Nypa fruticans* may have been introduced to eastern Micronesia. More recently, mangroves were brought to most of the main islands of Hawaii.

Despite their value, significant mangrove loss has occurred, notably in Papua New Guinea and the Solomon Islands. Both countries are still host to extensive natural mangrove forests, but the situation is changing. Conservation in the region in the form of traditional management practices and some formal legal measures probably covers only a small proportion of the mangrove resource.

North and Central America

The extent and structure of mangrove communities in North and Central America (Figure 8) are strongly influenced by climate. Cool air temperatures limit growth in the northern and central parts of the Gulf of Mexico but in southern Florida, warmer conditions and abundant freshwater flows have enabled the development of large areas of mangrove forest. Mexico has the largest area of mangroves of any country in the region (Table 8), including large tracts along its desert and semi-desert coastlines in the Pacific and the Gulf of Mexico. The climate becomes increasingly humid in Central America, and protected lagoons and estuaries support large areas of high-canopy mangroves. Mangroves are also widespread on many Caribbean islands, notably in fringing and lagoon formations. Aridity restricts the growth of many mangrove forests, from the Bahamas to the Lesser Antilles, but some are found around the larger and more mountainous islands, notably Cuba.

There are eleven mangrove species in the most diverse part of this region, which includes Puerto Rico, but most

Figure 9 Mangroves of northern Brazil

countries typically have only 4–5 species. Across the region, mangroves have considerable importance for fisheries. The use of mangroves for timber and fuelwood is not widespread. Tourism is a major industry in many countries, and while this has contributed to extensive and often damaging coastal development, some nature-based tourism—e.g. boat trips, bird-watching and sport fishing—is providing important economic incentives to protect mangroves.

The greatest drivers of mangrove loss include conversion for urban and tourist development and for agriculture and aquaculture, the latter notably in Mexico and Central America. Hurricanes are a major natural influence on mangroves in the region and can be highly destructive, with natural recovery taking years or decades. Several countries, including the United States, Mexico and Cuba, are now showing considerable interest in mangrove protection.

Table 8 Large mangrove extent countries in North and Central America

Country	Mangrove area (km^2)	Number of mangrove species	Number of mangrove protected areas	Number of international protected areas
Mexico	7700	5	36	51
Cuba	4940	5	27	13
USA	3030	5	47	4
Panama	1740	11	19	7

South America

With long coastlines in the Pacific Ocean, Caribbean Sea and Atlantic Ocean, and with numerous rivers and abundant rainfall, mangrove forests are widespread in South America (Figure 8). The largest areas are found along the wetter coastlines, including the Pacific and western Caribbean coasts of Colombia and an expanse of over 3000 km from the Orinoco Delta in Venezuela to northern Brazil (Figure 9, Table 9). Drier areas, such as the northern coasts of Colombia and Venezuela and the southern coasts of Ecuador and Peru, have fewer mangrove forests, although they are abundant in estuarine and lagoon formations. The southernmost limits of mangroves are probably determined by increasing aridity on the Pacific coast and by cooler temperatures on the Atlantic coast.

Some of the earliest human populations in the Americas lived adjacent to mangroves, and even today some groups, such as the Warao Indians in the Orinoco Delta, maintain close links to these ecosystems. Commonly used mangrove products include shellfish, timber, tannin and fuelwood. Commercial fisheries, both near-shore and offshore, rely on mangroves as breeding and nursery grounds. There is also increasing awareness of the role of mangroves in coastal protection and in helping to stabilize sediments.

While there remain large areas of mangroves in South America, there has also been considerable loss, notably in Ecuador and northern Peru, where shrimp aquaculture has transformed vast areas, and also in eastern Guyana, where mangroves have been converted to agricultural land. The

collapse of shrimp aquaculture through disease and the falling value of shrimp exports have highlighted the risks associated with mangrove clearance. In Guyana, costly ongoing coastal defense is required because of the threat of inundation.

Overall, the region's mangroves remain abundant and the benefits they provide are now appreciated quite widely. Mangroves are subject to increasing levels of protection through legislation and growing public awareness. In Brazil and Venezuela, remaining large areas of mangroves are being incorporated into protected areas.

Table 9 Large mangrove extent countries in South America

Country	Mangrove area (km²)	Number of mangrove species	Number of mangrove protected areas	Number of international protected areas
Brazil	13 000	8	101	5
Colombia	4080	11	12	4
Venezuela	3570	7	18	5
Ecuador	1580	8	6	6

West and Central Africa

Although mangroves are found all along the eastern Atlantic coast (Figure 10), Nigeria has by far the largest area of any country in the region (Table 10). At their latitudinal extremes, mangrove diversity is low, trees are dwarfed and distribution is limited by aridity and a lack of suitable sheltered sites. In the tropics, one of the most mangrove-rich coastlines in the world, known as *Les Rivières du Sud*, extends from the Saloum Estuary in Senegal to Sherbro Island in Liberia. It comprises 7900 km² of mangroves in a series of deltaic and estuarine formations that benefit from lower wave energies and high riverine inputs. To the east, the coast is dominated by high-energy sandy shores and most mangrove formations from Liberia to Nigeria are found in coastal lagoons, separated from the sea by extensive sandbars. Mangroves in the Niger Delta cover an area of over 6600 km², and east of there through Cameroon to Gabon are other very large and open estuarine and deltaic formations. In the south, most mangrove formations tend to be narrower estuarine and lagoon formations that become less frequent within increasing aridity along the Angola coast. Despite their large area, the mangroves of West and Central Africa contain only seven plant species and, despite their isolation, there are no regional endemics.

Mangroves are important for fisheries and as a source of timber and fuelwood. Aquaculture remains rare, although in some areas there is brush park or acadja fishing in lagoons and channels. Some mangroves in *Les Rivières du Sud* have been cleared for the development of rice fields.

There has been widespread loss of mangroves associated with conversion to urban and agricultural land and, in more arid areas, the creation of salt pans. In a number of countries, especially in the Niger Delta, oil and gas extraction has caused pollution, damaged fish stocks and contributed to the degradation and loss of mangroves.

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Figure 10 West and Central Africa

Issues in mangrove management

The *ISME Mangrove action plan for the sustainable management of mangroves 2004–2009* (ISME and ITTO 2004) identified the key issues in need of management attention. These are set out below.

Overuse for forestry and fisheries. Many mangroves are subject to the over-extraction of timber and non-timber forest products as well as to unsustainable fishing and wildlife use, often driven by poverty and the meeting of daily needs. Such over-use leads to degradation of the mangrove resource and, in some cases, its complete removal. Even if pressures can be removed, natural regeneration is sometimes poor and rehabilitation can be difficult and costly.

Aquaculture. The conversion of mangroves to aquaculture is widespread, particularly in Southeast Asia and Latin America but also now in East Africa. Poor management of aquaculture operations can lead to pollution and disease, rendering ponds unusable within a few years. Because of the massive disturbance to tidal flows and the coastal profile caused by aquaculture development, restoration, even in abandoned sites, can be challenging and costly.

Pollution. Pollution—derived from single or multiple sources including industry, sewage, dredging, pond effluent and agricultural and urban runoff and involving pollutants such as solid wastes, toxic chemicals, hydrocarbons and persistent organic materials—can lead to the loss of biodiversity, declines in mangrove productivity and, in extreme cases, complete destruction.

Hydrological modifications. Upstream activities such as dam construction, water diversion and deforestation alter the flow regimes of freshwater into mangrove ecosystems, often causing marked reductions, especially in dry seasons and arid environments. This can lead to a build-up of salinity in water and soils and changes in sedimentation patterns that affect coastal configuration and the structure of navigational channels, with the potential to alter physiological processes and cause the loss of mangrove species or their substitution by other communities. Coastal modifications such as the construction of sea walls, ports and dredging can also alter tidal circulation patterns, which in turn can lead to structural and functional changes.

Conversion to other land uses. Conversion due to the development of infrastructure, residential areas and for agriculture, cattle-ranching, salt pans and mining causes the direct, irreversible loss of mangroves. Mangrove soils are often only marginally suitable for agriculture, yet the conversion of mangroves for this purpose is widespread. Conversion in one area can often lead to uncontrolled degradation and elimination in adjacent mangrove ecosystems.

Continued from page 19

Concern about mangrove loss is highly variable, but a few countries—Guinea-Bissau, Cameroon and Gabon—have created networks of protected areas that include mangroves. In some cases considerable effort has been made to involve local communities and garner broad support, and ongoing but sustainable use of mangroves is encouraged. Other countries have paid little attention to the protection of mangroves, and wide areas, including in most of the Niger Delta, remain unprotected.

Table 10 Large mangrove extent countries in West and Central Africa

Country	Mangrove area (km^2)	Number of mangrove species	Number of mangrove protected areas	Number of international protected areas
Nigeria	7360	7	4	1
Guinea-Bissau	2980	6	4	1
Guinea	2030	7	-	5
Cameroon	1960	7	3	-
Gabon	1600	7	7	5
Senegal	1280	7	3	2
Sierra Leone	1050	6	-	1

Les Rivières du Sud, a vast complex of rivers and channels extending from Senegal to Liberia, is one of the largest areas of mangrove forest in the world.
Photo: © J.F. Hellio and N. Van Ingen