The Greater Mekong Subregion has a diverse geographic landscape that includes mountains, plateaus, and limestone karsts, fast-flowing rocky mountain streams, lowlands, fertile floodplains, and deltas.

The evolving geology of the Greater Mekong Subregion (GMS) is best seen by the development of the Mekong River. About 40 million years ago, its precursor drained into the sea roughly where the Red River now flows. Over time, the rise of the Himalayas with uplifting, folding and faults, turned much of the mountains’ drainage southward through steep gorges that appeared perhaps 13 million years ago and by 8 million years ago, formed the present course of three rivers—Thanlwin (Salween), Mekong, and Yangtze—running down parallel sutures. The Mekong followed a line of faults through southwestern Yunnan, an area still high in seismic activity, indicating that movements of the blocks are continuing.

Below this area, the Mekong crosses the Indosinia block, which has been stable since the Jurassic. There was a wide inland sea during the Upper Mesozoic. It is probable that the Mekong at this time was flowing directly south and to the west of the Khorat Plateau, joining what was to become the Chao Phraya River. However, during the late Cretaceous and early Tertiary, uplift in northern Viet Nam formed the Red River rift and Indosinia became warped, with northeastern Thailand, including the Khorat plateau area, and adjoining parts of the Lao PDR remaining low; the inland sea left salt deposits 250 meters thick in this region. Much of what is now Cambodia was lifted and has weathered to expose basement granite. The uplifting caused block faulting in northern Thailand resulting in flat basins and steep mountain ranges.

Upper: A spectacular bend in the Yangtze River in northern Yunnan Province, PRC. Lower: Monks stand on coastal slab formations made of fossil shells in Ban Laern Pho, Krabi Province, Thailand.
Subsequently, in the Cenozoic, there was much vulcanism as well as block movement, accompanied by climate changes and sea level change, particularly affecting southern Cambodia and southern Viet Nam. It was only about 600,000 years ago that basaltic areas of the Annamites between Viet Nam and the Lao PDR, and in northeastern Thailand and Cambodia were formed and dictated the present structure of the Mekong River in the area, including the Khone Falls.

The lower part of the Mekong River has also been influenced by tectonics in the Cenozoic and some stretches can be seen to follow these recent fault lines. It is believed that subsidence in the Tonle Sap basin in Cambodia perhaps within the last 12,000 years, drew the Mekong River eastward away from its former Chao Phraya connection and into the Tonle Sap basin. Tonle Sap itself is only about 5,000 years old.

Finally, the Mekong Delta began to form only 6,000–7,000 years ago when sea level rose to its present level after a rise of some 130 meters over the preceding 12,000 years, since the last glacial maximum period.

**Soils**

While the evolution of the Mekong countries created basic similarities in their geological structure, local vulcanism and water and sediment flows over millennia, as well as sea level changes, modified and overlaid these structures, resulting in wide differences in the present soils around the subregion.

Cambodia can be divided into three regions on the basis of the age and general origins of soils: (i) regions that retain their original parent material, such as the Cardamom and Central Annamite mountains; (ii) regions that are covered by ancient alluvial or colluvial plains; and (iii) regions that receive annual alluvial sediments, such as the Tonle Sap floodplain. Sandy surface soils are widespread throughout the country except the soils fringing the Tonle Sap, those of the alluvial plains along the major rivers (especially the Mekong), and soils developed on basalt. Substantial areas of these sandy, high permeability soils are used for lowland rainfed rice production. However, these soils have high water conductivity, such that rainwater drains quickly from the rice fields causing significant nutrient leaching and exposing rice crops to drought.

In the Guangxi Zhuang Autonomous Region, there are 18 soil types; lateritic and red soil being the two major soil types, accounting for 65% of the total land area. Of secondary importance are yellow earth, paddy, purple, and limestone soils. The major nutrient disorders in cultivated soils are deficiencies of nitrogen, phosphorus, and potassium. Calcium, magnesium, and molybdenum are also deficient in the acidic soils. Acid soils account for two thirds of the total; calcareous soils account for the remainder.

The soil materials in Yunnan Province are mainly debris from mountains, argillite, quartz, acidic rocks, limestone, purple rock, and lake sediments. The main soil types are red soil, paddy soil, purple soil, and laterite. Over 70% of cultivated land is medium to low in productivity. Red soils developed from basalt are deficient in potassium and phosphorus, with the exception of some soils near urban areas that are showing signs of phosphorus accumulation.
Soils in the Lao People’s Democratic Republic (Lao PDR) can be grouped into (i) those of the floodplains formed from alluvium deposited by rivers, and which are either sandy or sandy clay and neutral to slightly acidic; (ii) upland soils derived from crystalline, granitic, schistose, or sandstone parent rocks, generally more acidic and much less fertile than floodplain soils; (iii) areas of laterite (leached and iron-bearing) soils in the southern Lao PDR; and (iv) basaltic soils of the Bolovens Plateau.

Soils in Myanmar have been closely studied, with some 24 types recognized. Among them are red-brown forest soils in tropical evergreen forests and wet tropical monsoon forests mostly at altitudes of 300–1,300 meters; widespread yellow-brown forest soils of wet tropical monsoon forests at altitudes of 100–450 meters; and yellow-brown mountain forest soils at higher altitudes. Red earths occur at around 1,000 meters and mountain red earths replace them at higher altitudes. Mountain sod soils are found in the Mount Popa area and are the best soils for forestry purposes. Lateritic soils and laterites are found below 100 meters. Light cinnamon soils occur along the belt surrounding the central dry zone; red-brown savanna soils predominate in the dry zone along with gravelly savanna soils; and dark cinnamon soils occur at relatively wet sites. Dark compact savanna soils are mostly found in flat, even terrain and alluvial in the dry zone. Meadow soils are the best soils for rice farming.

Alluvial deposits in river valleys contain the most fertile soils in Thailand and are replenished annually with sediment washed down by rivers in the rainy season, especially nourishing the delta floodplain of the Chao Phraya River, but these rich alluvial soils are also found in the relatively flat basins in the northern mountains, on scattered lands along the Mun and Chi rivers on the Khorat Plateau, and on much of the coast. Soils elsewhere tend to be relatively infertile, highly leached laterites. Stony and shallow soils are typical of the hills and mountains of northern Thailand. Shallow sandy loams of low fertility cover a large part of the Khorat Plateau. Soils along the main rivers are more fertile, and alluvial loams of high fertility are found along the Mekong River. The central plain rice-growing area and the delta of the Tha Chin and Chao Phraya rivers has clayey soils of high to moderate fertility that are mostly flooded during the rainy season. Higher areas on the edges of the plain are generally well-drained soils of high to moderate fertility and suitable for intensive cultivation.

Northern Viet Nam is characterized by reddish soils, the result of heavy monsoonal rains washing rich humus down from the highlands, leaving slow-dissolving alumina and iron oxides that give the soil its red color. The soils of the Red River Delta vary: some are fertile and suitable for intense cultivation, while others lack soluble bases. However, construction of dikes to prevent flooding has deprived the delta’s rice fields of enriching silt they once received. The Mekong Delta in southern Viet Nam is considered to be typical of the clayey alluvial soils. Sandy soils are widely distributed in the coastal central provinces. The many steep slopes and deforested landscapes, especially in the highlands and northwestern regions, are very susceptible to soil erosion during heavy rains. The eroded topsoil is carried away and deposited as silt in rivers, lakes, and estuaries. Potential soil erosion of up to 3,200 tons per hectare per year affects about 23 million hectares, or some 70% of the country’s land area.
Mineral Resources

The subregion contains thousands of occurrences of base and precious metals, industrial minerals, and construction materials. The high geological and economic potential of mineral commodities has been confirmed by the inventories of geology and mineral resources undertaken by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Secretariat and published in the ESCAP Mineral Atlas volumes for Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam; and recent inventories of mineral resources in Yunnan Province, PRC. Also, in the case of the Lao PDR, donor assistance provided for the preparation of a Mineral Exploration and Development Plan in the early 1990s. This resulted in an excellent geological and mineral occurrence map, which gave a boost to further mineral exploration in the Lao PDR.

The potential for subregional development of mineral resources has been given impetus by new mining legislation in Cambodia, Lao PDR, Myanmar, and Viet Nam; and changes to national mining legislation in the PRC and Thailand. The resulting new policies and regulations have opened the subregion to foreign investment. Mineral development and production throughout the GMS are increasing and beginning to make significant contributions to national income in most countries.

Detailed information on mineral resources in Cambodia is scarce and the mineral potential is generally unknown. Small deposits of gold exist in the northern provinces. There is only artisanal and small-scale production at present. Gemstones, the major source of mineral wealth, are being recovered from several deposits. It is generally believed that the potential for gemstones is underdeveloped.

There is an extensive lateritic bauxite deposit at Chlong Leu in northwestern Cambodia with good potential for development. Among industrial minerals, limestone and dolomitic limestone have potential for further development. Kaolin and other clays occur frequently, but little is known about their quality and size of deposits. High-grade phosphorite occurs at Phnom Totung, but known reserves are only 78,000 tons. Other phosphorite deposits occur in the area surrounding Tuk Meas and in the Battambang area.

In 2009, Cambodia produced mainly industrial minerals, such as sand and gravel and crushed stone for domestic consumption by the construction industry, and limestone for cement production. The mineral industry of Cambodia is likely to continue to be dominated by the production of industrial minerals. Exploration for metals is expected to increase in the near future as a result of recent gold and base-metal mineralization.

About 120 million tons of new bauxite reserves were found in Guangxi in 2007. Currently, the proven reserves of bauxite in Guangxi are about 1 billion tons, making the region one of the PRC’s...
biggest bauxite sources. State-owned enterprises have diversified their core business into other sectors, such as rare-earth companies in Guangxi and copper companies in Yunnan Province. By 2010, Guangxi secured a major rare-earth concentrates production quota from the central PRC Government.

Yunnan’s reserves of aluminium, lead, zinc, and tin are the largest in the PRC, and there are also major reserves of copper and nickel. It is the PRC’s leading tin producer and has large deposits of iron, coal, lead, copper, zinc, gold, mercury, silver, antimony, bauxite, and sulfur.

The Lao PDR’s main resources are barite, coal, copper, gemstones, gold, gypsum, iron ore, lead, silver, tin, and zinc; also there is considerable potential for discovery of substantial additional mineral resources of iron ore, potash, and rock salt. The Government is promoting further exploration for coal, copper, gemstones, gold, iron ore, lead, potash, tin, and zinc.

At present, tin and gypsum are the main minerals produced in the Lao PDR, followed by barite, coal, construction materials, gemstones, gold, limestone, and zinc. Both tin and gypsum are produced by state mining enterprises. Tin concentrate is exported to Malaysia for smelting and refining, while gypsum is used in the domestic cement industry as well as exported to Viet Nam.

Barite, gemstones (sapphire, amethyst, zircon, topaz, beryl, and garnet), and coal are also produced mainly by the Lao PDR’s state mining enterprises while construction materials and limestone (for the local cement industry) are mainly produced by local companies. Small-scale mining of gold and gemstones also takes place.

Foreign companies are involved in the production of zinc in the Lao PDR, which is exported to Thailand for smelting and refining, and gold. Mining companies are exploring for copper-gold and copper deposits and it is expected that in the near future more privately owned gold/copper mines will become operational. There is also considerable interest by foreign companies in the production of gemstones.

Myanmar produces 10 metallic and 15 nonmetallic minerals, in addition to jade and gemstones. The main metals are copper, iron ore, zinc, lead, tin, wolfram, silver, and gold. The main nonmetallic minerals are limestone, coal, gypsum, and barite. However, production is low. Recent exploration by foreign companies through joint ventures with government enterprises has focused on gold, copper, diamonds, coal, and barite. In 2009, Myanmar produced a variety of mineral commodities, including cement, coal, copper, lead, natural gas, petroleum, gas products, precious and semiprecious stones, tin, tungsten, and zinc.

In 2010, oil and gas exploration activities continued to increase, mainly as a result of the many exploration projects that started in 2008 and 2009. Business ties between Myanmar and the PRC are likely to strengthen as a result of the agreements and projects that the two countries have committed to in the oil and gas sector, such as the construction of oil and gas pipelines that will connect the two countries.

Thailand produces 44 mineral commodities. The most important are lignite, limestone, gypsum, zinc, kaolin, dolomite, feldspar, and potash. There is potential to develop more zinc mines on deposits near Mae Sot. Gold also has more potential. Thailand’s reserves of rock salt, potash, coal, limestone, dolomite, diatomite, kaolin, and gypsum are large. There are also reserves of gemstones, primarily ruby and sapphire. From 2009 to 2010, Thailand’s mineral (including mineral fuels) production increased by 5.2% and manufacturing (which included mineral-related manufacturing) increased by 13.9%. Cement, crude steel, tin and natural gas production is also increasing.

Viet Nam’s mineral deposits with the greatest potential include lateritic bauxite, rare earths, coal, apatite, construction materials, kaolin, and silica sand. Tin, tungsten, gold, titanium minerals, chromite, iron ore, copper, nickel, zinc, lead, uranium, bentonite, pyrophyllite, and graphite are also considered to have some potential for development.

Construction materials are exploited on a large scale in Viet Nam. Limestone and clay are widely exploited and the reserves are large. Near Lao Cai, a large phosphate deposit has good potential for development. Lateritic bauxite deposits in the south are believed to be large, although it is uncertain if the deposits are economic.

Upper: The Stone Forest, made of weathered limestone, Yunnan Province, PRC. The forest is part of the South China Karst Complex (see satellite image, page 83). Lower: Closed quartz mine on the western forest border of Myanmar and Thailand.
Upper: Karst mountain peaks of Jinxiu County, Guangxi, PRC, shrouded in mist. Lower left: Satellite image of the South China Karst Complex in Guangxi, a bizarre landscape resulting from the chemical weathering of limestone. The area is rich in biodiversity and is a UNESCO World Heritage Site; Lower right: Satellite image of Bolaven Plateau in the Lao PDR, the remainder of an old volcano, rich in mineral deposits.
There is some small-scale and artisanal exploitation of gold in Viet Nam and recently, gemstones, primarily rubies and sapphires, were discovered. In recent years, mineral production has increased, mainly for refined copper, cement, crude steel, anthracite, crude petroleum, and natural gas. Viet Nam’s mining sector is expected to be dominated by the bauxite, coal, and oil and gas industries for the coming years, mainly as a result of many new exploration projects and discoveries.

Gemstones in the GMS. Throughout the GMS, two gemstones stand out: rubies and sapphires, among the most common and prized gems found in jewelry around the subregion.

The best sapphires are said to be found in Cambodia and Thailand. The blue of the sapphire is due to the presence of iron and titanium in the crystal structure and different colors are the result of inclusion of various other elements. Traditionally, it is believed that sapphire is the stone of the spirit and can help calm the mind and help improve relationships. Sapphires are also supposed to bring luck in love, career, and in achieving fame.

The deep red of rubies is due to traces of chromium and Thailand’s rubies are considered to be the best quality in the world. Rubies are mined in the border area of Thailand and Myanmar and in the provinces of Chantaburi, and Trat. Thailand is also one of the world’s largest producers of precious stones.
The Greater Mekong Subregion (GMS) has six major river basins of which four are transboundary—the Ayeyarwady (or Irrawaddy), Thanlwin (or Salween), Mekong (or Lancang), and Red (or Hong). The other two, the Chao Phraya and Pearl, are wholly within national territories. Apart from the Chao Phraya, these rivers originate in the mountainous terrain of the southwestern People’s Republic of China (PRC). The Ayeyarwady and Thanlwin drain into the Andaman Sea, while the Mekong, Red, and Pearl drain into the South China Sea and the Chao Phraya into the Gulf of Thailand. The combined catchments of these six rivers stretch over the majority of the subregion’s land area.

Agriculture is the primary use of water across the GMS, ranging from roughly 65% in the PRC to 95% in Viet Nam. Growth in agricultural production has more than doubled in the last two decades, with important implications for current and future water demand and water quality. Still, rainfed agriculture predominates; irrigated agriculture in the subregion remains relatively low, ranging from 7% of total cropland in Cambodia to 31% in Viet Nam.

The largest irrigated areas are found in the large deltas and low-lying floodplains of the Ayeyarwady.

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**River Basins and Wetlands**

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**River Basins**

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**River Basin Characteristics**

<table>
<thead>
<tr>
<th>River Basin Characteristic</th>
<th>Ayeyarwady (Irrawaddy)</th>
<th>Thanlwin (Salween)</th>
<th>Chao Phraya</th>
<th>Mekong (Lancang)</th>
<th>Red (Hong)</th>
<th>Pearl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>Myanmar (May Kha and Mal Kha rivers, Kachin) and PRC (Du Long River, Xizang Autonomous Region)</td>
<td>PRC (Xizang Autonomous Region)</td>
<td>Northern Thailand</td>
<td>PRC (Yunnan); Myanmar, Lao PDR, Thailand; Cambodia; Viet Nam</td>
<td>PRC (Yunnan); Lao PDR, Viet Nam</td>
<td>PRC (Yunnan and Guangxi)</td>
</tr>
<tr>
<td>Length (kilometer)</td>
<td>2,170</td>
<td>2,400</td>
<td>980</td>
<td>4,909</td>
<td>1,149</td>
<td>2,210</td>
</tr>
<tr>
<td>Basin area (square kilometer)</td>
<td>413,710</td>
<td>271,914</td>
<td>178,785</td>
<td>795,000</td>
<td>169,000</td>
<td>409,480</td>
</tr>
<tr>
<td>Average annual discharge (cubic meter/second)</td>
<td>13,000</td>
<td>1,659</td>
<td>718</td>
<td>14,500</td>
<td>4,239</td>
<td>10,591</td>
</tr>
<tr>
<td>River mouth</td>
<td>Gulf of Martaban, Andaman Sea</td>
<td>Gulf of Martaban, Andaman Sea</td>
<td>Gulf of Thailand</td>
<td>South China Sea</td>
<td>Gulf of Tonkin, South China Sea</td>
<td>South China Sea</td>
</tr>
</tbody>
</table>

GMS = Greater Mekong Subregion, Guangxi = Guangxi Zhuang Autonomous Region of the PRC, Lao PDR = Lao People’s Democratic Republic, PRC = People’s Republic of China, Yunnan = Yunnan Province of the PRC.

Chao Phraya, Mekong, and Red rivers. Although they make up only 10% of the total land area, they produce roughly half of the subregion’s production. Complex waterworks are used to direct and retain monsoon floodwaters. Overall, agricultural withdrawals are only a fraction of total renewable resources, but demand for agricultural water is increasing and the strongly seasonal patterns of rainfall and irrigation demand mean that seasonal shortages are increasingly common.

Withdrawals of surface water for industrial, municipal, and domestic use are relatively small in comparison with that for agriculture, although competition is growing, particularly in rapidly expanding urban areas. The constraints in water supply are generally related to the lack of treatment and distribution systems rather than limits of raw water.

Although hydropower accounts for relatively little water consumption, existing and expanding hydropower development is probably the largest driver of change for water resources and aquatic ecosystems in much of the subregion, because water is stored in reservoirs in the wet season and released in the dry season.

Water quality in most of the subregion is generally good but degradation occurs in all of the deltas, associated with high population densities and still inadequate domestic and industrial wastewater treatment. Agricultural chemical loadings are significant in the Chao Phraya, Mekong, and Red rivers. Irrigation-induced salinity affects parts of northeastern Thailand and the central Lao PDR. Soil erosion, particularly in upland areas, also affects water quality downstream.

The subregion contains extensive and diverse aquatic ecosystems, comprising riverine floodplains, fresh- and brackishwater wetlands, and major lake systems, including Tonle Sap (Southeast Asia’s largest freshwater lake) in Cambodia, Lake Inle in Myanmar, and large upland lakes in Yunnan Province of the PRC. Altogether there are 19 designated Ramsar Convention wetland sites in the GMS.

Consumption of fish and other aquatic animals is an important part of people’s diets, and the bulk of consumption is from freshwater sources, including tributary and mainstem rivers, wetlands, reservoirs, and irrigated rice fields.

Concerns are heightening that the current level of capture fishing is not sustainable. Although the biomass of overall catches is stable or shows signs of rising, the larger migratory fish are declining compared to smaller migratory and non-migratory species, and the average size of fish is decreasing; these are signs of excessive harvesting. Ten of Cambodia’s freshwater fish species are now listed as endangered. Further alteration of river flow regimes and disruption of fish migration as a result of agriculture infrastructure and hydropower development pose additional threats to freshwater fisheries in the GMS if not well managed.
The Ayeyarwady River runs the entire length of Myanmar, with the basin covering 413,710 square kilometers, or roughly 61% of the total country area. It is the largest of Myanmar’s five major rivers. The 2,170 kilometer river originates at the convergence of the May Kha and Mali Kha rivers in Kachin State. The headwaters of both these rivers originate in the southeastern Himalayas. The larger May Kha River is fast flowing and not navigable, while the Mali Kha is navigable upstream despite a few rapids. Further downstream, three main tributaries—the Chindwin, Shweli, and Myitnge—enter the Ayeyarwady as it meanders through a central dry plain past the country’s second largest city of Mandalay. The river then narrows and flows between forest-covered mountain ranges. Finally, the Ayeyarwady drains into the Andaman Sea through several distributaries including the Pathein River and the smaller Yangon River which flows beside Myanmar’s former capital city. The delta formed by the river covers 69,600 square kilometers.

Due to monsoon rains, which occur between mid-May and mid-October, the volume of the Ayeyarwady and its tributaries varies substantially year-round. The discharge fluctuates between a high of 32,600 and a low of 2,300 cubic meters per second, with an average discharge of 13,000. Water levels vary greatly between seasons with records showing a level difference of 9.66 to 11.37 meters between the highest point in August and the lowest in February. The Ayeyarwady carries a high concentration of sediment and is one of the world’s largest in terms of suspended load. Although data are scarce, estimates of sediment flux are in the order of 260–360 million tons per year.

The Ayeyarwady is Myanmar’s most important commercial waterway, with year-round transport being possible for about 1,300 kilometers of the river’s length. More than 3,200 kilometers of navigable waterways exist in the delta via a system of interconnecting canals. Large quantities of teak are floated down the river and are a major export. Rice cultivation predominates in the fertile delta, producing nearly 60% of country’s total rice production.
Data on capture fisheries in the Ayeyarwady River basin are limited, but it is home to 79 known fish species and could have inland fish resources similar to those in parts of the Mekong. Near Mandalay, the river supports the Irrawaddy dolphin, one of only four species of river dolphins in the world. The Irrawaddy dolphin is considered critically endangered, with an estimated remaining population in the river of only 59 individuals. Loss of prey due to disturbances in fish migration patterns, degradation of water quality, and change in river hydrology caused by upstream development pose a serious threat to this dwindling population.

Marshes, lakes, rivers and streams, and mangrove forest in the lower section of the delta provide important nesting and feeding grounds for many species of resident and migratory birds. The delta is home to several species of large mammal (including the Asian elephant, Malayan Sambar, hog deer, and wild boar), the estuarine crocodile, and sea turtles.

Myanmar is endowed with abundant water resources. However, with an increasing population and expanding economic activity, there is increasing pressure on both surface water and groundwater. Total utilization of the country’s water resources is currently about 3% of potential, of which 90% of withdrawals are by the agriculture sector while industry and domestic demand represents less than 10% of total water use. Available data on water quality status and trends in the Ayeyarwady indicate that some deterioration of surface water quality is occurring, mainly related to agricultural chemical loadings, untreated urban wastewater discharges, and sedimentation.

Hydropower development on the Ayeyarwady main stem has considerable potential, including for export to neighboring GMS countries, but also poses a significant threat to fisheries, riverbank agriculture, and floodplains. Some dams exist on tributaries to the Ayeyarwady. The largest development is the 3,200 megawatt Myitsone Dam at the confluence of the May Kha and Mali Kha tributaries. Construction was suspended in 2011. Upstream there are plans to build six dams on the May Kha and Mali Kha rivers with combined generating capacity of 13,360 megawatts. Unless adequate mitigation measures are developed, these dams will damage the ecosystems of both the pristine May Kha river and the Ayeyarwady downstream.
The transboundary Thanlwin River basin covers a total area of 271,914 square kilometers, of which 53% is in the PRC, 42% in Myanmar, and the remaining 5% in Thailand. Stretching 2,815 kilometers, the Thanlwin is the second longest river in Southeast Asia after the Mekong River. Originating in the Himalayas in the Tibetan Plateau at 4,000 meters above sea level, the river drains a narrow and mountainous watershed extending south through Yunnan, along Myanmar’s eastern Shan and Kayah states, forming the border between Myanmar and Thailand, then passes through Myanmar’s Kayin and Mon states before discharging into the Gulf of Martaban in the Andaman Sea. Numerous major tributaries, including the Pang, Teng, Pawn, Hka, and Hsim rivers join the Thanlwin River as it makes its way south. The river is only navigable in the final
89 kilometers from the mouth, where the channel deepens and widens sufficiently to accommodate larger vessels. Average annual discharge at the mouth is 1,659 cubic meters per second.

In the PRC, the river runs parallel to the upper reaches of the Mekong and Yangtze rivers in an area designated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as a World Heritage site for its rich biodiversity. In Myanmar and Thailand, the topography is mountainous, with long river valleys and varied habitats that support rich, unique Indo-Burmese fauna. The river is home to at least 143 fish species, of which a third are endemic, that migrate between the Thanlwin and its tributaries; and a high diversity of turtles.

The basin supports a population of approximately 7 million people and is an integral part of the people's livelihoods and culture. At least 13 different ethnic groups inhabit valleys and floodplains along the river and its tributaries in Myanmar and Thailand, in addition to ethnic groups living along the river in Yunnan. Although deeply incised, with steep canyon walls and rapid currents for most of its length, the river widens about 240 kilometers from its mouth and flows through agricultural valleys before spreading out into the small delta at Mawlamyaing. The most populated section of the basin is the fertile floodplain area of the delta.

Estimated total water withdrawals from the Thanlwin in 2000 were 33.23 cubic kilometers, of which 89% was for agriculture, 10% for municipalities, and 1% for industry. Approximately 91% of total water withdrawals come from surface water. Total irrigated area in the basin is estimated at 400,000 hectares, of which 50% is in Myanmar, 42% in the PRC, and 8% in Thailand.

Hydropower development in the basin has to date been confined to tributaries but there are plans for large-scale main stem development in the upper section of the river. In the PRC where it is called the Nu River, a cascade of dams has been proposed. Several proposed dams are situated in the world heritage site “Three Parallel Rivers Protected Area”, posing a threat to biodiversity. A series of 5 large dams is also planned further downstream on the Thanlwin River and its tributaries, namely: the Hatgyi, Tasang, Wei Gyi (Upper Thanlwin Dam), Dagwin (Lower Thanlwin Dam), and Upper Thanlwin.

Mining and deforestation, including shifting cultivation in upper reaches of the Thanlwin River, increase sediment flows, reduce storage capacity of reservoirs and raise the bed level in the lower reaches of the river. Development of industry and increasing population density are contributing to deterioration of water quality.
The Chao Phraya is the most economically important basin in Thailand, stretching 980 kilometers in length and covering 30% of the country’s land area. The basin catchment area is 178,785 square kilometers, of which 14,000 are in the low-lying delta. The river’s headwaters originate in the mountainous terrain of the northern part of the country and consist of four large tributaries, the Ping, Wang, Yom, and Nan rivers, which meet to create the Chao Phraya at Nakhon Sawan. The river then flows southward through a large alluvial plain before splitting into four channels, the Tha Chin, Noi, Lop Buri, and Chao Phraya rivers.

The Pasak River joins the Chao Phraya at the ancient capital of Ayutthaya. The main river system passes through the capital city, Bangkok, situated at its downstream end. The expanse of the Chao Phraya and the Tha Chin rivers and their distributaries, forms the Chao Phraya delta, which is bisected by canals that serve both for irrigation and transportation.

Extensive canals have been built to exploit the agricultural potential of the floodplain since the 1800s. The first of a number of irrigation dams, the Rama VI dam on the Pasak River was completed in 1924 and was followed by a number of other tributary and main stem dams, such as the Bhumibol Dam on the Ping River, the Sirikit Dam on the Nan River, and the Chao Phraya Dam at Chainat.

About 40% of the Thai population live in the Chao Phraya basin, and two thirds of the national gross domestic product are generated by development activities in the basin. The mountainous upper region is characterized by agriculturally productive valleys, while in the lower region, highly productive alluvial plains predominate. This area has extensive irrigation networks, including about 3,000 small dams to store monsoon flows, permitting extensive exploitation of the basin’s vast agricultural potential. The agriculture sector accounted for 12% of Thailand’s gross domestic product in 2009.

Although average discharge from the Chao Phraya is 718 cubic meters per second, the
discharge fluctuates widely with maximum average discharge spiking to 5,960 cubic meters per second. Floods are a natural phenomenon in the basin; extreme events were experienced in 1942, 1983, 1995, and most recently in 2011 when areas of Ayutthaya and outer Bangkok were inundated for weeks with the loss of more than 500 lives and major impact on industries, agriculture, and tourism. Factors that worsen the flood peak and duration include a decline of flood retention areas and the confinement of flood plains due to increasingly intensive agricultural development, as well as rapid urbanization and industrial growth around Bangkok. Some parts of Bangkok have experienced land subsidence of 1 meter over a 25-year period, due to overpumping of groundwater; further subsidence was reduced substantially after pumping controls were introduced in the mid-1990s.

The lowland areas of the Chao Phraya watershed in central Thailand are designated as freshwater swamp forest, a tropical and subtropical moist broadleaf ecoregion. These forests have been extensively reduced through conversion to agriculture, predominantly rice cultivation, and urban development. Habitat loss has affected numerous freshwater fish, birds, and mammals that had previously been abundant in the inland and coastal areas of the basin. The remaining wetlands, including those in the Khao Sam Roi Yot National Park, provide habitats for breeding and wintering bird populations.

While conditions in the upper and central Chao Phraya and upper Tha Chin are considered fair, water quality in the lower Chao Phraya and lower and central Tha Chin is deteriorating due to increasing discharges from domestic, industrial, and agricultural sources. Water quality in the Ping, Wang, Yom, and Nam rivers is also deteriorating, associated with urban, industrial, and agricultural loadings and, more generally, the rapid development occurring in provinces.

Over the past decade, Thailand has established river basin committees for the 25 basins across the country, including the Chao Phraya, composed of local administrative body representatives, water users, local nongovernment organizations, government officials, and private sector delegates. Collectively, they are responsible for dialogue among stakeholders in the basin to identify solutions to water-related issues and to act as a coordinating body with government.
Floating Market at Nga Nam in the Mekong Delta, Viet Nam.
The Mekong River is 4,909 kilometers in length from its source on the Tibetan Plateau (Xizang) in the PRC to its mouth at the Mekong Delta in Viet Nam. The basin has an area of 795,000 square kilometers, extending over six countries—the PRC (21%), Myanmar (3%), the Lao PDR (25%), Thailand (23%), Cambodia (20%), and Viet Nam (8%). The upper region, known as the Lancang River, stretches some 2,000 kilometers with a drainage area of 165,000 square kilometers. The Lancang and tributaries in Yunnan are confined by narrow, deep gorges, where the river rapidly descends nearly 4,500 meters as it flows through the province. Approximately 90% of the elevation drop occurs in the PRC. As it approaches the Lao PDR border the river widens and slows. Average annual runoff from the Lancang is 74 cubic kilometers, contributing 14%–16% of the average total annual flow of the Mekong River of 460 cubic kilometers at its mouth, but up to 30% of the dry season flow.

On leaving the PRC, the Mekong River forms the border between Myanmar and the Lao PDR, then between Thailand and Lao PDR. The contribution from the PRC throughout the year has a major influence on flow regimes and water levels in the Mekong River in northern Thailand and the Lao PDR, in addition to the significant amount of water added downstream from the large left bank tributaries in the Lao PDR (Nam Ou, Nam Khan, and Nam Ngum rivers) and the Mun and Chi right bank tributaries in Thailand. Upstream of Luangprabang, the river continues within the Lao PDR then again forms the border with Thailand before entering the Lao PDR. At Si Phan Don, just before entering Cambodia, the river divides into a 9 kilometer wide array of braided channels and drops over the Khone Falls into Cambodia and later into southern Viet Nam, where it flows via a complex delta system into the South China Sea.

The lower Mekong basin has 21 sub-basins with more than half of its main stem flow being contributed by tributaries entering from the Lao PDR. The Mekong Delta begins in Phnom Penh, where the river divides into its two main distributaries, the Mekong and the Bassac. The
Mekong then divides into six main channels and the Bassac into three channels, to form the Nine Dragons of the outer delta in Vietnam. Average river discharge is 14,500 cubic meters per second, peaking to an annual mean average of 39,000 cubic meters per second as a result of extreme seasonal variations in flow. Flows from year to year are highly variable as demonstrated by the range of flood peak discharges measured at Kratie in Cambodia—from about 77,000 cubic meters per second in 1978 to 34,000 in 1992. Severe flooding with return periods of 30–40 years was experienced along the main stem in northern Thailand and the Lao PDR in 2008 while in 2000, almost 900 people were killed and 2.5 million hectares of agricultural land were affected in Cambodia and Vietnam. Flash flooding in tributary rivers has similarly caused extensive loss of life and damage. Early 2010 saw a widespread subregional drought affecting Yunnan and the northern Lao PDR and Thailand, and low levels in the Mekong halted commercial and tour river transport.

Cambodia’s Tonle Sap forms part of a unique hydrological system in the Mekong complex. The Mekong River and Tonle Sap are connected by the 120 kilometer Tonle Sap River, which reverses its direction of flow as water levels in the Mekong rise and fall. From July to the end of October, when the level of the Mekong is high, water flows into the Tonle Sap River, which fills the lake, increasing its size more than four-fold from 2,600 to about 10,500 square kilometers at its maximum. In November, when the level of the Mekong drops below the threshold point, the Tonle Sap River reverses its flow and water flows from the lake back into the Mekong River.

The Mekong River Basin maintains diverse and exceptionally productive ecosystems. Basin fauna include 14 critically endangered species, 21 endangered species, and 29 vulnerable species. The basin is home to one of the world’s most diverse fisheries, of more than 1,300 species of fish that support a capture fishery of about 2.3 million tons per year valued at some $2 billion. These high annual fish yields are under pressure from human-induced activities, including overfishing, fragmentation and reduction of floodplains, and the blockage of fish migration by hydropower development both on tributaries and proposed for the main stem. There are approximately 400 deep pools in the Mekong that act as refuges for fish populations in the dry season.

The basin population was approximately 70 million in 2007. Population density is comparatively low, averaging 88 inhabitants per square kilometer, although there is considerable variability between countries. There are over 100 different ethnic groups living in the basin, making it one of the most culturally diverse regions in the world. It is predominantly a rural basin; roughly 85% of the people rely on agriculture, forestry, and fishing for their livelihoods. Agriculture in Thailand and Vietnam is intensively developed. Total irrigated area in the lower basin is roughly 4 million hectares, of which Vietnam accounts for 41%, Thailand 30%, the PRC 12%, Cambodia 8%, the Lao PDR 7%, and Myanmar 2%. The river is also of great importance for fisheries, especially in the Lao PDR, Cambodia, and Vietnam, where local communities are highly dependent on fish for food security. Large-scale fishing and aquaculture have expanded rapidly, especially in Vietnam.

Overall water quality in the upper part of the Mekong River Basin is classified as good. Of the 17 surface water stations monitored in
2009, 88.2% were considered acceptable for drinking water and as fish habitat, 5.9% were acceptable for agricultural use, and 5.9% were considered extremely polluted. Water quality and ecological health conditions in the lower Mekong River Basin are monitored routinely and annual status reports are issued by the Mekong River Commission. Quality is generally good, although localized pollution occurs from agricultural, industrial, and urban sources. Nutrient concentrations continue to remain within acceptable levels for aquatic life and humans, despite elevated values near major urban centers, in tributaries draining predominantly agricultural sub-basins, and in the delta. Chemical oxygen demand progressively increases with distance downstream, due to organic matter discharges from densely populated areas, and runoff from forested areas, agriculture, aquaculture, and industry.

Sediment and associated nutrients are important for the morphology of the Mekong River, particularly the delta, and for the capture fisheries. Data on sediment flows are limited but the total load has been estimated at up to 125 million tons per year of which 50% comes from the Lancang catchment, although this has been reduced since completion of hydropower dams. Another significant source of sediment is the transboundary “3S” (Sekong, Sesan, and Srepok) sub-basin.

Two subregional agreements exist for transboundary cooperation in the basin. The Mekong River Commission was established by treaty in 1995 signed by the four lower riparian countries for cooperation on the sustainable development of the basin. The PRC and Myanmar became active Dialogue Partners in 1996. For the upper basin, the Joint Committee for the Coordination of Commercial Navigation was established to cooperate on matters related to navigation improvements, safety, and river-borne trade between the upper (Lancang) and lower reaches of the river.

The Mekong River Basin has high hydropower development potential. Four large hydropower projects have been completed since 1992 on the upper reaches in the PRC, while another three large dams and a number of smaller ones are under construction or planned. Plans for another dam, the closest to the lower basin, have been dropped, reportedly due to concerns over the migration routes of fish to an upstream tributary.

Feasible hydropower projects in the lower basin have a total potential of 30,000 megawatts, of which 13,000 megawatts are on the Mekong main stem and the remainder on its tributaries. Existing hydropower projects on the tributaries in the lower basin have an installed capacity of 2,612 megawatts, with a further 3,574 megawatts currently under construction and agreements with private developers in place to carry out feasibility studies on more than 50 other projects. Environmental concerns include risks to ecosystems and biodiversity in the project areas and disruption to fish migration, habitats, and feeding grounds. Although not a major consumptive use of water, hydropower projects have resulted in rapidly fluctuating flows downstream, which, if not mitigated, cause disruption to river transport and fishing activity.

Since 1994, up to 12 run-of-the-river main stem dams have been proposed for the lower Mekong in the Lao PDR and Cambodia and some of these are reaching advanced stages of planning by private developers. Xayaburi, the first of these to be submitted to the Mekong River Commission for consideration under

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**Mekong River Commission**

The Mekong River Commission (MRC) is an intergovernmental agency, the only one that works directly with the governments of Cambodia, Lao PDR, Thailand, and Viet Nam on their common specific interests—joint management of shared water resources and sustainable development of the Mekong River. The MRC aims to ensure that the Mekong’s water is developed in the most efficient manner that mutually benefits the four countries and minimizes harmful effects on people and the environment in the lower Mekong basin. The MRC plays a key role in regional decision making and the execution of policies in a way that promotes sustainable development and poverty alleviation. The MRC has adopted a number of rules and procedures, such as the Procedures for Water Quality, to provide systematic and uniform information. It also acts as a regional knowledge hub on key issues related to the Mekong.

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*Upper: Transporting produce to market, Nga Nam, Viet Nam. Lower: Floating houses on the lower Mekong River at Chau Doc, Viet Nam.*
its prior consultation procedure is a proposed 32 meter high 1,260 megawatt dam, to be located 150 kilometers downstream of Luangprabang. Member countries of the commission requested additional studies be undertaken to evaluate the extent of potential impacts, particularly on capture fisheries and livelihoods.

**Sesan, Sre Pok, and Sekong (3S)-Largest Transboundary Tributary**

The Sesan, Sre Pok, and Sekong river basins (3Ss) have a total catchment area of about 78,650 square kilometers and are collectively the largest tributary system to the Mekong. They extend through parts of Cambodia (33% of total basin area), the Lao PDR (29%), and Viet Nam (38%). The sources of the three rivers are in the Central Highlands of Viet Nam from where the Sekong flows through the Lao PDR before merging with the Sesan and Sre Pok. The Sesan and Sre Pok rivers flow from Viet Nam to Cambodia where the three rivers merge over a distance of about 40 kilometers before the confluence with the main stem of the Mekong River at Stung Treng. With a combined discharge of about 17% of the annual discharge of the Mekong, managing these basins requires innovative arrangements that involve the three countries to ensure sustainable management of land and water resources and equitable benefit sharing.

The 3S region is important for its biodiversity and natural resources, especially the fish and their connection with the Mekong. Changes in land use and forest cover put significant pressure on the rich terrestrial biodiversity. The national protected areas cover over 20% of the basin, but are under pressure themselves from illegal logging, encroachment, and the wildlife trade. Aquatic biodiversity and resources are threatened by changes in flows and water quality. All basins report declines in fish production from a combination of loss of habitat, fishing pressure, and illegal fishing methods. In the future this decline is expected to increase due to changes induced by hydropower dams, particularly for projects located near the confluence with the Mekong, which threaten to disconnect the extensive migratory fish habitats.

### Distribution of the 3S sub-basins (square kilometer)

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Cambodia</th>
<th>Lao PDR</th>
<th>Viet Nam</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Se Kong</td>
<td>5,565</td>
<td>22,565</td>
<td>690</td>
<td>28,820</td>
</tr>
<tr>
<td>Se San</td>
<td>7,630</td>
<td>—</td>
<td>11,260</td>
<td>18,890</td>
</tr>
<tr>
<td>Sre Pok</td>
<td>12,780</td>
<td>—</td>
<td>18,160</td>
<td>30,940</td>
</tr>
<tr>
<td>Total</td>
<td>25,975</td>
<td>22,565</td>
<td>30,110</td>
<td>78,650</td>
</tr>
<tr>
<td>Total %</td>
<td>33.3</td>
<td>28.7</td>
<td>38.3</td>
<td>100</td>
</tr>
</tbody>
</table>

The Red River system is the second longest in Viet Nam. It is an international river system, originating in Yunnan and flowing 1,149 kilometers through northern Viet Nam into the Beibu Gulf (Gulf of Tonkin). The total basin catchment area is 169,000 square kilometers, of which 81,240 square kilometers are in the PRC, 1,100 in the Lao PDR, and 86,660 in Viet Nam. The main reach of the river commences at the confluence of the Da, Thao, and Lo rivers upstream of Ha Noi. Further downstream, the river forms a large delta covering an area of 14,788 square kilometers. Total annual flow volume to the Gulf of Tonkin is approximately 134 cubic kilometers, an average discharge of 4,249 cubic meters per second, of which 61% is generated in Viet Nam, and 39% in the PRC and the Lao PDR. Inflows to the river basin
are unevenly distributed both spatially and temporally, leading to water shortages in the dry season and flooding in the rainy season.

The estimated basin population is 28 million, of which 17.2 million live in the delta and 3.6 million in urban areas, including the main cities of Ha Noi and Hai Phong. The Red River Delta is one of Viet Nam’s key economic regions, with agriculture playing an especially important role in the country’s socioeconomic development. Other major economic activities in the delta include industry, services, and river transport. In the coastal region, rice cultivation is being replaced by brackishwater aquaculture. Water demand from industry, services, and municipal use is rising rapidly as industrial development intensifies and urban density increases.

The reddish-brown, heavily silt-laden water that gives the Red River its name supports extensive agriculture in the lower basin and delta. Irrigated agriculture is the primary water-use sector. Irrigation development in the delta represents approximately 37% of the total national irrigated area and encompasses roughly 4.5 million hectares of small, medium, and large irrigation schemes.

The Red River Basin supports rich freshwater and marine wetland biodiversity. About 50 aquatic species are harvested in the upper basin, including many fish, crabs, turtles, snails, and clams. Catches of fish and other aquatic species have been declining due to hindrance of fish migration, use of destructive fishing methods, and overfishing. The coastal zone of the delta supports a great biodiversity of fish and water birds, which are increasingly under pressure from dense human settlements and intense agricultural production. A Ramsar wetlands site has been designated at Xuan Thuy National Park to preserve 12,000 hectares of mangrove in the mouth of the Red River.

Water quality in the upper basin is considered generally acceptable, meeting national surface water standards for industrial and domestic uses. Although localized deterioration occurs near urbanized areas. Water quality in the lower basin, where the river flows through intensively cultivated, industrialized, and urbanized areas, progressively deteriorates. Industrial (from fertilizer producers, food and foodstuff processors, pulp waste, and textile producers) and domestic wastewater are the key contaminant sources, while suspended matter, organic matter, nitrates, and coliforms are the main pollutants. Localized heavy metal and toxic organic pollution occurs as a result of industrial effluent discharges. Agricultural runoff containing high fertilizer residue also causes localized pollution. Fertilizer and pesticide use in agriculture continues to increase, with fertilizer imports rising from 900,000 tons in 2000 to almost 3 million tons in 2008. Nationally, wastewater discharges reached 3 million cubic meters per day by 2009. Biochemical oxygen demand in major rivers is increasing, with concentrations consistently exceeding standards during 2005–2009.

Three hydropower schemes have been developed in the Red River Basin, the 1,920 megawatt Hoa Binh and 2,400 megawatt Son La projects on the Da River and the 120 megawatt Thac Ba project on the Chay River. During the rainy season, there is some trade-off to hydropower generation because these reservoirs and the Day River barrage are operated by the Government to control flooding, particularly to protect the city of Ha Noi. Nine main irrigation reservoirs serve 60,000 hectares, representing about 6% of average annual flow. There is considerable potential for further storage development, particularly on the Da and Lo-Gam rivers.
The Pearl River Basin comprises an extensive river system in the southern PRC and northeastern Viet Nam. It is the largest river system in the southern PRC and the fourth largest in the country. The basin has a total drainage area of 409,480 square kilometers and consists of three main tributaries, the Xi Jiang, the Bei Jiang, and the Dong Jiang, that have in common the Pearl River delta. The Pearl River system extends 2,210 kilometers from its origin in Xi Jiang to the delta, making it the PRC’s third longest river after the Yellow and Yangtze rivers, and the second largest in volume after the Yangtze. As well as referring to the system as a whole, the Pearl River name applies to a specific branch of the system—the widest distributary within the delta, flowing through the major city of Guangzhou before forming a large bay in the southeast of the delta that separates Macau and...
Zhuhai from Hong Kong, China. The river is named for the pearl colored shells found on the river bottom as it flows through Guangzhou. Average annual discharge into the South China Sea is 10,591 cubic meters per second.

The Pearl River is situated in the PRC’s humid south-southwest agro-climatic region. It has a subtropical monsoon climate that allows for year-round agriculture, with rice being dominant in the lowlands. Agriculture is the main user of the river’s water in the PRC, with an estimated 65% of water withdrawals for agriculture, followed by 23% for industrial, and 12% for municipal uses. With annual precipitation exceeding 1,000 millimeters, the region is classified as a supplementary irrigation zone. Irrigation is still necessary for rice, especially to improve cropping intensity, and supplementary irrigation may be required for upland crops.

The PRC has established a water quality classification system based on water use and human and aquatic life protection targets. Based on this classification, water quality is monitored at 17 stations in the southwestern rivers. Overall quality of the Pearl River is considered good, with 85% of monitoring stations meeting the standard for drinking water and as fish habitat, 12% meeting the standard for industrial use, and 3% primarily in tributaries being considered extremely polluted. Water quality degradation is typically most prominent as rivers flow through large cities, where discharge of organic materials causes increased concentrations of various pollutants.
The Ayeyarwady Delta, Myanmar, with its dense network of rivers, has a floodplain ideal for rice production.
Tonle Sap, Cambodia

Tonle Sap, the Great Lake, is the largest freshwater body in Southeast Asia, harboring Cambodia's major source of protein for over 2 million people.
Wetlands

Wetlands are among the most productive ecosystems, comparable with rain forests and coral reefs. Wetlands vary enormously in size and character, from tiny village ponds to lakes, bogs, marshes, and rivers. A source of great biodiversity, wetlands also support numerous species from all major groups of organisms, from microbes to mammals. Wetlands serve as habitats for fish and wildlife, naturally improve water quality, store floodwater, protect shorelines against erosion, provide opportunities for recreation and aesthetic appreciation, and yield natural products for human consumption at little or no cost. Protecting wetlands, in turn, reduces flood damage and preserves water quality, thus protecting health and safety. The biggest wetland in the subregion, apart from the large rivers, is Tonle Sap.

Cambodia

Seasonal and permanent wetlands make up more than 30% of the area of Cambodia. They include the Mekong River and its floodplain, Tonle Sap and its floodplain, the Stung Sen River, and the coastal estuaries of Stung Kep and Koh Kapic in Koh Kong. Three sites in the country have been proposed for inclusion in the Convention on Wetlands of International Importance (commonly known as the Ramsar Convention), particularly as Areas of Importance for Waterfowl. These sites are:

- Boeng Chhmar and its associated river system and floodplain of Tonle Sap,
- the middle stretches of the Mekong River north of Stung Treng, and
- Koh Kapic and its associated islets in Koh Kong Province.

Koh Kapic is an area of around 12,000 hectares on the western part of the Cambodian coastline near the border with Thailand. Most of Koh Kapic is in the Peam Krasaob Wildlife Sanctuary, which was made a protected area in November 1993 by the Royal Decree on the Creation and Designation of Protected Areas.

Tonle Sap, Tonle Sap, or Great Lake, is situated in the center of the Cambodian central plain, which has an elevation of 10–30 meters above sea level and covers about 6% of the country. The lake is connected to the Mekong River through the 120

Wetlands Defined

Under the Convention on Wetlands (Ramsar, Iran, 1971) "wetlands" are defined by Articles 1.1 and 2.1 as shown below.

Article 1.1 states “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.”

Article 2.1 provides that wetlands “may incorporate riparian and coastal zones adjacent to the wetland and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands.”
kilometer Tonle Sap River. The two rivers join at the Quatre Bras near Phnom Penh, after which the river immediately branches into two arms, the larger main Mekong and the smaller Bassac River. Further downstream these two arms are reconnected to form two equal channels as they start to fan out to form the delta, discharging into the South China Sea.

The vast floodplain of Tonle Sap supports one of the most productive inland fisheries in the world, and was declared a UNESCO World Biosphere Reserve in 1997.

The volume of water stored yearly in the lake is about 72 cubic kilometers, draining an area of 85,000 square kilometers, 10.7% of the total drainage area of the Mekong River. Tonle Sap contributes 6.4% of the average annual flow of the river.

The lake varies in dimensions seasonally, between 160 and 300 kilometers long and between 35 and more than 100 kilometers wide, its surface area from 2,600 to about 10,500 square kilometers, and its volume from about 1.3 to 75 cubic kilometers.

The extent of the lake expansion varies from year to year depending on flows from upstream and this has an influence on fish catch. Tonle Sap accounts for about 60% of Cambodia’s inland fisheries production. More than 1.2 million people in the Tonle Sap area depend on fishing for their livelihood.

The rise in water levels at the beginning of the flood season triggers many migrating fishes to move from the dry season habitats just below the Khone Falls, e.g., in deep pools along the Kratie–Stung Treng stretch, toward their floodplain habitats in southern Cambodia and the Mekong Delta in Viet Nam.

Maintaining the natural reverse flow of the Tonle Sap River at an acceptable level is so important that it is formally recognized in the Mekong River Commission’s Agreement on Cooperation for the Sustainable Development of the Mekong River Basin. The extent to which dams in the Mekong basin affect downstream wetlands by changing the flood regime is reported in the MRC’s analysis of basin development scenarios.

Guangxi Zhuang Autonomous Region

Thickly criss-crossed by rivers, Guangxi is rich in water resources. It is estimated that the surface water flowing in the region amounts to 188 cubic kilometers, about 7% of the PRC’s total flow. The three largest water systems running through the region are the Pearl (Zhujiang), Yangtze, and Duliu rivers. Other extensive wetlands exist and include 10 nature reserves. Of particular interest are coastal wetlands.

Shankou Mangrove Wetland. Shankou Mangrove Wetland, covering 8,000 hectares, is located southeast of Hepu County. It has a north tropical marine monsoon climate and is the most representative and best preserved natural mangrove zone in the PRC. It includes a 4,000-hectare Ramsar Convention wetland of international importance, consisting of a mangrove forest and its ecosystem, which contains many species of mangroves, all of great value. Besides the mangroves, there are abundant marine organisms, such as various algae and pearl oysters, as well as many nationally protected bird species. The site also supports a number of vulnerable and endangered species, including a dugong, which is under state protection.
Guangxi Beilun Estuary Wetland. Guangxi Beilun Estuary Wetland, situated at the extreme southwestern coast of mainland PRC, covers 3,000 hectares and is also a Ramsar Convention protected wetland of international importance. It contains mangrove forest and intertidal mudflats on the Beilum River, the boundary river between the PRC and Viet Nam, which also lies on the East Asian - Australasian Flyway, an important migration corridor for some migratory bird species. The reserve contains semi-closed bays, open estuary coasts, and sandy beaches with mangrove vegetation that provide habitat for 187 bird species, including vulnerable and endangered species. The site plays a substantial role in shoreline protection, alleviating floods caused by typhoons and resisting tidal impact.

Yunnan Province, People’s Republic of China

Yunnan has several large natural lakes in the catchment of the Mekong River. Of these, two are protected as nature reserves: Dian Chi, the largest lake in the catchment and eighth largest lake in the PRC, is a nationally important lake in Kunming. Er Hai Lake is second largest in area although bigger in volume due to its greater depth. Nearly comparable in size is Fuxian Lake and there are several minor lakes of environmental and cultural importance.

Dian Chi Lake. Dian Chi Lake is a large, freshwater fault lake located on the Yunnan-Guizhou Plateau in Kunming, 1,886 meters above sea level and covering over 309 square kilometers. It is 39 kilometers long from north to south, and the average depth is 5.3 meters. It is the eighth largest lake in the PRC and the largest in Yunnan Province.

Er Hai Lake. Er Hai is situated at 1,974 meters above sea level. The north-south length of the lake is 40 kilometers and the east-west width is roughly 7–8 kilometers. Its area is 251 square kilometers, making it the second largest highland lake of the PRC, after Dian Chi Lake. Its circumference reaches 116 kilometers with an average depth of 10.6 meters and a total storage capacity of 2.7 cubic kilometers. The lake is sandwiched between the Cangshan Mountains to the west and Dali City.

Fuxian Lake. Fuxian Lake stretches out through Chengjiang, Jiangchuan, and Huaning counties in Yunnan, spanning an area of 217 square kilometers. The storage capacity of 20.6 cubic kilometers is the largest in Yunnan; as well as the third largest lake in area in Yunnan, it is the deepest lake, at 158.9 meters—making it the second deepest freshwater lake in the PRC after Tianchi Lake, a volcanic body of water in Changbai Mountain in northeastern PRC.

Lugu Lake. Lugu Lake is an alpine lake at an elevation of 2,691 meters located in the North West Yunnan plateau bordering Sichuan Province. Surrounded by mountains, it is the highest lake in Yunnan and contains islands, peninsulas, bays, and beaches. The lake’s shores are inhabited by many ethnic groups, such as the Mosuo, Norzu, Yi, Pumi, and Tibetan. The most numerous are the Mosuo (or Moso) people, said to be a sub-clan of
The Naxi People with an ancient family structure considered as “a live fossil for researching the marital development history of Human beings” and “the last quaint Realm of Matriarchy.” Lugu Lake is called the “mother lake” by the Mosuo people.

The Lao People’s Democratic Republic
The major wetlands in the Lao People’s Democratic Republic are the Mekong River, Khone Falls–Siphandong (60 square kilometers), Xe Pian–Xe Khampho (300), Bung Nong Ngom complex (30), Xe Kong Plains (350), Xe Champhone (240), Nong Luang (90), and the Nakai Plateau (100). These areas have not yet been officially designated for protection.

Beung Kiat Ngong. Beung Kiat Ngong Wetland in Champasak Province is an important wetland complex within the Xe Pian National Protected Area; the Dong Hua Sao National Protected Areas covers an area of 2,360 hectares and includes swamps, lakes, and marshes. It is the only place in the Lao People’s Democratic Republic where peatland areas are found. The tributary of the Xe Khampho River supports up to 300 fish species and is important for fish spawning, providing a migratory path upstream during the wet season. During the dry season it acts as a sanctuary for many fish species. Aquatic habitats are home to freshwater tortoises, such as the vulnerable Malayan snail-eating turtle, and the site is important as a feeding area for waterbirds that occasionally alsonest there. The site is important for flood control and maintaining groundwater. Local residents engage in subsistence and commercial fishing, growing rice, and harvesting wild vegetables and nontimber forest products, including over 350 species of medicinal plants. Threats include peat extraction for fertilizer, unsustainable fish harvesting, and conversion of marsh areas into rice fields.

Ngong Xe Champhone. Ngong Xe Champhone Wetlands in Savannakhet Province form a large plain consisting of marshes, swamps, and flooded woodland forest; it is an outstanding and rare example in the Lao People’s Democratic Republic of a river with many oxbow lakes, deep pools, and mats of dense floating vegetation. It supports the largest population of the critically endangered Siamese crocodile in the country and protects other species, such as the endangered elongated tortoise. As the water level recedes during the dry season, crocodiles and fish migrate to permanently flooded deep ponds and marshes. Fish use the site as a spawning area and as a migration path during the wet season. Local people engage in rice farming, communal fishing, and raising cattle and water buffalo. Traditional management systems, such as sacred areas and local taboos, play an important role in the protection of some parts of Xe Champhone wetlands and their resources. Threats to the site include conversion for agriculture, collection of crocodile eggs, and disturbance to crocodile hatching areas due to flooding caused by the construction of weirs.

Myanmar
Myanmar has extensive mangroves in the Ayeyarwady Delta and other coastal areas. Lake Indawgyi is the largest lake in the country and features a large wildlife sanctuary. Lake Inle, the next largest, is also considered to have outstanding significance for biodiversity.

Indawgyi Lake. Indawgyi Lake, located in the Kachin State of Myanmar, is one of the largest inland lakes in Southeast Asia. The lake measures 13 kilometers east to west, and 24 kilometers north to south. There are over 20 villages around the lake. The predominant ethnic groups living around the lake are the Shan and the Kachin, who mainly practice agriculture. Half of the site is covered by mixed deciduous forest and 30% is wetland. Evergreen forest (riverine), mixed deciduous forest (bamboo), and hill forest (pine forest), are other forest types of the site. At least 165 types of trees and medicinal plants, 38 mammals, 448 birds, 41 reptiles, 34 amphibians, and 50 butterflies are present in the site. The area is an International Bird Area with some 10 threatened bird species, including the critically endangered white-rumped vulture and the nearly threatened hooded treepie, endemic to Myanmar.

Inle Lake. Inle Lake is one of The Association of Southeast Asian Nations’ heritage sites; vast as well as picturesque, the lake measures 22 kilometers long and 10 kilometers wide, located 900 meters above sea level in the hilly Shan State in eastern Myanmar; it is one of the country’s
main tourist attractions. It is famous for its scenic beauty and the unique leg rowing of the Inthas, the native lake dwellers. Aquatic animals are highly endemic, to an unusual degree, in this relatively shallow lake. The key resource of the site is a large population of many migratory and resident birds (175 species have been recorded), besides native aquatic plants and freshwater fishes. Some 170,000 people live spread out in 400 villages around the lake, many on floating islands of vegetation. The lake has been modified through land reclamation. Floating gardens built in many places have transformed the lake surface into a series of canals. Runoff of pesticides and fertilizer from the gardens, combined with sewage from surrounding communities and sedimentation from cattle grazing, poses a potential threat to this ecosystem. An estimated 310,000 tons of sediment enter the lake each year from 29 creeks flowing through the watershed area. In 2010, the depth of Inle Lake reached its lowest point in 50 years due to weather variability and unsustainable practices of natural resource use. An unprecedented surge in temperature in the summer of 2010, deforestation in the watershed, eutrophication, and overuse of chemical fertilizer and insecticides, in addition to the heavy sedimentation, have resulted in the decrease of the Inle Lake area by about one quarter.

**Thailand**

Rapid industrialization has reduced Thailand’s important wetland ecological systems. To protect its remaining wetlands, the country has signed the Ramsar Convention. The Thale-Noi Non-Hunting Area, Khao Sam Roi Yod National Park, and Bung Boraped are considered wetland sites of international importance, and Thale-Noi has been placed under the protection of the Ramsar Convention.

**Songkhla Lake.** Songkhla Lake is the largest natural lake in Thailand, located on the Malay Peninsula in the southern part of the country. The lake covers an area of 1,040 square kilometers and borders the provinces of Songkhla and Phattalung. The southern part becomes a 380-meter wide strait flowing into the Gulf of Thailand at the city of Songkhla. This part contains brackishwater while the northern part consists of freshwater. Connected to Songkhla Lake are the Phru Khuan Khi Sian wetlands and Thale Noi Lake, located just north of Thale Luang, one of the few surviving intact freshwater wetland ecosystems in Thailand. Among the specific wetland types found here are marsh, melaleuca (also termed “paperbark”) swamp forest, rice fields, and swamp grasslands. They have been protected as a Ramsar wetland since 1998, and are part of the larger Thale Noi Non-Hunting Area, created in 1975. A small population of endangered Irrawaddy dolphins is
found in the lake; they are threatened by extinction from the overfishing and pollution of the lake.

**Sam Roi Yod Wetland.** Sam Roi Yod (literally, “mountain with 300 peaks”) is a national park in the Pranburi and Kuiburi districts of Prachuap Khiri Khan Province. It is home to at least 116 species of birds (residents and winter migrants), 24 species of fish, and many species of reptiles and amphibians, as well as insects and plants. Although relatively small (98 square kilometers), the park has a vast array of habitats—from limestone mountains, rocky shores, and sandy beaches to mangrove forests, mudflats, and marshes, including islands. One particularly important and fertile habitat is the nearshore marine ecosystem, a refuge for the endangered serow. A freshwater wetland with an area of 30 square kilometers just west of the national park also supports an abundant biodiversity. It is home to at least 50 plant species and 349 kinds of animals, of which at least 28 are found only in this marsh. There are 21 villages in the vicinity with more than 3,600 households, whose members depend on the marsh for their livelihood. The park is threatened by disputes among local people over landownership and land claims within its boundary. In an attempt to solve the conflicts, the Government cancelled all landownership documents within the boundary of the national park. But other problems—encroachment of land for agriculture and shellfish farms, wastewater release from communities and factories, and basin agriculture—have appeared. The Government has called for cooperation with the surrounding communities in joint activities that could make the park more valuable for all.

**Viet Nam**

Viet Nam has a great diversity of wetland habitats: large estuarine and delta systems with extensive mangrove swamps and tidal mudflats, immense seasonally flooded plains with rice paddies and melaleuca forests, many small offshore islands, large coastal brackishwater lagoons, salt pans, many freshwater lakes, and numerous rivers and streams. By far the largest wetland area is the Mekong Delta in the south, with its elaborate network of river channels and vast areas of rice fields, mangrove forests, melaleuca forests, and tidal mudflats. In the central part of Viet Nam, most of the significant wetlands are coastal lagoons. In the north, there are numerous lakes in the Red River Basin and extensive mudflats and mangrove swamps in its delta.

**Mangroves in the Mekong Delta.** The Nam Can mangrove forests and U Minh Ha melaleuca forests of Ca Mau Province stretch...
250 kilometers along the coastline of the southernmost tip of Viet Nam. These areas protect the coast from erosion and create a 5,200 square kilometer coastal ecosystem that is rich with marine life.

The Dat Mui Nature Reserve is in this ecosystem. Natural mangrove forest originally covered the site but was mostly destroyed by war and later conversion to fishponds and agricultural land. The now-abandoned fishponds support extensive areas of recolonizing mangrove forest. There are also extensive mudflats that are sites for colonization by mangroves.

On the western coast of the Ca Mau Peninsula is the Bai Boi Protection Forest, which is proposed as a nature reserve. Bai Boi is also composed of abandoned fishponds and extensive mudflats that are being recolonized with mangroves, which also help to protect coastal areas from tropical storms.

**Can Gio Wetland, Ho Chi Minh City.** The Can Gio Biosphere Reserve is a mangrove-dominated 757 square kilometer area between Ho Chi Minh City and the sea that is highly valued for its biological diversity and provides the “green lungs” for the country’s largest urban area. More than 200 species of animals and 52 species of plants have been identified in the area. At least 35 bird species have been recorded in the Can Gio forest. In the past, the mangrove forest of Can Gio sheltered various wild animals, such as tigers, panthers, and crocodiles. Now there are only monkeys, deer, wild boars (including some newly found herds), otters, reptiles, and amphibians.

After severe damage three decades ago, Can Gio’s ecosystem has been restored to some extent. This marks the first time that an entire rehabilitated ecosystem has been designated as a biosphere reserve. However, many challenges remain. Local communities in Can Gio earn much less than those in other parts of the country, especially nearby Ho Chi Minh City. Education levels are still low and environmental awareness rudimentary.

**Ba Be Lake, Bac Kan Province.** Ba Be, the biggest natural lake in Viet Nam, is located in the Cho Ra-Ba Be-Cho Don karst terrain. Ba Be Lake has a water area of about 500 hectares spread out over 8 kilometers and is a part of the Ba Be National Park. The Ba Be Lake remains permanently filled with water in contrast to other such lakes that contain water only in the wet season. Ba Be Lake is recognized as one of the 20 special freshwater lakes in the world that need protection. Ba Be National Park is recognized as a heritage park of the Association of Southeast Asian Nations. The park covers an area of 23,340 hectares. The terrain is mostly limestone rocks with a few earth hills of medium to abrupt slope. Three river flows discharge water into the lake, which has an average depth of 20–25 meters and a maximum of 35 meters. The lake bed contains submerged grottoes, which are ideal habitats for many aquatic animals.
The Greater Mekong Subregion (GMS) sits atop a chain of land masses extending southward to Australia, that effectively separate the tropical waters of two of the world’s major oceans, the Indian and the Pacific. As the waters of these oceans approach land, their currents and physical and chemical characteristics become modified by the presence of the continental shelf, the land, and freshwater from rivers and runoff. Thus, on the west coast of the GMS, the Indian Ocean becomes the Andaman Sea and Gulf of Martaban facing Myanmar and southwestern Thailand, while in the east, the Pacific Ocean forms the South China Sea facing Viet Nam, and the waters of Beibu Gulf facing northern Viet Nam and Guangxi Zhuang Autonomous Region of the People’s Republic of China (PRC), and the Gulf of Thailand facing Cambodia and Thailand.

While these seas and gulfs have unique biophysical properties, their waters share much of their biodiversity due to much earlier tectonic events, the gradual separation and reshaping of the parts of the ancient megacontinent of Gondwana. Up until about 25 million years ago, the Indian and Pacific oceans were joined across a wide expanse and tropical marine fauna had free access to both sides of the present subregion. Subsequent movements of the earth’s crust closed much of this passage apart from further south in the Malacca Straits and gaps between the Indonesian islands and New Guinea. When the last ice age began, as more water became locked up in ice, sea level began to fall, reaching a minimum level 18,000 years ago (the last glacial maximum), when the present GMS, Malaysia, and Indonesia formed a single land mass; even the Malacca Straits and most of the gaps between the Indonesian islands and New Guinea were dry land.

Andaman Sea

The Andaman Sea is a narrow water body lying between the coast of Myanmar and Thailand in the east and the Andaman and Nicobar Islands in the west, with a pointed tip in the Gulf of Martaban in the north and stretching to the top of Sumatra in the south, a length of about 1,200 kilometers. While traditionally a fishing ground criss-crossed by vessels trading along its shores, nowadays it is seeing increasing use in tourism due to its pristine coral reefs and many islands. The fishery and tourist infrastructure was severely damaged by a tsunami following a strong earthquake in the Indian Ocean in December 2004. The average depth of the sea is about 1,000 meters. More than 95% of the sea does not exceed 3,000 meters depth but, in a system of submarine valleys east of the Andaman-Nicobar Ridge, the depth exceeds 4,000 meters. The sea floor is covered with pebbles, gravel, and sand.

The northern and eastern parts are shallower than 180 meters due to the silt deposited by the Ayeyarwady River where it flows into the sea from the north through Myanmar. The climate and water
Salinity of the Andaman sea are mostly determined by the monsoons of Southeast Asia. The average surface water temperature is 26–28°C in February and 29°C in May. Tides are semidiurnal (i.e., rising twice a day) with an amplitude of up to 7.2 meters. The coastal areas of the Andaman sea are characterized by mangrove forests and seagrass meadows. Mangroves cover more than 600 square kilometers of Thailand’s shores along the Malay Peninsula; seagrass meadows occupy an area of 79 square kilometers. Mangroves are largely responsible for the high productivity of the coastal waters. Their roots trap soil and sediment and provide shelter from predators and a nursery for fish and small aquatic organisms. They also protect the shore from the wind and waves, and their detritus forms part of the aquatic food chain.

A significant part of Thailand’s mangrove forests in the Andaman Sea was removed for construction of shrimp farms. Mangroves were also significantly damaged by the 2004 tsunami. They were partly replanted but their area is still gradually decreasing due to human activities, including wastewater discharge from coastal industry, shrimp farms, and other forms of coastal development, as well as fishing using trawl nets, push nets, and drag nets. The 2004 tsunami affected some of the seagrass area along the Andaman Sea through siltation and sand sedimentation.

Within the sea, to the east of the main Great Andaman island group, lies Barren Island, the only active volcano associated with the Indian subcontinent. This island-volcano is 3 kilometers in diameter and rises 354 meters above the seal level. Its activity resumed in 1991 after a dormancy of almost 200 years. The island was formed by the ongoing subduction of the India Plate beneath the Andaman island arc, which forces magma to rise in this part of the Burma Plate. The most recent eruption, which still continues, began on 13 May 2008. The volcanic island of Narcondam, which lies further to the north, was also formed by this process. The Andaman Islands are around 90 kilometers away.

**Gulf of Martaban**

The Gulf of Martaban, forming the northern extremity of the Andaman Sea, is named after the port city of Moattama (formerly known as Martaban). The Thanlwin, Sittaung, and Yangon (or Rangoon) rivers empty into it. It has a tide-dominated coastline with a tidal range of 4–7 meters, the highest being at Elephant Point in the western Gulf of Martaban. During spring tide, the turbid zone covers an area of more than 45,000 square kilometers, making it one of the largest perennially turbid zones of the world’s oceans. The edge of the highly turbid zone migrates back and forth by nearly 150 kilometers with every tidal
cycle. The small port of Martaban, located at the mouth of the Thanlwin and across the river from Mawlamyine, is famous for its glazed pottery.

*Gulf of Thailand*

The Gulf of Thailand, formerly the Gulf of Siam, is an inlet of the South China Sea. Bordered by Thailand, Cambodia, and the southwestern edge of Vietnam, the gulf’s maximum width is 560 kilometers and it extends approximately 725 kilometers in length. The Gulf of Thailand is quite shallow along the coastal areas, which provide lucrative fishing grounds. Many rivers flow into the gulf, with the Chao Phraya being the most significant in Thailand. At the height of the last ice age, the Gulf of Thailand did not exist, due to the lower sea level, and was part of the Chao Phraya river valley. Being shallow, water exchange in the Gulf of Thailand is slow, and the strong water inflow from the rivers makes the gulf low in salinity (30.5–32.5 parts per thousand) and rich in sediments. Only at greater depths does water with a higher salinity (34 parts per thousand) flow into the gulf from the South China Sea, filling the central depression below a depth of 50 meters. The main rivers emptying into the gulf are the Chao Phraya (including its distributary Tha Chin River), Mae Klong, and Bang Pakong rivers, and to a lesser degree the Tapi River into Bandon Bay in the southwest of the gulf. Most of the streams, water channels, and rivers in southwestern Cambodia drain into the Gulf of Thailand.

*South China Sea*

Within the Greater Mekong Subregion (GMS), the South China Sea is part of the Pacific Ocean, located south of Guangxi Zhuang Autonomous Region, PRC, and east of Vietnam. Major GMS rivers that flow into the South China Sea are the Pearl, Red, and Mekong. The South China Sea is the second most used sea lane in the world; more than 50% of the world’s annual merchant fleet tonnage passes through the Strait of Malacca, the Sunda Strait, and the Lombok Strait. Over 1.6 million cubic meters (10 million barrels) of crude oil a day are shipped through the Strait of Malacca, where there are regular reports of piracy, although much less frequently than before the mid-20th century. The region has proven oil reserves of around 1.2 cubic kilometers (7.7 billion barrels), with an estimated 4.5 cubic kilometers (28 billion barrels) in total. Natural gas reserves are estimated to be around 7,500 cubic kilometers (266 trillion cubic feet). This body of water also holds one third of the entire world’s marine biodiversity, thereby making its ecosystems highly important.
Beibu Gulf and Hạ Long Bay

Beibu Gulf, also known as the Gulf of Tonkin, is a natural semi-enclosed gulf in the northwest of the South China Sea. It borders northern Viet Nam on the western side, and smaller areas of Guangxi in the north and Guangdong in the northeast, with the island of Hainan forming the eastern limit of the gulf. It covers an area of 129,300 square kilometers, with the depth of water averaging 42 meters and the deepest point at 100 meters. Haiphong in Viet Nam, and Beihai in Guangxi, PRC, are the chief ports. The Red River is the main river flowing into the gulf. Numerous small islands are located in the gulf, most of which are concentrated in the northwestern gulf. The largest islands are Bach Long Vi and Cat Ba of Viet Nam and Weizhou of the PRC.

Hạ Long Bay, a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site, is located in northeastern Viet Nam; it is bordered on the south and southeast by Beibu Gulf, on the north by the PRC, and on the west and southwest by Cat Ba island. Cat Ba is the largest island in Hạ Long Bay and about half of its area is a national park, which is home to the highly endangered Cat Ba langur. The island has a wide variety of natural ecosystems, both marine and terrestrial, leading to incredibly high rates of biodiversity. Types of natural habitats found on Cat Ba Archipelago include limestone karsts, tropical limestone forests, coral reefs, mangrove and seagrass beds, lagoons, beaches, caves, and willow swamp forests. Cat Ba Island is one of the only populated islands in Hạ Long Bay, with roughly 13,000 inhabitants living in six different communes, and 4,000 more inhabitants living on floating fishing villages off the coast.

Coastal Zones

Cambodia, Myanmar, Thailand, Viet Nam, and Guangxi have large coastal zones with economically important areas and medium to large coastal towns containing millions of people. The coastal areas are characterized by the geologic nature of landforms, such as sandy beaches and dunes, coastal wetlands, rocky coasts, cliff coasts, and islands. These areas were formerly rich in both living and nonliving natural resources. During the last two decades, overexploitation of resources, population growth, and intensified developments in tourism, aquaculture, and industry have caused degradation of the resources.

Cambodia's coast is 435 kilometers long, with 69 islands. Administratively, the coastal zone includes two provinces of Koh Kong and
Kampot, and two municipalities of Sihanoukville and Kep. Marine resources include coral reefs (28 square kilometers), mangrove forests (650 square kilometers), and seagrass beds (300 square kilometers), together with all the living organisms they contain. Cambodia’s reefs are generally associated with offshore islands and rocky substrates. Main threats to the coral reefs are destructive fishing practices, anchor and trawling damage, overfishing, coastal development, agricultural run-off, and sedimentation. The recent practice of sand mining in rivers and along the coast is also affecting nearby reefs, as does land reclamation, mainly around the relatively urbanized areas of Sihanoukville and Kep, and areas that are being newly developed, such as near the naval base in Ream and the new port of Oknha Mong at Keo Phos. Although the reclamation is generally of a small scale, the impact on currents and the littoral transport processes may still be significant, particularly for adjacent areas of the coastline, which do not have any protection.

Guangxi is the only entity in the western PRC that has a coastline and an international border. Guangxi faces Beibu Gulf, serving as an important gateway for, and the most convenient passage between, southwestern PRC and Association of Southeast Asian Nations (ASEAN) countries. Scattered along the 1,595-kilometer coastline of Guangxi are 697 islands, with a total area of 67 square kilometers. Weizhou Island, the largest of these islands, covers an area of about 25 square kilometers. The coast also features numerous seaports. At present, there are 21 operational ports, the largest ones being Fangcheng, Beihai, and Qinzhou. All these ports have deep water, are protected from the wind and waves, and are close to Hong Kong, China, and other Southeast Asian countries. The ports have been given a strong role in the development strategy of the Guangxi government and will undoubtedly become the most active areas in terms of economic development in Guangxi and southwestern PRC.

Myanmar has a coastline of about 2,400 kilometers, which can be divided into three coastal regions: the Rakhine coastal region (from the mouth of the Naaf River to Mawtin Point, about 740 kilometers), the Ayeyarwady Delta and the Gulf of Moattama (Martaban) coastal region (from Mawtin Point to the Gulf of Moattama, about 460 kilometers), and the Thantharyi coastal region (from the Gulf of Moattama to the mouth of the Pakchan River, about 1,200 kilometers) in the Bay of Bengal and the Andaman Sea. With several large estuaries, delta systems, and numerous offshore islands, Myanmar possesses a considerable diversity of coastal habitats, including coral reefs, mangroves, sandy beaches, and mudflats. The north-central part of the country is dominated by the vast delta of the Ayeyarwady River. Myanmar has the largest expanse of mangrove areas.
found. The Mergui reefs are thought to be similar in structure and diversity to the reefs around the offshore islands of Thailand.

Thailand is a littoral country with total coastal length of about 2,815 kilometers, which includes the Andaman Sea coast of 937 kilometers and the Gulf of Thailand coast of 1,878 kilometers. The Gulf of Thailand coast is usually classified into three parts: eastern coast, upper gulf, and western gulf. The coast of Thailand is characterized by beaches and sand dunes, coastal wetlands (tidal flat and marshes), rocky coasts, and cliff coasts. The Andaman Sea coast is dominated by small beaches, extensive and well-preserved tidal flats vegetated with mangrove forest, cliff coasts, and numerous islands, while the Gulf of Thailand coast contains long curving beaches, interspersed with raised beaches and dunes, and a variety of lagoons, tidal flats, and marshes. However, in the last two decades, the sandy beaches and dunes have become popular sites for development of industries, aquaculture, infrastructure, recreation, and tourism. Coastal mining for heavy minerals and tin was formerly prominent but most mines ceased operations after tin prices collapsed in 1985. However, the property boom in the early 1990s led to construction of tall hotel and condominium buildings close to the water's edge, obstructing public access to many beaches. Moreover, naturally accumulated sand and dunes in the subregion; mangrove forests are dominant in the Ayeyarwady, Thanintharyi, and Rakhine state/divisions. Shrimp aquaculture is also prominent in these areas. The chain of islands between the Ayeyarwady Delta and the Andaman Islands contains coral reefs, but they have been only minimally surveyed. Along the southern coast is a complex of forested offshore islands known as the Mergui Archipelago, where most of Myanmar's coral reefs are
Above: Mangroves in water channels at Botum Sakor Park, Cambodia. Left: Satellite image showing mangrove areas in Koh Kong Province, Cambodia, 2010. Community-based mangrove restoration work under the Cambodian Nature Conservation and Protection Department has been ongoing in the area since 2006.
Some areas have been converted to shrimp farms, which has accelerated coastal erosion and caused seawater intrusion into adjacent rice fields and the coastal freshwater aquifer. Moreover, some wastewater is drained into the sea, affecting the seawater quality and biodiversity near the shore. Global warming and sea level rise will affect Thailand’s coast. Subsidence of land in the Bangkok area has been caused by over-pumping of groundwater.

The coastline of Viet Nam extends through territories of 28 provinces and 7 cities (Ha Long, Vinh, Hue, Da Nang, Nha Trang, Quy Nhon, and Vung Tau). Narrow, flat, coastal lowlands extend from south of the Red River Delta to the Mekong River Delta. On the landward side, the Annamite Mountains rise precipitously above the coast, with spurs jutting into the sea at several places. Generally the coastal strip is fertile and rice is cultivated intensively. Viet Nam’s coastal zone provides a diverse range of natural resources and favorable conditions for social and economic development, such as fisheries, aquaculture, agriculture, tourism, transportation, and urbanization. However, the ecosystems are highly vulnerable to such hazards as typhoons, storm surge, erosion, environmental pollution, global climate change and sea level rise, over-exploitation of resources, and other human activities (such as mangrove logging for shrimp farming and fuelwood, and waste disposal). These factors constrain sustainable use of coastal wetland resources.
The Convention on Biological Diversity of 1992 defines biological diversity, or biodiversity, as the variability among living organisms from all sources including, among others, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; hence, the term includes diversity within species, between species, and of ecosystems.

Maintaining the biodiversity of plants and animals, which entails keeping enough habitat for their sustained existence, is important: we depend on many animals and plants for our own existence, not only as food but also as sources of enzymes, genes, chemicals, resins, and fibers that we can exploit to cure disease, provide raw materials, contribute to the provision of ecosystem services, and create economic wealth. If we are to continue to enjoy these and other benefits—such as aesthetic and recreational—we must also conserve the ecosystems, that is, the animals and plants and the habitats on which they depend.

The Greater Mekong Subregion (GMS) is one of the world’s richest biodiversity hotspots and harbors several irreplaceable biomes. It has been estimated that between 1997 and 2010 over 1,500 new species were discovered in the GMS, which illustrates the diversity of ecosystems in the subregion. Many of these ecosystems are critically threatened—their fragility is demonstrated by the fact that a high proportion of the world’s threatened species, as assessed by the World Conservation
Biodiversity defined

Biodiversity is of three general kinds: habitat diversity, species diversity, and genetic diversity. Each depends on the health of the other two.

Habitat diversity refers to the variety of places where life exists—coral reefs, old-growth tropical forests, grasslands, coastal wetlands, and many others. As the habitat disappears, many of the species it harbors also disappear. However, as has happened in the old-growth forests and coastal wetlands throughout the Greater Mekong Subregion, a habitat often does not disappear completely but dwindles to scattered patches.

Species diversity is what most people commonly understand as biodiversity. The species is the basic classification of living things that share common characteristics. The earth has about 1.5 million named and many more unnamed species. All in all, probably about 5–15 million species exist.

Genetic diversity is the varied mix of genes within species that allows plant and animal populations to adapt to changes in their environment. Genetic homogeneity, which occurs when a species’—be it elephant, tiger, or dolphin—population size becomes small, making the species far less adaptable and less likely to survive.
Yunnan Province of the People’s Republic of China (PRC), unique as a meeting place of northern and southern biotas of the region, sweep across northern Myanmar, linking with the elephant corridor into the Lao People’s Democratic Republic (Lao PDR), and continuing into the rain forests of the Annamite Range in Viet Nam.

The Cardamom Mountains in Cambodia and the Indochina dry forests of the tri-border area between Cambodia, the Lao PDR, and Viet Nam are some of the most spectacular biodiversity-rich areas in the GMS. On the western flank of Thailand bordering with Myanmar, the Kayah-Karen Montane Rain Forests sweep down into Thailand’s Western Forest Complex connecting to Kaeng Krachan and continuing on to the Peninsular Malaysian Montane Rain Forests.

In the northeast of the GMS, the karst landscape of Jingxi county in Guangxi Zhuang Autonomous Region of the PRC and Cao Bang Province in Viet Nam harbor the Cao Vit gibbon, one of the rarest apes in the world. Flanked by mountain ranges on the east and west, the mighty Mekong River flows from its origin in the Tibetan Plateau, through the headwaters in northern Yunnan down through Myanmar and the Lao PDR, bordering with Thailand into Tonle Sap’s flooded forests in Cambodia to finally feed into the rich delta in southern Viet Nam before discharging into the sea; a journey of 4,900 kilometers providing resources and livelihoods to over 60 million people along its banks.

**Ecoregions**

The surface of our planet is composed of ecosystems—areas of land or bodies of water, or a combination of both, and the complex webs of life they support. The subregion is made up of many montane, forest, river, wetland, and marine ecosystems.

The concept of ecoregions—natural ecological communities with shared species, dynamics, and environmental conditions—offers a useful way of understanding the biodiversity of the ecosystems of the subregion and planning for their protection. To represent the original distribution of plants and animals on earth, the WWF has divided the entire planet into 867 terrestrial ecoregions, of which 40 are in the subregion.

In its Global 200 project, WWF selected approximately 200 ecoregions that are outstanding examples of biodiversity. Six terrestrial ecoregions fully within the subregion are in the Global 200 list: (i) Northern Indochina Subtropical Moist Forests, (ii) Annamite Range Rain Forests, (iii) Cardamom Mountains Rain Forests, (iv) Indochina Dry Forests, (v) Peninsular Malaysian Lowland and Montane Forests, and (vi) Kayah-Karen Montane Rain Forests. A seventh ecoregion, Eastern Himalayan Broadleaf and Conifer Forests, overlaps with the northwestern corner of Myanmar.
The forests of the GMS are simultaneously among the richest forests in the world for biodiversity and among the most threatened with destruction. Although more than 100 species per year on average have been discovered in the GMS since 1997, almost 6 million hectares of forest have been lost in the GMS countries, excluding the PRC, since 1997.

This richness in biodiversity is considered to be a result of the climate changes that took place during the last ice age, when sea levels were lower and tropical forest species were able to migrate and survive in the land that is now covered by sea between Thailand, Malaysia, and Indonesia, while more temperate forest species invaded the cooler mountainous areas. As the climate warmed, the tropical forest with all its associated biodiversity recolonized most of what is now the GMS. The recent more rapid phase in climate change attributed to human activities is also reported to be affecting the ecology of the subregion and changes in the frequency of storms and periods of drought combined with rising temperatures and melting of glaciers in the Himalayas, are all affecting the ecology of the subregion as well as agricultural productivity.

### Forest Cover and Type, 2010

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* = not available, ha = hectare, Lao PDR = Lao People’s Democratic Republic, PRC = People’s Republic of China.

At the opening of the 20th century, forests covered about three quarters of the land surface of Thailand and it is reasonable to assume that they covered a similar proportion of the lower Mekong Basin, in Cambodia, the Lao PDR, and parts of the central highlands of Viet Nam. The vast majority of the population lived in the Mekong, Chao Phraya, and Red River deltas and coastal plains and practiced irrigated agriculture, while a minority of “hill tribes” lived in small scattered communities in the hill areas and practiced mainly shifting cultivation.

Forestlands of the subregion are under pressure from population growth, agriculture, mining, and infrastructure development. The resulting conversion of forest has gradually altered the landscape. Current estimates of forestland indicate just how much change has occurred.

In 2010, about 46.8% of the subregion was classified as forestland. The proportion of forestland varies from country to country, with Cambodia and Guangxi being more than 50% forested; Yunnan, the Lao PDR, Myanmar, and Viet Nam more than 40%; and Thailand only about 37%. The subregion has about 118 million hectares of forestland remaining. Myanmar has about 27% of this total, and each of the other countries has between 9% and 16%.
Forestlands in the subregion, except Guangxi, Viet Nam, and Yunnan, declined over the decade 2001–2010. Viet Nam invested heavily in afforestation including rubber and reforestation during this period; Guangxi and Yunnan put a moratorium on logging, allowed degraded secondary forest to bounce back, and also invested heavily in industrial plantations. Average annual rates of decline varied from 2.9% for the Lao PDR to 0.9% for Myanmar and 1.3% for Cambodia. The average annual rate of increase was 0.1% for the subregion overall. However, it is believed that deforestation rates in some parts of the subregion in the late 1990s may have been as high as 2% per year.

The Food and Agriculture Organization of the United Nations (FAO) 2010 forest resource assessments, which include reforested areas and plantation forest, show that plantation forest makes up about 21% of all forestland in Thailand and almost 25% in Viet Nam. These plantations are predominantly monocultures of fast growing species that contribute little to biodiversity. Great variation in the area of planted forests and rates of establishment are evident across the subregion. Within the Asia-Pacific region as a whole, 80% of the expansion in planted forest between 2005 and 2010 took place in the PRC, where establishment averaged 2 million hectares per annum. In Guangxi, expansion of planted forest averaged 230,000 hectares per annum between 2000 and 2010. An increase in plantation area is indicative of increasing demand for wood products, and a declining wood supply from and condition of the natural forests.

**Forest Species**

The dipterocarp forests of the GMS, covering parts of Cambodia, the Lao PDR, Myanmar, Thailand, and Viet Nam characteristically contain tree species like *Dipterocarpus dyeri*, *D. corbatus*, *D. Alatus*, *Anisoptera cochinchinensis*, *Hopea adorata*, *H. pierrei*, *Roherea vulgaris*, and...
Syzygium species; along with dryland forests and dry, deciduous dipterocarp forest species, such as Dipterocarpus intricatus, D. obtusifolius, Shorea obtusa, Terminalia tomentosa, and Shorea siamensis. Dry dipterocarp forests occur in shallow, often laterite, soils, and trees have a comparatively small diameter, the crown is not widely spread out, and trees reach heights of 8–25 meters. On the poorest and shallowest soils, trees are crooked and do not exceed 10 meters in height. In contrast, in the dry evergreen forests, two or three species tend to dominate, tree heights in the upper layer usually exceed 30 meters, tree density in the lower layer prevents most sunlight from penetrating to the ground, and there are climbers and lichens on tree stems. Some typical species of this forest type are Hopea species, Pterocarpus pedatus, Dipterocarpus alatus, and Anisoptera species.

Spectacular seasonally flooded forests occur around Tonle Sap, Cambodia. At higher elevations, 200–2,000 meters, there are coniferous forests in Kirirom in Cambodia and the Central and Northern Annamites bordering the Lao PDR and Viet Nam, dominated by two pines (Pinus kesiya and P. merkusii) and sometimes other coniferous trees like Cunninghamia species. Bamboo is common in evergreen rain forests and deciduous stands from lowland to mountainous areas in Thailand and Viet Nam. Some species, such as Bambusa stenostachya, can tolerate flooding for up to one month. Coastal areas in GMS countries feature extensive mangrove forests, mainly of Avicennia and Brugiera species.

The tropical rain forests of Xishuangbanna in Yunnan are seasonal and stratified in three tree layers, reaching up to 35–45 meters high. Ravine seasonal forests are characterized by Pometia pinnata, large buttresses of Tetrameles nudiflora, and woody lianas of Ventilago calyculata (denticulate). Another famous tree species, Shorea wantianshuea, occurs in dipterocarp forests in this area, reaching 60 meters high.
Forest Ecosystem Services

Non-timber forest products (NTFPs). In Cambodia 70–90% of households are engaged in collection and trade in forest products in areas with evergreen and semi-evergreen forests, despite the pressure from logging and economic concessions. In addition, fuelwood is widely collected throughout the region for domestic use and is the primary source of energy. Resin collection, hunting and other NTFPs accounted for almost half of household income in Mondulkiri, Cambodia, and loss of the income from these trees due to logging or clearance for economic concessions was a major catastrophe for the households concerned. In Lao PDR, most villagers relied on NTFPs for their livelihoods, but that availability has been declining. Honey and herbs have retained their level of availability over the past three decades, leaves and fruit have declined slightly, birds and wildlife have declined more severely, and timber is no longer available. In Viet Nam, NTFPs provide about half the annual income for households living in or near protected areas in the Central Annamites, worth around $300.

Soil and water conservation. These services are site specific, since they depend on the proportion of an upper river basin that is protected from soil erosion and the current land use, which determine both the quantity of the soil loss that can be avoided and the scale of the overall impact on the seasonal distribution, quality and quantity of water supply within the river basin. In communes or villages located in the upper reaches of an important river basin, the management of the land will have a direct impact on the downstream river flow and water quality, but the magnitude of the benefit will vary from one commune or village to another. However, loss of topsoil due to erosion is an avoidable cost in the form of reduced agricultural output or increased input costs and to downstream water users in the form of increased suspended solids. These later take the form of increased siltation of reservoirs, increased damage to hydro-generator turbine blades, increased costs of water purification and increased costs for cleaning up after flash floods. As an example, for Huong Linh Commune in Viet Nam, it is estimated that reforestation of about 150 hectares will reduce the loss of soil by around 4,400 tons annually, with a replacement value of about $1,600 annually.

Carbon sequestration and climate change mitigation. These services are more easily quantified, since carbon has a market value and the quantity of carbon that can be sequestered can be assessed relatively easily. At the local level, as for example in Huong Linh Commune in Viet Nam with about 2,600 hectares of medium to low density forest, it is estimated that the value of the carbon sequestered will vary over time, but has an average value of about $2,200 annually. In the Lao PDR, at the landscape level within the Biodiversity
Conservation Corridor, prevention of further decline in about 150,000 hectares of intact forest and its protection to allow natural regrowth will result in a net sequestration of around 100,000 tons annually of carbon dioxide in the short term, rising to over 200,000 tons over the next two decades. In Mondulkiri Province in Cambodia, which still has a large forest area, carbon sequestration is relatively high, and protection of about 700,000 hectares will result in a net sequestration of around 300,000 tons of carbon dioxide annually in the short term, rising to over 1 million tons by 2020. With the current price of carbon dioxide conservatively taken at $5 per ton the annual value of the carbon sequestered is about $1.5 million, rising to over $5 million. The net present value of the carbon sequestered over the next 40 years at 12% is estimated at just over $180 million even with a very small differential in the rate of reduction of the forest, because of the large area.

Forest Cover

Forest cover maps help us assess and monitor changes in land use and forest cover over time. These maps underpin studies on biodiversity and conservation to gauge the sustainability of forest ecosystems.

The subregional forest cover map is based on a global forest cover map for Asia produced by FAO during a global assessment of forest resources. The most recent assessment for the reference year 2010 was conducted to estimate forest area, forest conditions, and the rate of change in some important parameters, such as area and forest type. This forest cover map provides another perspective on forests in the subregion. It distinguishes between closed forest and open (and fragmented) forest. While large areas of closed forest still exist, these areas are interspersed with areas of fragmented forest. The main agricultural areas (Red River Delta, eastern Viet Nam, Mekong Delta, area around Tonle Sap, Khorat Plateau, Chao Phraya Delta, and much of the Ayeyarwady watershed) are clearly visible as “other land cover” on the map.
Greater Mekong Subregion Atlas of the Environment

Expansion of rubber plantations in Xishuangbanna, Yunnan, PRC, from 1988 (left) to 2011 (right).
Forest Ecoregions

Northern Indochina Subtropical Forests. The Northern Indochina Subtropical Forests are globally exceptional for their biological diversity. This ecoregion has the second highest species richness of mammals in Asia and has a diversity of tree species comparable to the humid tropical forests of Malaysia. The highest level of endemism of some plants, mammals, and birds can be found in this ecoregion. It has the richest and most intact subtropical forest in Asia.

The ecoregion extends across the northern Myanmar highlands, the southern part of Yunnan, where the tropical forests of Xishuangbanna are found, Thailand, the Lao PDR, and Viet Nam. An intricate system of hills and rivers stretches south of the Yunnan Plateau to include the middle catchment areas of the Red, Mekong, and Thanlwin rivers.

The whole of the northern subregion has a summer monsoonal climate and a yearly precipitation of 1,200–2,500 millimeters on average. Mean temperatures differ depending on elevation, but the hottest time of the year occurs before the rainy season, and the coldest in January. Frost forms at higher elevations, although infrequently. The cool winters and high elevation support the growth of montane plants. Well-developed montane deciduous forests are found on the Shan Plateau in northern Myanmar.

About 183 mammal species, 4 of them endemic and 5 near-endemic, and 707 species of birds, including the near-endemic short-tailed scimitar babbler, occur in this ecoregion.

Twenty-seven protected areas, totaling 15,948 square kilometers, make up 5% of the ecoregion. Most protected areas are small (590 square kilometers on average) and are found in northern Viet Nam. The biggest areas are mostly in the Lao PDR.

Land clearing for shifting cultivation, poppy farming, logging, and extensive illegal hunting for food and income pose the greatest threats to the biodiversity of this ecoregion.

Annamite Range Rain Forests. This ecoregion is composed of two of the WWF ecoregions—the Northern Annamites Rain Forests and Southern Annamites Montane Rain Forests. These forests, insulated by their unique geography from major climatic changes worldwide, sustain one of the world’s rarest and most diverse ecosystems of plants and animals. The forests are situated along the border between the Lao PDR, Cambodia, and Viet Nam. In these relatively intact rain forests are several endemic species of mammals and birds and some endangered and threatened species. Four large mammal species discovered only in the last 20 years can be found in the area.
The saola, which belongs to a distinctive branch of the cattle and antelope family, was discovered in 1992; the large-antlered muntjac, a new deer species, in 1994; and another, smaller muntjac, the Annamite striped rabbit, in 1997, and the Laotian Rock-rat, member of a family formerly only known from ancient fossils, found in 2005. Globally, such discoveries are very rare events and to have six in such a short period in one area is truly exceptional. The forests are home to threatened species like the Indochinese tiger, the Asian elephant, and the douc langur. Some bird species, such as Edward's pheasant and the orange-necked partridge, both endangered, are found only in this ecoregion.

Threats to the biodiversity of the ecoregion come from increased legal and illegal logging, the construction of dams, agricultural expansion, mining, and intensive illegal hunting.

**Cardamom Mountains Rain Forests.** The Cardamom Mountains Rain Forests lie across the Cardamom Mountains and the Elephant Range, extending from southwestern Cambodia into southeastern Thailand. They are separated from other rain forests by the Khorat Plateau in Thailand to the north and east and by the Gulf of Thailand to the west. Although largely unexplored, this ecoregion is considered one of the most species-rich and undisturbed natural habitats in the subregion.

The mountains are very wet and rise from sea level to more than 1,500 meters, collecting moisture from the monsoon winds. Average annual rainfall can reach around 5,000 millimeters in some areas, resulting in a rain forest dense with plant life. At lower elevations, trees grow as high as 30 meters, allowing light to pass through to support a mid-canopy of palms and rattans. Shrubs, climbers, and lianas are abundant in the dense understory. The upper montane forests are less rich but sustain dwarf rain forest trees half as tall as those found at lower elevations.

More than 100 mammal species, none of them known to be endemic, thrive in the ecoregion. There are threatened species, the Asian elephant, the clouded leopard, the wild dog or dhole, the gaur, the banteng, the pileated gibbon, and the serow. Two bird species found nowhere else in the world are among the 450 bird species in the ecoregion.

Sixteen protected areas covering about 14,500 square kilometers, or 33% of the whole ecoregion, have been identified. Six of these areas—Aural, Phnom Bokor, Botum-Sakor, Roniem Daun Sam, Khao Ang Ru Nai (in Thailand), and Phnom Samkos—exceed 1,000 square kilometers. Phnom Samkos National Park is larger than 3,000 square kilometers. Phnom Kirirom in Cambodia is also in the Cardamom ecoregion.

The sparsely peopled forests of the Elephant Range and the Cardamom Mountains in Cambodia are rapidly seeing development of settlements, hydropower, mining, and cash crops in an industrial scale. Some large tracts of forests still remain relatively intact, but forest areas in southeastern Thailand have been greatly reduced and exist in only a few protected areas.

Illegal logging, even in the protected areas, threatens the ecoregion’s biodiversity. Wildlife trade has also caused excessive capture of animals throughout Cambodia and Thailand. Construction of dams and roads, mining operations, and agricultural expansion are also taking their toll.

**Indochina Dry Forests.** This ecoregion is composed of two WWF ecoregions, the Central Indochina Dry Forests and Southeastern Indochina Dry Evergreen Forests. The dry, open, deciduous forests are interspersed with evergreen forest patches, where soils or rainfall permit it. Significant to some of the most characteristic large mammals and waterbirds are ponds and wet pastures of varying sizes.

The Central Indochina Dry Forests cover most of the center of the subregion, with its flat to slightly undulating terrain and hills generally no higher than 200 meters. The ecoregion stretches widely in Thailand, from the dry lower slopes in the northern part and the foothills of the Tenasserim Range to uplands of the Chao Phraya Basin and across the Khorat Plateau. It extends along the broad valley of the Mekong River and its tributaries in central and southern Lao PDR and over the seasonally arid, seasonally flooded plains of northern, eastern, and south-central Cambodia.

These forests support about 167 kinds of mammals, of which two species of Vespertilionidae bats are endemic. Moreover, there are many threatened large vertebrates characteristic of tropical Southeast Asia as a whole. These include Eld’s deer, tiger, Asian elephant, gaur, banteng, wild water buffalo, serow, and other species like the pileated gibbon, the Indochinese silvered leaf monkey, dhole, Malayan sun bear, clouded leopard, and common leopard.

The more than 500 bird species in the ecoregion include threatened species, such as the green peafowl, the greater adjutant, the giant ibis and the white-shouldered ibis.

Sixteen protected areas, which cover more than 15,000 square kilometers, compose 6% of the ecoregion. Four (Phu Kao-Phu Phan Kham, Xe Plane, Phnom Prich, and Yok Don) exceed 1,000 square kilometers, and three (Kulen Promtep, Lomphat, and Mondulkiri Protected Forest) exceed 2,000 square kilometers. Most of these protected areas are in Cambodia and the Lao PDR and have intact natural habitat.

Under increased population pressure, forests in this ecoregion have been converted to farms and settlements. Forest fires are often set to clear...
land for cultivation or for livestock pasture, and to make wildlife hunting easier. Parts of the ecoregion in Cambodia, the Lao PDR, and Thailand are threatened by hydropower development and growing tourism.

**Peninsular Malaysian Lowland and Montane Forests.** The Peninsular Malaysian Lowland and Montane Forests include two WWF ecoregions—the Peninsular Malaysian Rain Forests and Peninsular Malaysian Montane Rain Forests. They cover the montane forests in Peninsular Malaysia and the extreme southern part of Thailand. The ecoregion is warm and has abundant rainfall all year round. It is composed of many distinct montane habitats where the trees are smaller than those in the lowlands. Oaks and chestnuts dominate the lower elevations and rhododendrons can be found in the upper montane areas.

Most remaining forests of the ecoregion are found only in high, steep areas and only two thirds are still intact. Four protected areas comprise 5,120 square kilometers, or 30% of the whole ecoregion.

The ecoregion contains more than 200 mammal species, including nearly 100 bats and an endemic rodent species. There is also a tiger population consisting of 300–650 Indochinese tigers, highly threatened. The smallest rhinoceros, the Sumatran rhinoceros, is also found in these forests. This species was once scattered all over Southeast Asia but now the 500 or so of them that remain are believed to be found only in Borneo, Peninsular Malaysia, and Sumatra. Other endangered species living in these forests include the Malayan tapir, the Asian elephant, and the gaur.

More than 250 bird species are present in this ecoregion, of which 75 are found only in montane forests and two are classified as threatened: the mountain peacock-pheasant and the crested argus.

Intensive logging in both uplands and lowlands, despite the rugged terrain, endangers biodiversity in the area. Other threats are the conversion of lowland forest to farms and cities, tourism, and roads.

**Kayah-Karen Montane Rain Forests.** The Kayah-Karen Montane Rain Forests cradle a rich diversity of plants, birds, mammals, and amphibians. The ecoregion is one of the richest in forest animal life in the subregion, second richest in bird species, and fourth in mammal species. Even greater biological variety is expected when more of the ecoregion is surveyed.

This ecoregion lies in the northern part of the Tenasserim Mountain Range, on the border between Myanmar and Thailand. Most of it is rugged, folded, and composed of Paleozoic...
limestone with overhanging cliffs, sinkholes, and caverns. Plants and animals living in these forests have distinct characteristics and some are unique to the area.

The region has an average annual rainfall of 1,500–2,000 millimeters and a monsoonal climate with a warm, moist summer and a mild, dry winter. The Myanmar side (west-facing slopes) receives more rain than the Thailand side (east-facing slopes), and the difference between these areas is reflected in their vegetation. Forests in the west are abundant with deciduous and evergreen species while dry deciduous trees dominate the east side.

The ecoregion harbors 168 species of mammals, one of which, the tiny Kitti’s hog-nosed bat, is endemic in the area, particularly in the limestone caves of western Thailand. This bat, weighing about 2 grams with an 8-centimeter wingspan, is the smallest mammal in the world.

The relatively intact and contiguous habitat in these forests makes them a potential area for the conservation of threatened species like the tiger. Most of Thailand’s biggest wildlife reserves and several protected areas are in this ecoregion. Thailand’s Huai Kha Khaeng Wildlife Sanctuary, which has an area of 2,575 square kilometers, is endowed with a high diversity of cat species, intact vertebrate communities, and intact lowland dipterocarp forests.

With 568 bird species, the ecoregion ranks high in avian diversity. Two species, the Deignan’s babbler and the Burmese yuhina, are endemic in the area.

Almost one third of the forests has been cleared or degraded because of shifting cultivation and settlement. However, 20% of the ecoregion (23,500 square kilometers) is given over to 28 protected areas. These have an average size of 725 square kilometers, although some, like Thailand’s Huay Kha Khaeng-Thung Yai Naresuan Reserve complex and Omgoy-Mae Ping-Mae Tuen Reserve complex, are much more extensive.

Fauna

Recent discoveries of new species (such as the saula, a forest dwelling ox, found in the Annamites in 1992) and the dedicated search for the elusive kouprey have captured the imagination of conservationists worldwide and heightened global awareness of the need to conserve the biodiversity of the subregion. Biological surveys continue to turn up new discoveries, emphasizing the region’s high concentration of unique plants and animals. Some 549 new animals, including 15 mammals, were identified in WWF surveys in the subregion.
from 1997 to 2007 and a further 63, including a new monkey species, in 2010. These surveys also highlight the fact that the subregion is home to some of the world’s most threatened species. While a few have become extinct (such as Schromburk’s deer, the pink-headed duck, and the white-eyed river martin), most species are still relatively widespread in the subregion. However, wildlife populations are coming under high and increasing pressure from growing human populations, infrastructure development, and extraction for international markets. Many species of large mammals are extinct or close to extinction in several countries. These include the tiger, banteng, wild water buffalo, Eld’s deer, and Javan and Sumatran rhinoceroses. Other threatened groups include large water birds (such as cranes, storks, ibises, and pelicans), pheasants, large foragers (hornbills, imperial pigeons), freshwater turtles, and large migratory fish.

**Asian Elephant** (*Elephas maximus*). The Asian elephant is the largest land mammal species in the subregion, growing to about 6.5 meters long and 3 meters high. Adult males weigh about 5 tons; females, 3 tons. They live for about 40 years. While some significant populations are believed to survive, the species is nearing extinction in the wild in many areas. The animals need space, preferring tropical grassy plain and rainforest habitats. Deforestation and human encroachment have led to widespread habitat loss. Calves of Asian elephants are also kidnapped for use as beasts of burden, especially in the logging trade.

**Banteng** (*Bos javanicus*). Considered one of the most beautiful kinds of wild cattle, the banteng is an endangered species found mostly in Cambodia, Myanmar, and Thailand. It looks similar to an ox, only larger. It has white “stockings” on its legs, a white rump, a white muzzle, and white spots above the eyes. The banteng prefers to live in open, dry, deciduous forest, although in Borneo, some dwell within evergreen forests. This huge animal is very timid and retiring and feeds at night in areas where humans encroach. Bantengs usually roam in herds of one bull and several cows and calves. Some bulls stay alone and join the herds only during the breeding season. Bantengs are known to be grazers but they also consume available leaves and fruits. They live up to 20–25 years.

A rapid decline in their population was observed in the early 1990s. By 2010, recent surveys in the Eastern Plains in Cambodia confirm previous estimates by IUCN (2000) of their numbers ranging between 5,000 and 8,000. Hunting and loss of habitat endanger their existence. Interbreeding with domestic and other cattle threatens the genetic integrity of the banteng.
**Douc Langur (Pygathrix)**. Douc langurs of the genus *Pygathrix* are native to Southeast Asia. Up until only a few years ago, two distinct taxa were recognized—the red-shanked and the black-shanked douc langur. Between August 1995 and January 1998, however, six male specimens of the new and distinctive grey-shanked douc langur *Pygathrix cinereus* were found, some confiscated by Vietnamese wildlife authorities and the others donated by private individuals and placed in Cuc Phuong National Park. The animals had evidently originated in the southeastern part of Viet Nam’s Central Highlands where field primatologists had also identified wild populations of the same description in a region occupied by red- and black-shanked monkeys. Wild populations of the three doucs have been reduced to small numbers by habitat loss and hunting. While Cambodia and the Lao PDR may have more sizeable populations of the red-shanked and black-shanked douc, the newly discovered *Pygathrix cinereus* is known only from Viet Nam and is considered the most critically endangered species.

**Indochinese Tiger (Panthera tigris corbetti)**. The Indochinese tiger is found in Cambodia, southern PRC, the Lao PDR, Myanmar, Thailand, and Viet Nam. It is one of only five surviving tiger subspecies in the world, all of which are endangered. Only about 880–1,200 Indochinese tigers are left in the wild. Tigers thrive in remote forests and hilly, mountainous terrain. As predators, tigers also depend on other animals like wild pigs, cattle, and deer to survive. Habitat destruction, along with the loss of their prey species, threatens the tiger’s survival. Another big threat comes from the ancient belief that a tiger’s body parts can give humans the potency of this animal, driving a very high demand in the trade for traditional medicines.

**Kouprey (Bos sauveli)**. Its name literally means “forest bull” in Khmer, but the kouprey is more commonly known as the Cambodian forest ox, and is the Cambodian national animal. First discovered in 1937, the kouprey is a gray forest ox with frayed horns and a long dewlap. Koupreys are found in small numbers in northern and eastern Cambodia, and have also been known to exist in the southern Lao PDR, eastern Thailand, and western Viet Nam, although sightings anywhere are rare. Koupreys inhabit low, rolling hills with patches of dry forest, near denser monsoon forests. They live in herds of up to 20, grazing in open areas by night and entering the forest for shelter from predators by day.

The kouprey has always been rare. However, the destruction of its habitat by shifting cultivation, logging, and warfare, along with hunting and disease, has severely affected it. By 1970, there were fears that the species might have become extinct. At most, there could only be a few koupreys remaining, certainly less than 250 mature individuals.

**Saola (Pseudoryx nghetinhensis)**. The saola, also known as the Vu Quong ox, is an endangered, nocturnal forest-dwelling ox weighing about 100 kilograms. Its habitat is
the dense montane forests in the Annamite Mountains, which run through the Lao PDR and Viet Nam. It is thought to be restricted to a 4,000-square kilometer area along the border between Viet Nam and the Lao PDR. The saola is generally considered the greatest animal discovery of recent times. First documented in Viet Nam in 1992, it is so different from any other known species that a separate genus had to be created for it. The classification of the saola has generated some controversy; different physiological and genetic studies classify it with goats, antelope, or cattle. Only 11 saolas have ever been caught. Much of what is known about them comes from villagers’ tales and unearthed skeletons. The saola seems to prefer the edges of wet lowland and montane evergreen forests. Villagers say that it eats the leaves of fig trees and other bushes along riverbanks. The saola stays at higher elevations during the wetter summer season, when streams at these altitudes have plenty of water, and moves down to the lowlands in winter, when the mountain streams dry up. They are said to travel in groups of two or three animals, rarely up to six or seven. The animal has been classified as endangered by IUCN. Hunting and the loss of forest habitat due to logging and conversion to farmland threaten its survival.

**Siamese Crocodile (Crocodylus siamensis).** The Siamese crocodile, also known as the softbelly crocodile, is an endangered species found in Cambodia, the Lao PDR, Thailand, and Viet Nam. It prefers to move in groups in slow-moving areas of freshwater, feeding on fish, amphibians, reptiles, birds, small mammals, and carrion. It grows to about 3 meters. The Siamese crocodile is not considered dangerous to humans, although it has been mistaken for its far more threatening cousin, the saltwater crocodile, which is larger and has a narrower snout. The Siamese crocodile has all but disappeared from many countries in the subregion, although a new population has been discovered in the Cardamom Mountains. Expectations for its survival are poor because it is under significant threat from poaching and habitat destruction.
There are more than one thousand freshwater species of fish recorded from the Mekong Rivers, as well as about 250 species of coastal or marine origin. The number is expected to increase as more field studies are done and the system of classification improves. For instance, among 1,500 new species discovered in the subregion since 1997, over 279 new fish species were identified. The discovery of new species is especially likely in the mountain tributaries of the Lao PDR and Yunnan, where little or no research has been done. Only the Amazon River system of South America has greater fish diversity—about 2,000 fish species are found in a river basin roughly nine times the size of the Mekong. Many fish species found in the Mekong are also found in other rivers of the subregion. The Ayeyarwady, Thanlwin, and Red rivers, however, have endemic fish species not found in the Mekong. In fact, the Ayeyarwady River is more like the Ganges River in its fish species composition. Yunnan, through which all four rivers run, probably has the highest fish diversity of any region in the PRC.

Several fish species in the subregion’s rivers are already endangered and, if protective measures are not taken soon, many more could become endangered. Perhaps the most famous endangered fish are the giant Mekong catfish and the giant barb, both of which can grow up to 3 meters long. The giant Mekong catfish is an important species endemic to the Mekong River system. One of the largest freshwater fish in the world, it can weigh more than 300 kilograms. The catfish migrate along the rivers to spawn in tributaries. The species has recently gained recognition because of the increasing threat posed to it by humans. Although listed as endangered, the fish are still caught and sold for meat in Cambodia, the Lao PDR, and Thailand. Because of its size, it is increasingly sought after by sport fishers.

The giant catfish and barb qualify for protection under the Convention on Biological Diversity (CBD) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS). While all six countries represented in the subregion have signed the CBD, Cambodia and the Lao PDR have yet to ratify it, and none of the six have signed the CMS.
Another famous endangered “fish” in the subregion is a mammal, the Irrawaddy or Mekong River dolphin, whose numbers have fallen drastically over the past 3 decades. The Irrawaddy dolphin prefers to live near the coast and at the mouth of rivers. It also lives upstream in some tropical rivers. In Myanmar, Irrawaddy dolphins have been reported at Bhamo, 2,300 kilometers upstream from the mouth of the Ayeyarwady River. Freshwater populations are also found in the Mekong and Se Kong. A few years ago, Irrawaddy dolphins were a relatively common sight in rivers and waterways of the Lower Mekong and in Tonle Sap. Little is known about the dolphins, which grow up to 2.8 meters long and can weigh as much as 150 kilograms. A recent survey discovered a small population of 80 dolphins living in the stretch of the Mekong River from Cambodia’s northeastern Kratie Province to the far northern border with the Lao PDR. These dolphins and their prey are seriously threatened by entanglement in gill nets, blast fishing, and the potential barrier effects and habitat degradation from planned dams. Although fishing, hunting, and increased river traffic have wreaked havoc on the dolphin’s habitat, in some areas dolphins are considered sacred. And they are said to have a special relationship with fishers on the Ayeyarwady and Mekong rivers, helping fishers drive fish into their nets.

Action is being taken in some areas to protect critical fish habitats and, thus, fish production in the Mekong and other rivers of the subregion. Some Buddhist temples in Thailand and elsewhere provide protection to small stretches of river habitat or wetlands, to ensure that some fish will survive each dry season to spawn and repopulate the river. Over the past decade, several local communities in Champasak Province, Lao PDR, have also established fish protection areas in the Mekong River, typically around the deep pools where many fish species seek refuge during the dry season.
Marine Biodiversity

The waters around the GMS—the Andaman Sea and South China Sea—are largely tropical; they support several kinds of marine mammals and turtles, hundreds of fish and coral species, dozens of species of macroalgae (seaweeds and seagrass) and innumerable invertebrates, particularly crustaceans like crabs and shrimps; mollusks like clams, oysters, and mussels; and echinoderms like sea cucumbers, sea urchins, and starfish.

Among the marine mammals, populations of dugongs occur in the Andaman Sea in Myanmar, especially in Rakhine State, and in Trang Province of Thailand, totaling about 200 individuals. There is also a population of about 50 dugongs in the Gulf of Thailand. Dugongs are hunted for meat or caught in trawl nets. Dugongs were formerly abundant in Cambodia and Viet Nam but nowadays are rarely sighted. Their survival in the subregion is threatened not only by hunting but also by disturbance or degeneration of beds of seagrass, their main food.

The subregion holds many kinds of cetaceans—whales and dolphins. Surveys have shown the presence of the short-finned pilot whale and a large rorqual whale, spotted dolphin, striped dolphin, spinner dolphin, Indo-Pacific humpback dolphin, bottlenose dolphin, finless porpoise, and Irrawaddy dolphin. Interestingly, 16 cetacean species are known from Viet Nam waters from their bones but few species are seen there now.

Five of the world’s seven marine turtle species—hawksbill, green, loggerhead, olive Ridley, and leatherback—are found in the waters of maritime GMS countries. All five are known to feed and/or nest along the coastal regions of the Andaman Sea and most species nest on coastal beaches of Thailand, including the inner Gulf of Thailand, and Cambodia and Viet Nam. However, populations in most places have been decimated by hunting or habitat disturbance.

The total number of marine fish species in the subregion has not been assessed. Surveys at different times have recorded over 800 species in Myanmar, 520 in Cambodia, 880 in Thailand, and a remarkable 2,458 in Viet Nam. All are probably underestimates, given the paucity of surveys and cryptic behavior of many species, but the total is somewhat less than in the Coral Triangle in the southwestern Pacific Ocean, which contains the world’s highest marine biodiversity, including some 3,000 fish species.

Elasmobranchs—sharks and rays—are far fewer in number, with 36 species known from Myanmar’s waters and 41 in Cambodia, and similar numbers likely in Thailand and Viet Nam. Some 15 shark species are caught as by-catch in commercial and small-scale fishing activities around the GMS coastline. They are also targeted for their fins, which are used for making a specialty soup, with the result that some species are now endangered in the subregion.

Beds or meadows of 9–14 species of seagrass are scattered throughout the coastal zones of the five maritime GMS countries, ranging from 28 square kilometers in Cambodia to 40 hectares in Guangxi.

Coral reefs exist in all five countries. Thailand, for example lists around 420 coral reefs in its waters. Those in the Gulf of Thailand have 388 coral species while 645 species are recorded from the more remote Andaman Sea reefs.
Offshore reefs in Cambodia similarly have higher coral diversity than inshore reefs. Guangxi is at the northern end of coral distribution in the South China Sea and only 45 species of reef building corals are found on the few fringing reefs there. Offshore from Guangxi is Hainan Island, which holds 98% of all the coral reefs in the PRC. However, more than 90% of PRC coral reefs are said to have been totally or partly destroyed. The reefs of Guangxi, Thailand, and Viet Nam face the most severe threats from destructive fishing (dynamite and poisoning); overfishing; sedimentation from river outflows; pollution from land sources, including agriculture, industry, and domestic sources; and coral bleaching from high water temperatures, possibly associated with climate change. In Viet Nam, 85% of the coral reefs face such threats; reefs in Myanmar are healthier due to lower levels of both fishing and onshore activities.

Coral Bleaching in Thailand

Coral bleaching is a process during which coral is deprived of pigmentation within its tissues as a result of unusually high temperatures in the sea. This condition puts coral reefs in an unhealthy state due to insufficient nutrient uptake, which may ultimately lead to the death of corals unless they are able to tolerate the crisis. In recent years, coral bleaching has emerged at increasing scales covering national and regional territorial waters.

Thai seas experienced unusually high temperatures in 1991, 1995, 1998, 2003, and 2005. In 1991 and 1995, the coral reefs in the Andaman Sea were extensively affected, resulting in the death of up to 20% of corals. In 1998, the reefs in the Gulf of Thailand were more severely damaged than those in the Andaman Sea and Andaman Sea reefs experienced little bleaching during the last two bleaching events. The corals rapidly recovered to their previous state because the southwest monsoon waves helped to reduce regional water temperatures. But in 2010, coral reefs both in the Andaman Sea and the Gulf of Thailand were more severely damaged than previously as sea temperatures reached 31-33°C during April to June. The impact varied widely from place to place, depending on the structure of coral communities. Areas dominated by sensitive species, especially staghorn and table corals, were most damaged. Between 30% and 95% of the corals were bleached. The damage caused by coral bleaching was exacerbated by waves, which shattered the reef structures. Most species were affected to some extent except for a few species, such as blue coral (Heliopora coerulea), flower coral (Pavona decussata), and double star coral (Diploastrea heliopora), which seemed resistant to the event. The impact was less on the west side of islands in the Andaman Sea as reefs with this aspect were more exposed to currents and did not experience consistently high temperatures.
Flora

The subregion is home to an enormous number of plant species, at least 20,000 and possibly many more. Thailand has about 12,600, Viet Nam 10,500, and Myanmar 7,000 species of higher plants. About 20% of the plant species in Thailand and Viet Nam occur only in those countries. The flora of Yunnan is estimated to contain 14,000 species. There is undoubtedly great overlap between the countries and considerable overlap with the more temperate Yunnan. Numbers recorded depend not only on the actual numbers that occur, but also on the nature of the country, and efforts taken to survey and collect data. The more intensively an area is studied, the greater the number of plants and animals likely to be discovered.

The flora in the subregion includes many rare ornamental flowers and trees that beautify the entire region and support a thriving horticulture industry in most of the countries. The flora also includes highly valued hardwood tree species like teak and rosewoods that generate a major share of the forestry income and are currently the focus of major conservation efforts to stop illegal logging and cross-border trade.

Significant numbers of plant species are threatened with extinction within the subregion, nearly 400 species in Thailand and more than 300 in Viet Nam, although only a handful in Cambodia, the Lao PDR, and Myanmar. Around 300 species are threatened in the entire PRC; presumably those in Yunnan are far fewer.

The Three Parallel Rivers of Yunnan Protected Areas, a World Heritage Site, contains the richest diversity of higher plants in the PRC and a wide spectrum of fungi and lichens. The protected area is one of the world’s least disturbed ecological areas. It has 22 vegetation subtypes and harbors 6,000 plant species. This represents more than 20% of the PRC’s higher plants, 10% of which are endemic to the area.

Botanical explorations in the subregion continue to yield new plant species. WWF surveys brought to light 519 new plant species between 1997 and 2007 and a further 145, including five carnivorous plants, in 2010. In 1999, a new genus and species of conifer was discovered on steep limestone ridges in a mountainous area in northern Viet Nam. In 2002, a new genus and species of fern was found in a collection made by a National Geographic Society expedition.

Human activities such as deforestation, illegal trade of endangered species, and agricultural encroachment, however, threaten the richness of plant species in the subregion. Nevertheless, the flora continues to be a resource to be conserved and a beauty to be appreciated.

Flowers of Yunnan. Because of the unusual natural conditions in Yunnan—no extreme cold in winter and no intense heat in summer—the province is home to 2,500 kinds of ornamental rare flowers and uncommon trees. Yunnan is said to produce the best quality and cheapest flowers in the world. Flowers are grown on a vast scale and are produced with very minimal requirements.

The province has a long history of growing flowers. One thousand years ago, people from the area cultivated flowers to uplift their spirits, decorate their gardens, and enhance their environment. In Kunming, breeding of flowers began as early as in the Tang and Song dynasties. Camellias became popular and were widely grown during
In the Yuan Dynasty, there were about 70 famous types of ornamental flowers and the number grew to more than 180 during the Qing Dynasty and the rise of the Republic. The province presently identifies “eight famous flowers of Yunnan.” They are camellia, rhododendron, indigo, primrose, lily, orchid, rough gentian, and meconopsis. Camellia was chosen as the city flower of Kunming.

In the late 1980s, Yunnan started to develop a flower industry and the Government of Yunnan decided to support this as a way to boost the local economy. By 1994, Yunnan had replaced Shanghai as the flower center of the PRC. The province now contributes more than 80% of the total sales volume of cut flowers in the PRC.

Aside from the domestic market, Yunnan also exports flowers to more than 40 countries, mainly Japan; Republic of Korea; Hong Kong, China; Thailand; and Singapore. Export earnings in 2010 amounted to $150 million compared to only $5 million a decade earlier. In 2010, the Yunnan flower industry produced a total of 6 billion fresh flowers valued at 23.2 billion yuan ($3.5 billion!) on an area of 42,000 hectares, mostly in Kunming, up from only 2,000 hectares in 2000.

The success of the flower industry in Yunnan can be attributed to the initiatives of farmers in the village of Dounan in the late 1980s. They used to grow vegetables for their living until a farmer in the village, during his trip to Guangzhou, found that there was a high demand for flowers in the cities. At the same time, there was a decrease in prices of vegetables because of oversupply. He planted some gladioli in his land and other farmers in the village soon followed his example. The flower cultivation area expanded quickly and in less than half a decade, Dounan had become one of the major production and wholesale centers for cut flowers in the PRC.

**Orchids of Thailand.** Thailand is well known for its many beautiful orchids, locally known as “Gluay Mai.” There are around 1,300 species of orchids in the country. They come in many gorgeous colors and shapes and vary from common to rare. Although they are most prolific in the north, orchids are found in all parts of Thailand, from the low plains of the central region to the highest mountains of the north, from the forests of the south to the dry northeastern plateau.

The most beautiful of Thailand’s orchids are the white, the bright yellow oncidium, and the brick red orchids. The white orchid commands a high price because of its scarcity in the wild. Other orchid varieties are easy to grow and are abundant year round, such as the violet bloom, which is usually offered to visitors. There are many orchid farms in northern Thailand; Chiang Mai is considered the center for cultivation and exhibition of these exotic flowers.

Interest in orchid cultivation in Thailand can be traced back to 1913 when some exotic plants were brought to the attention of Prince Krompranakornswanvorapinit. He became interested in growing orchids, both as a hobby and for commercial purposes. In 1957, the Orchid Society of Thailand was formed under royal patronage.

The most important orchid study center in the north of Thailand is found in Doi Inthanon National Park. This park is an abode to more than 25% of all the orchid species in Thailand. Orchids are found in the deciduous forests from the foothills to the forests at the top of the mountain within the park. The most common species is *Dendrobium infundibulum*. Also, many rare montane orchids can be found along the Keo Mae Pan Nature Trail near the summit of the park. Farmed on some 3,500 hectares, orchids are an important source of export earnings in Thailand. In 2009, the kingdom’s exports of tropical orchids, comprising more than 24,000 tons of cut orchid flowers and more than 30,000 live orchid plants, were valued at more than US$80 million.

**Vanishing Teak.** Teak is a highly-valued wood because of its elegance, quality, and high resistance to weathering. Teak trees grow in groups among other tropical species and are oily to the touch. The oil makes the trees extremely durable against water, rust, and termites, and the wood can last for more than a thousand years. Teak plantations are abundant in the subregion, particularly in Myanmar and Thailand. Myanmar is now one of the world’s biggest suppliers of teak. Teak production there is the biggest source of forestry sector earnings and provides significant foreign exchange to the country. In 1995, teak
exports reached 200,000 cubic meters, with a value of $200 million. If managed properly, teak production could become one of the pillars of Myanmar’s economy in the future.

Before the Second World War, teak was the third most important export commodity of Myanmar. In the early 1970s, teak exports accounted for 25% of total export earnings. With the decline in rice exports, Myanmar identified the forestry sector as a primary source of foreign exchange to boost the economy. Increased investment led to an increase in annual teak production from 291,000 tons in 1971 to 440,000 tons in 1991. A major cause for the increase was the ban by Thailand in 1989 on cutting timber from its forests. To ensure supplies of wood, Thailand signed a series of logging contracts with Myanmar. The increased rate of timber extraction in Myanmar caused growing concern about Myanmar’s forest resources. At 1990 felling rates, it was estimated that the teak stock would be depleted within 15 years.

Because of the unsustainable cutting of teak, Myanmar has now focused its forest management on the sustainable management of natural teak-bearing forests. The annual allowable felling of teak trees was lowered from 609,000 to 409,060 cubic meters. Myanmar has also programmed the planting of trees on 40,500 hectares per year, of which teak plantations cover 8,100 hectares, on a 40-year rotation. The country has also established two model forests in which natural teak forests are prominent, namely Oktwin and Pauk Khaung model forests in Bago Yoma region.

Ecosystem Fragmentation

The forest ecosystems of the GMS are a source of livelihood for local people, biodiversity richness, and ecosystem services. In spite of establishment of a large number of terrestrial protected areas or complexes by governments of the GMS countries, a glance at the map of the subregion shows ecosystem fragmentation across the landscapes. Between 2005 and 2010, development pressures and subsequent land-use change have contributed to an increase in ecosystem fragmentation in some landscapes; land-use planning and development need to take cognizance of the importance of maintaining forest connectivity.
Protected Areas

Protected areas are the primary means of protecting biodiversity. IUCN defines a protected area as an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.

As defined by IUCN, protection must maintain biodiversity and natural resources. And it must have an explicit legal or social basis.

Sites that combine attraction, recreation, and nature conservation uses can also qualify if at least 75% of the area is managed primarily for conservation. Nonconsumptive and low-intensity uses are compatible with some categories within the IUCN scheme, but such sites as forest plantations managed primarily for timber production do not qualify.

IUCN categories

The IUCN system of classifying protected areas was designed to standardize and facilitate the collection and dissemination of data and to improve communication among countries. Standardization of parks and protected areas in differing ecosystems and in different political, legal, and cultural contexts is achieved by using management objectives as the basis for comparison. This provides enough flexibility to account for a range of possible combinations of management objectives, socioeconomic contexts, and ecosystems. Definitions of the categories, and examples of each, are provided in Guidelines for Protected Area Management Categories (IUCN 1994).


CATEGORY Ib. Wilderness Area: protected area managed mainly for wilderness protection.

CATEGORY II. National Park: protected area managed mainly for ecosystem protection and recreation.

CATEGORY III. Natural Monument: protected area managed mainly for conservation of specific natural features.

CATEGORY IV. Habitat/Species Management Area: protected area managed mainly for conservation through management intervention.

CATEGORY V. Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation.

Three Parallel Rivers of Yunnan Protected Areas

This World Heritage Site consists of eight geographical clusters of protected areas within the boundaries of the Three Parallel Rivers National Park in the mountainous northwest of Yunnan. The 1.7-million hectare site features sections of the upper reaches of three of the great rivers of Asia: Thanlwin, Mekong, and Yangtze (Jinsha). These rivers run roughly parallel, north to south, through steep gorges that, in places, are 3,000 meters deep and are bordered by glaciated peaks more than 6,000 meters high. The site’s special features are

- outstanding value for displaying the geological history of the last 50 million years associated with the collision of the Indian Plate with the Eurasian Plate, the closure of the ancient Tethys Sea, and the uplifting of the Himalaya Range and the Tibetan Plateau;
- dramatic expression of ecological processes—a mix of geological, climatic, and topographical effects;
- outstanding natural features—the deep, parallel gorges of the Jinsha, Lancang (Mekong), and Nu Jiang (Thanlwin) are the dominant scenic elements in the area, and high mountains are everywhere, with the glaciated peaks of the Meili, Baima, and Haba Snow Mountains providing a spectacular scenic skyline; and
- location in northwestern Yunnan, the area of richest biodiversity in the PRC and possibly the most biologically diverse temperate region on earth, encompassing most of the natural habitats in the Hengduan Mountains, one of the most important remaining areas for conservation of the earth’s biodiversity.
Upper Left: Mangroves in Peam Krasaob, Koh Kong, Cambodia. Lower Left: Crested serpent eagle. Upper Right: Mountain stream, Bach Ma National Park, Viet Nam.
History of Protected Area Management

Cambodia was the first country in Southeast Asia to establish a national park: the 10,800-hectare forest around the Angkor Temple complex, in 1925. Twenty-nine IUCN categorized protected areas were designated in 2009, covering about 22% of the total land area and representing a diversity of habitats.

In Guangxi, there are four major categories of protected area: nature reserves, forest parks, scenic spots, and geological parks. Both Guangxi and Yunnan’s Provincial Forest Departments exercise overall authority for protected areas, which are managed at four levels: national, provincial, prefectural, and county. By the end of 2011, Guangxi had 78 protected areas with a total area of 14,510 square kilometers, accounting for about 6.1% of Guangxi’s land area. In Yunnan, there are 162 protected areas (2010) that cover in total about 7.5% of the province.

The Lao PDR has one of the youngest and most comprehensive protected area systems in the world. Established in 1993, the system of national biodiversity conservation areas, now called national protected areas, was based on sound scientific principles and currently includes 24 sites covering 14.7% of the land area.

The Protection of Wildlife, Wild Plants and Natural Areas Law was promulgated in Myanmar in June 1994 in order to carry out biodiversity and environmental conservation more effectively. Currently, protected areas cover about 4.7% of the land area of Myanmar, including 22 wildlife sanctuaries and 6 national parks, with plans to increase this eventually to 10% of the land area.

Protected areas in Thailand were given a legislative basis in the early 1960s with technical assistance from IUCN through promulgation of the Wildlife Act (1960) and National Park Act (1961). Khao Yai was the first National Park, established in 1961, followed by Salak Pra Wildlife Sanctuary in 1965. Currently, more than 21% of the country is covered by protected areas.

Viet Nam established an extensive national network of protected areas in the 1990s. This has succeeded in slowing the rate of destruction of the country’s forests. The network is now being expanded to include wetlands and marine areas. Currently, only about 5% of the country is covered by protected areas.

Conservation Coverage

There are now 692 IUCN categorized protected areas in the subregion, of which 380 are judged to have biodiversity conservation as a major function. Their classification varies from country to country and there are 18 different classes of protected areas around the subregion. Not all classes appear to fulfill major roles in conserving biodiversity. For example, the forest parks of Thailand and Yunnan, Thailand’s nonhunting areas, and the protected landscapes of Cambodia and Viet Nam may have limited value for biodiversity conservation.

Cambodia, the Lao PDR, and Thailand have relatively large protected area systems. Thailand’s system is long established, although several areas have been added in recent years. Those in Cambodia and the Lao PDR are of recent origin, designed specifically with biodiversity conservation and representation in mind. In these larger systems, cover of biotic communities and their species is very good although there is a paucity of lowland dry evergreen forest. Forests of this type, where they occur inland, have been extensively destroyed throughout Southeast Asia.

In Cambodia, 16 out of 29 IUCN categorized protected areas are larger than 500 square kilometers, and comprise 94% of the total system. The figures for the Lao PDR (21 areas) are even higher. The average size of Thailand’s protected areas is less than half those for Cambodia and the Lao PDR, only 73 out of 207 IUCN categorized areas being larger than 500 square kilometers, covering 71% of the total protected area. Guangxi’s, Yunnan’s, and Myanmar’s protected area systems have the smallest average sizes in the subregion.

In Guangxi, the nature reserves have the potential to play a vital role in protecting endangered species, ecosystems, and natural resources. The Conservation Department is working with government agencies to train reserve managers to effectively manage, patrol, and monitor reserves, develop ecotourism and address the needs of people living in and around the reserves, which are off-limits to human activity.

In Yunnan, only 10 of the 162 protected areas exceed 500 square kilometers although, because 5 areas are larger than 1,000 square kilometers, they make up about two thirds of the total system by area.

The protected area system in Myanmar has scope for enlargement. The ultimate target of 10% cover, according to the Myanmar National Forest Policy of 1995, is believed to be a realistic target because large, well-forested, and sparsely populated tracts of country exist in the north. At present, Myanmar still has the lowest proportion of cover in the subregion (4.7%), and most of its protected areas cover an average of 840 square kilometers. Fifteen of its 38 IUCN categorized protected areas are larger than 500 square kilometers and 10 exceed 1,000 square kilometers.

Viet Nam’s system has good biodiversity representation but individual protected areas are relatively small. Only 9 out of the 88 IUCN categorized protected areas are larger than 500 square kilometers—covering 47% of the total protected area.

Legal instruments for biodiversity conservation and protected area management vary from country to country. Thailand has the most sophisticated set of laws and regulations while the Lao PDR has the least...
developed. Viet Nam promulgated a Biodiversity Law in 2010, while Cambodia and the Lao PDR plan to undertake similar steps. In many cases, the broad umbrella of laws and policies is in place but the implementing regulations are still to come.

Thailand, Viet Nam, and Yunnan have already used up a large portion of their forests. The remaining forests are now mostly within protected areas. However, in many cases, this has not stopped the continuing unsustainable and illegal extraction of timber. To safeguard the biodiversity of the subregion for future generations, this issue must be tackled. In Cambodia, the Lao PDR, and Myanmar, governments at the highest levels must support the protected area system while committing the human resources necessary to ensure that the areas are managed appropriately. In the short run, the much needed support is likely to continue to come from international and nongovernment organizations.

<table>
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<th>Protected Area Type</th>
<th>UCN Category</th>
<th>Cambodia</th>
<th>Guangxi</th>
<th>PRC</th>
<th>Yunnan</th>
<th>Lao-PDR</th>
<th>Myanmar</th>
<th>Thailand</th>
<th>Viet Nam</th>
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