

Forecast Mekong

The great deltas of the world are among our most heavily populated and agriculturally productive landscapes, yet these low-lying coastal areas are extremely vulnerable to climate change and development impacts. An international challenge is to transform these vulnerable ecosystems to resilient ones. Through comparative studies and ecological forecasting, such as what is being done with the Mississippi and Mekong Rivers, we can work towards balancing natural landscape functions with economic development to produce healthy ecosystems and sustainable deltas.

The waters of the Mekong River are critical to the food security and livelihoods of millions of people in southeast Asia. The fertile wetlands of the Mekong Delta are the “rice bowl” of Vietnam, the world’s second-largest exporter of rice after Thailand. In addition, Mekong nations have among the highest rates of freshwater fish consumption in the world. Roughly 70% of the protein in the diet of the Cambodian people comes from fish, and recent estimates place the value of fish catch in the Mekong fisheries at up to 4 billion U.S. dollars per year.

River sediment is the lifeblood of deltaic ecosystems, providing nutrients for agriculture and fisheries, and sustaining coastal wetlands. Sediment starvation caused by dams, navigation, and flood control structures compounds problems of subsidence, or sinking of the ground surface, that increases the vulnerability of deltas to sea-level rise. Capturing sediment before it reaches the delta can have unintended consequences, including high rates of land loss, coastal erosion, and sinking cities that are more vulnerable to flooding. In the Mississippi Delta, sediment delivery to the coast has decreased 50% in the 20th century, particularly after the construction of levees and major dams. With these essential minerals and nutrients no longer reaching the coast, the Mississippi Delta is experiencing a staggering rate of land loss, coastal erosion, and subsidence.

In comparison, the Mekong still carries large amounts of nutrient-rich sediment downstream, nourishing the highly productive Tonle Sap Lake and the fertile Mekong Delta. Water is a critical resource in the Mekong Basin, but with five different nations contributing water to the Mekong River, management of this system is an issue in which the actions of each nation affect the entire basin. Although China contributes only 16% of the Mekong River flow, over half the sediment reaching the delta comes from the Upper Mekong in China. Some studies indicate that flow reduction and sediment trapping by upstream dams on the Mekong would damage the productivity of the Tonle Sap Lake in Cambodia, the heart of the world’s largest inland fishery. Regulating the flow of the Mekong River can be seen as a benefit of building dams, but changing natural water flow patterns could be devastating for fisheries.

The annual cycle of expansion and contraction of the Tonle Sap Lake is what makes its fisheries so abundant. The submerged vegetation of the floodplains provides young fish with food and shelter from predators. Dams will likely cause changes to the volume and timing of Mekong flows, degrading fish habitat along the river and reducing fisheries productivity. Dams on the

Mekong mainstem, or lower tributaries, can block the passage of migrating fish and could damage the food security of a region more dependent on its inland fisheries than anywhere else in the world.

Climate change can also add uncertainty to the future of the Mekong. Human activities in coastal deltas can exacerbate subsidence, which further accelerates the local rate of sea-level rise. In Thailand's Chao Phraya delta, a combination of groundwater withdrawal and a severe reduction in the amount of sediment replenishing coastal wetlands has caused a serious subsidence problem. In the Mekong delta, sea-level rise projections indicate that millions of people could be displaced by increased coastal flooding, and vast areas of rice fields could be inundated with salt water. Maintaining the Mekong River's natural sediment levels and preventing the overuse of groundwater will help the Mekong delta avoid the higher rates of relative sea-level rise found in the Mississippi and Chao Phraya deltas.

Comparative science can help guide decision-making about the river's future, balancing economic development and the protection of ecosystems and water resources in ways that make communities more resilient to climate change impacts. For instance, hydropower dams in the United States have affected important commercial fisheries, such as salmon. A series of large dams can transform a flowing river into a series of lakes and block or limit the passage of salmon and other migratory fish. Overfishing, habitat loss, and water diversion for agricultural use can further contribute to salmon declines. Hydropower dams have brought inexpensive power to the northwestern United States, but the cost has been a steep reduction in salmon and other migratory fish populations. Similar impacts could be seen on commercial fisheries in the Mekong in the future. Although modifications to hydropower dams have improved the survival of fish moving through the cascade of dams, many salmon populations are still endangered, and the United States now spends over \$160 million per year on salmon recovery.

Satellite-based tools can be used to monitor ecosystems, providing early warnings of drought or flood conditions, or to track the health and growth patterns of rice crops. Parts of the Mekong basin were gripped by one of the worst droughts in decades during the first part of 2010, resulting in extremely low river levels and salt water intruding further into the Mekong Delta. This series of satellite-based maps shows that vegetation growth was much lower than normal during that period, indicating that yields from rice and other crops were expected to be lower than usual.

The Forecast Mekong framework, in partnership with local governments and universities in the Mekong region, is developing tools to monitor ecosystems and forecast the consequences of climate change. Forecast Mekong will provide global climate model projections that can help support the development of strategies to adapt to our changing environment. Information and tools such as ecological monitoring systems, hydrological models, and the transfer of new technologies will aid scientists and policymakers working in the Mekong basin.

We are addressing challenges to transform these vulnerable ecosystems of the Mekong Delta to more resilient ones. Through comparative studies and ecological forecasting we are beginning to harmonize natural landscape functions with human socioeconomic drivers to guide management of healthy ecosystems and a sustainable delta. We must embrace the future of delta resources *now* so that they will be resilient for many years to come.