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Mangroves: specificities, threats, adaptations and human uses

Introduction

Mangroves are unique coastal forests that grow where land and sea meet in tropical and subtropical regions. These ecosystems are made up of salt-tolerant trees and shrubs that survive in muddy, oxygen-poor soils regularly flooded by tides. Although mangroves may appear harsh and difficult environments, they are among the most productive ecosystems on Earth and support a wide range of marine and terrestrial life. They provide food, income, coastal protection, and environmental stability for millions of people worldwide, especially for fishing communities.

Today, mangroves face serious threats from climate change and human activities. Rising sea levels, stronger storms, pollution, deforestation, shrimp farming, and coastal development are causing rapid degradation of mangrove forests around the world. As these ecosystems disappear, coastal communities lose important natural protections and economic resources. This paper explores the characteristics of mangroves, the main threats they face, the ways they adapt to difficult environmental conditions, and the importance of protecting them through both local and global conservation efforts.

1. What are mangroves and why are they important?

Globally, mangroves cover around 150,000 square kilometers and are found across Asia, Africa, the Americas, Oceania, and parts of the Middle East. Asia contains the largest concentration of mangroves and the highest diversity of species. Southeast Asia is considered the global center of mangrove biodiversity, containing around 51 mangrove species.

Mangroves provide extremely valuable ecosystem services. One of their most principal functions is coastal protection. Their dense roots help stabilize shorelines, reduce erosion, and weaken the force of waves and storm surges during hurricanes, cyclones, and tsunamis. This natural barrier helps protect millions of people living in coastal regions.

Mangroves are also major carbon sinks. They store enormous quantities of carbon in their soils and vegetation, often much more than tropical forests on land. Because of this, mangroves play an important role in reducing climate change by capturing and storing atmospheric carbon dioxide.

In addition, mangroves support fisheries and biodiversity. Their root systems create safe nursery habitats for juvenile fish, crabs, shrimp, mollusks, and many other marine species. Many fish species important for local and commercial fisheries spend part of their life cycle in mangrove ecosystems . Birds, reptiles, mammals, and insects also depend on mangroves for food and shelter.

Mangroves also provide economic resources to local populations. Coastal communities use mangrove wood for houses, boats, fences, tools, and fuel. Some mangrove species are used in traditional medicine, cosmetics, soaps, and insecticides. Millions of people worldwide depend directly or indirectly on mangroves for their livelihoods and food security.

2. Special characteristics and adaptations of mangroves

Mangroves grow in salty wetlands and intertidal zones where conditions are difficult for most plant. These environments are characterized by high salinity, muddy soils, extreme tides, strong winds, and low oxygen levels in the soil. Despite these conditions, mangroves have evolved special adaptations that allow them to survive and flourish.

Salt tolerance

One of the main challenges for mangroves is salt. Many mangrove species grow in areas flooded daily by seawater. To survive, they have developed different mechanisms to manage excess salt. Some species filter salt at the root level before it enters the plant (Ibid.). Others excrete salt through special glands in their leaves. In some cases, salt accumulates in older leaves that later fall off the tree. These adaptations allow mangroves to survive in salinity levels much higher than most other plants can tolerate.

Adaptation to low oxygen soils

Mangroves grow in muddy soils that contain truly little oxygen. To solve this problem, they have developed specialized root systems that allow them to breathe above the water surface (Tomlinson, 1986). Species varies in root shapes:

- Stilt roots help stabilize trees in soft sediments.
- Pneumatophores are vertical roots that rise above the mud to absorb oxygen from the air.
- Knee roots and plank roots also help with oxygen intake and structural support.

These root systems not only help the trees survive but also create habitats for fish, crabs, oysters, algae, and many other organisms.

Ecotonal nature

Mangroves are considered an ecotone because they form a transition zone between terrestrial and marine ecosystems. This position between land and sea makes them biologically rich and highly productive. Mangrove ecosystems connect with coral reefs, seagrass beds, lagoons, and rivers. Many marine species move between these habitats during various stages of their lives. Juvenile fish often use mangroves as nurseries before moving to coral reefs or open waters as adults. Because of this ecological connectivity, the destruction of mangroves can negatively affect entire coastal ecosystems and fisheries.

3. Climate change and its effects on mangroves

Climate change is becoming one of the greatest threats to mangrove ecosystems. Rising temperatures, sea level rise, changing rainfall patterns, and stronger storms are already affecting mangrove forests around the world.

Sea level rise

Sea level rise is particularly dangerous for mangroves because they depend on a delicate balance between land and water. If sea levels rise too quickly, mangroves may become permanently submerged. Historically, mangroves adapted by slowly migrating inland. However, today many coastlines are occupied by cities, roads, and infrastructures, preventing this natural migration. Scientists estimate that a large portion of global mangroves could disappear or become submerged by 2050 if sea levels continue to rise rapidly.

Rising temperatures

Temperature strongly influences mangrove growth and distribution. Moderate warming may allow mangroves to expand into new regions farther from the equator. In some areas, mangroves are already spreading into temperate salt marshes. However, excessive heat can damage mangrove physiology. High temperatures reduce photosynthesis, increase evaporation, and raise salinity levels in soils. This can reduce forest productivity and biodiversity.

Stronger storms and extreme weather

Mangroves help reduce the impact of storms by slowing waves and storm surges. However, severe cyclones and hurricanes can also destroy mangrove forests. Extreme storms can uproot trees, break branches, strip leaves, and alter sediment patterns. Repeated

disturbances may reduce biodiversity and slow forest recovery. Some mangrove species are more resilient than others and can regrow after storms.

Changes in rainfall and salinity

Climate change is altering rainfall patterns in many parts of the world. Reduced rainfall increases salinity in mangrove soils because less freshwater dilutes seawater. Extremely salty conditions can limit seedling survival, reduce tree growth, and transform mangrove areas into barren mudflats. On the other hand, increased rainfall may improve mangrove productivity in some regions by reducing soil salinity.

4. Human threats to mangroves

Although climate change is a major challenge, human activities remain one of the main causes of mangrove destruction worldwide.

Aquaculture and agriculture

Shrimp farming is one of the biggest causes of mangrove deforestation, especially in Southeast Asia. Large areas of mangrove forest have been cleared to build shrimp ponds and fish farms. While shrimp farming can generate short-term profits, it often causes serious environmental damage. Wastewater from shrimp farms contains chemicals, antibiotics, pesticides, and organic waste that pollute nearby ecosystems. Agriculture also contributes to mangrove destruction. Mangrove areas are often cleared for rice cultivation, palm oil plantations, and other agricultural activities.

Coastal development

Hotels, ports, roads, power plants, and urban expansion frequently replace mangrove forests. Coastal development alters natural water flow, increases erosion, and introduces pollution into fragile ecosystems. Once mangroves are destroyed for infrastructure projects, restoring them becomes extremely difficult.

Deforestation

Mangroves are cut for wood, charcoal, and land conversion. In many regions, growing coastal populations increase pressure on mangrove resources. Although some harvesting may be sustainable, excessive cutting leads to ecosystem degradation and biodiversity loss. Over the past several decades, large portions of global mangrove cover have disappeared due to human activities.

Pollution

Mangroves trap large amounts of pollution because their roots collect debris and sediments. Plastic pollution is becoming a growing problem. Plastic waste can suffocate mangrove roots and reduce tree survival. Oil spills are also extremely harmful. Oil coats mangrove roots and blocks oxygen exchange, often killing entire sections of forest. Other pollutants such as heavy metals, pesticides, and chemicals accumulate in mangrove ecosystems and affect wildlife.

Invasive species

Certain non-native plants and animals threaten mangroves by competing with native species or damaging habitats. Invasive grasses, rats, cats, and other introduced species have caused ecological problems in several mangrove regions worldwide.

5. Conservation efforts and community-based management

Despite these threats, many organizations, governments, and local communities are working to protect and restore mangroves.

Global conservation initiatives

Several international programs focus on mangrove conservation. The Global Mangrove Alliance works with scientists, governments, NGOs, and local communities to reduce mangrove loss and promote restoration projects worldwide. Another important initiative is Mangroves for the Future, created after the 2004 Indian Ocean tsunami. This program supports sustainable coastal management, disaster risk reduction, and community resilience in several Asian countries. Large-scale restoration projects are also being developed through international climate initiatives such as the Mangrove Breakthrough, which aims to protect and restore millions of hectares of mangrove forests by 2030.

Sri Lanka’s efforts

Sri Lanka has become an important example of mangrove conservation. The country has implemented programs that combine environmental protection with community development. Organizations such as Seacology support mangrove restoration while helping coastal communities develop sustainable livelihoods (Seacology, n.d.). Women and youth receive training and microloans to create small businesses in exchange for participating in mangrove conservation activities. Sri Lanka has also developed national guidelines for mangrove restoration that emphasize scientific planning, ecosystem management, and community participation rather than simply planting trees without proper ecological assessment.

Community-based management

Community participation is increasingly recognized as essential for successful mangrove conservation. Local fishing communities often have strong knowledge of coastal ecosystems and directly depend on mangroves for survival. Community-based mangrove management involves local residents in restoration, protection, monitoring, and sustainable resource use. In Sri Lanka, Fishermen Cooperative Societies play an important role in organizing restoration activities, nursery management, and community engagement. When communities receive economic benefits, secure land rights, and proper support, conservation efforts tend to be more successful and sustainable.

Conclusion

Mangroves are among the world's most valuable coastal ecosystems. They protect shorelines, store carbon, support biodiversity, sustain fisheries, and provide livelihoods for millions of people. Their unique adaptations allow them to survive in difficult coastal environments while supporting rich ecological communities. However, mangroves are under increasing pressure from climate change, pollution, deforestation, aquaculture, and coastal development. The loss of mangroves threatens biodiversity, food security, coastal protection, and the well-being of vulnerable coastal populations.

Protecting mangroves requires cooperation between governments, scientists, local communities, and international organizations. Community-based management, sustainable coastal development, and effective restoration programs offer promising solutions for the future. Ultimately, conserving mangroves is not only about protecting trees. It is about protecting ecosystems, livelihoods, climate resilience, and the future of coastal communities around the world.

Biography

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