



Natural Coastal Defense Functions of Salt Marshes and Mangrove Bio-Shield Systems

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DESCRIPTION

Coastal zones are constantly exposed to wave energy, storm surges, tidal currents, and wind-driven processes that reshape shorelines over time. In many low-lying coastal regions, natural vegetation systems such as salt marshes and mangroves provide effective protection against these forces. These ecosystems function as bio-shields, reducing the intensity of coastal hazards while also supporting biodiversity and maintaining ecological balance. Their role in coastal protection has gained attention in both scientific research and environmental planning due to their ability to reduce erosion and improve shoreline stability.

Salt marshes are coastal wetlands found mainly in temperate regions where saline water regularly floods low-lying land. They are characterized by salt-tolerant grasses, sedges, and herbaceous plants that grow in waterlogged soils. Mangroves, on the other hand, are tropical and subtropical coastal forests composed of salt-tolerant trees and shrubs that develop complex root systems above and below the ground. Although these ecosystems differ in structure and geographic distribution, both provide similar protective functions along coastlines.

One of the main protective functions of salt marshes and mangroves is wave energy reduction. When waves travel toward the shoreline, vegetation slows down water movement by increasing surface friction. Stems, roots, and leaves absorb part of the wave energy, reducing its force before it reaches inland areas. Mangrove root systems, especially prop roots and pneumatophores, create dense physical barriers that disrupt wave flow. Salt marsh grasses perform a similar function by reducing water velocity across shallow coastal flats. This reduction in energy helps limit coastal erosion and protects inland infrastructure from damage.

Both ecosystems also play a role in stabilizing shorelines. The root systems of mangroves bind soil particles together, reducing soil loss caused by wave action and tidal currents. Salt marsh plants similarly stabilize sediment through dense root mats that hold soil in place. This stabilization reduces the likelihood of

shoreline retreat and helps maintain the integrity of coastal landforms such as deltas, estuaries, and tidal flats.

Storm protection is a key function of mangrove and salt marsh systems. During extreme weather events, such as cyclones or coastal storms, these ecosystems act as natural buffers that reduce the impact of storm surges. Studies in various coastal regions have shown that areas with intact mangrove forests experience lower levels of flood damage compared to areas where vegetation has been removed. Salt marshes also reduce storm impact by slowing down floodwaters and decreasing the height of incoming waves.

Despite their benefits, salt marshes and mangroves face significant pressure from human activities. Coastal development, land reclamation, aquaculture expansion, pollution, and deforestation have led to the loss of large areas of these ecosystems. Removal of vegetation reduces natural protection and increases vulnerability to erosion and flooding. In many regions, conversion of mangrove forests into agricultural or industrial land has resulted in long-term environmental degradation.

Scientific tools such as satellite imaging, field surveys, and ecological modeling are used to study the performance of salt marsh and mangrove systems. These tools help researchers understand vegetation growth patterns, sediment movement, and shoreline changes over time. Data collected from these studies supports better management decisions and helps identify areas that require conservation or restoration.

In conclusion, salt marshes and mangroves provide essential bio-shielding functions that support coastal stability, reduce wave energy, trap sediments, and protect against storm impacts. They also contribute to biodiversity conservation and carbon storage. Protecting and restoring these ecosystems supports both environmental and social benefits, especially in coastal regions exposed to natural hazards. Their continued conservation remains important for maintaining resilient shoreline systems under changing environmental conditions.

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