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Commentary

# Understanding Coastal Hazards: Global Challenges, Environmental Impacts and Strategies for Sustainable Resilience

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## DESCRIPTION

Coastal hazards are among the most complex and devastating natural phenomena affecting human societies and ecosystems along the world's shorelines. They encompass a wide range of events such as storm surges, tsunamis, coastal erosion, flooding and sea level rise, all of which pose serious threats to human life, infrastructure and the environment. With more than forty percent of the global population living within one hundred kilometers of the coast, understanding and managing coastal hazards has become a critical aspect of sustainable development, climate adaptation and disaster risk reduction.

The dynamics of coastal hazards are primarily driven by the interaction between natural processes and human activities. Coastal regions are shaped by oceanic forces including tides, waves and currents, which continuously modify the shoreline. However, when these natural processes intensify due to climatic or geological factors, they can evolve into destructive hazards. For example, storm surges generated by tropical cyclones cause sudden and severe rises in sea level, inundating low-lying coastal areas. Similarly, tsunamis triggered by undersea earthquakes can travel across entire ocean basins, striking coastlines with catastrophic energy. In recent years, global climate change has amplified the frequency and intensity of such events, exposing more people and assets to risk than ever before.

Erosion is one of the most persistent coastal hazards, gradually wearing away beaches, dunes and cliffs. It occurs when wave energy and currents exceed the natural replenishment of sediments, leading to the retreat of shorelines. In many regions, human interventions such as sand mining, construction of seawalls and alteration of river systems have accelerated this process. The loss of beaches not only threatens property and infrastructure but also diminishes tourism and weakens the natural buffer zones that protect inland areas from storms and flooding. Coastal flooding, on the other hand, often results from a combination of high tides, heavy rainfall and storm

surges, causing extensive damage to homes, agriculture and transportation networks.

Tsunamis represent another category of coastal hazards with profound human and ecological impacts. Originating from submarine earthquakes, volcanic eruptions, or landslides, tsunamis can devastate entire coastlines within minutes. The 2004 Indian Ocean tsunami and the 2011 Tōhoku tsunami in Japan highlighted the immense destructive potential of these events, leading to global efforts to improve early warning systems and community preparedness. Despite these advances, the unpredictability of geological hazards and the high density of coastal populations continue to make tsunami risk management a formidable challenge.

Climate change acts as a powerful multiplier of coastal hazards. Rising global temperatures contribute to sea level rise through thermal expansion of seawater and melting of ice sheets, leading to permanent inundation of low-lying islands and deltas. Warmer ocean temperatures also fuel more intense tropical storms, increasing the occurrence of storm surges and coastal flooding. Moreover, ocean acidification and the degradation of coral reefs and mangroves reduce the natural defenses that coastlines rely on for stability and protection. The cumulative impact of these factors threatens not only coastal infrastructure but also food security, freshwater availability and biodiversity in some of the most productive and densely populated regions of the world.

Human activities have further intensified coastal hazards through unplanned development and environmental mismanagement. Rapid urbanization in coastal zones often leads to the destruction of wetlands, dunes and mangrove forests that act as natural buffers. The extraction of groundwater and fossil fuels causes land subsidence, making certain areas even more susceptible to flooding and storm damage. Poorly planned coastal engineering structures, such as jetties and groynes, can disrupt sediment transport, creating erosion hotspots downstream. These actions demonstrate that the interplay

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between human and natural systems often determines the scale and severity of coastal hazards.

Mitigating coastal hazards requires an integrated and adaptive approach that combines scientific research, technological innovation and community-based strategies. Early warning systems, supported by satellite monitoring and ocean buoys, have proven effective in reducing casualties during extreme events. Coastal zone management policies should emphasize ecosystem-based adaptation, restoring mangroves, coral reefs and dunes to enhance natural resilience. Soft engineering techniques such as beach nourishment and wetland restoration can offer sustainable alternatives to traditional hard structures. Urban planners must incorporate hazard mapping, land-use regulations and resilient infrastructure design to minimize future risks.

Education and awareness play crucial roles in building community preparedness. Empowering local populations with knowledge about evacuation routes, disaster response and environmental stewardship can significantly reduce vulnerability. Collaboration between governments, scientists and international organizations such as UNESCO and the

Intergovernmental Oceanographic Commission fosters the sharing of best practices and data across regions. Coastal hazard management should also be rooted in equity, ensuring that marginalized and economically disadvantaged communities receive adequate support to adapt and recover.

## CONCLUSION

In conclusion, coastal hazards represent an escalating global challenge that demands coordinated scientific, social and policy-driven responses. As climate change accelerates and human pressures on coastal environments intensify, the risks associated with storms, erosion and flooding are expected to rise dramatically. Yet, through proactive planning, sustainable management and international cooperation, societies can build resilience against these threats. Understanding coastal hazards is not only a matter of environmental science but also of survival, social justice and global responsibility. Safeguarding our coasts today ensures the protection of future generations and the ecosystems upon which humanity depends.