



Differential Impact of Coastal Flooding on Tree Species

For Prelims: [Global warming](#), [Coastal Flooding](#), [Forest Conservation Act of 1980](#), [National Forest Policy of 1988](#)

For Mains: Sea-level rise, and their implications for coastal communities and ecosystems, Impacts of Floods in India.

Source: TH

Why in the News?

A recent study in **Frontiers in Forests and Global Change** highlights that rising sea levels, driven by [global warming](#), result in varying effects on coastal tree species as a result of coastal flooding.

Note:

- The study used **dendrochronology (tree-ring dating)** and a **machine-learning technique** called **gradient-boosted linear regression** to examine how rainfall, temperature, and tidal levels affect tree growth, revealing complex interactions between these factors.

What are the Key Findings of the Study?

- **Diverse Effects on Tree Species:** The study indicates that species like **American holly (Ilex opaca)** prosper with elevated water levels, while **loblolly pine (Pinus taeda)** and **pitch pine (Pinus rigida)** show restricted growth under these conditions.
- **Resilience by Species:** Certain species are better suited to adapt to shifts in precipitation, temperature, and sea levels.
 - Trees are adapting rapidly to these changes; as sea levels rise by a few millimetres(mm) each year, many coastal tree species are gradually migrating inland to regions with lower tides and reduced salt exposure.
- **Broader Impact:** Over **three billion people** reside near coastlines and depend on coastal ecosystems. Protecting coastal vegetation is essential for sustaining ecosystem services and supporting livelihoods.
- **Future Implications:** Since 1993, sea levels have doubled their rise from 2mm per year, with researchers forecasting a threefold increase in coastal floods and double the flood days by 2050.
- **Study Relevance:** Findings help forest managers prioritize species protection in coastal areas, emphasizing the importance of local conditions in assessing forest vulnerability to climate change.

What is Coastal Flooding?

- **About:** [Coastal flooding](#) is a sudden inundation of coastal areas caused by short-term water

level increases from storm surges and extreme tides, influenced by local topography and bathymetry.

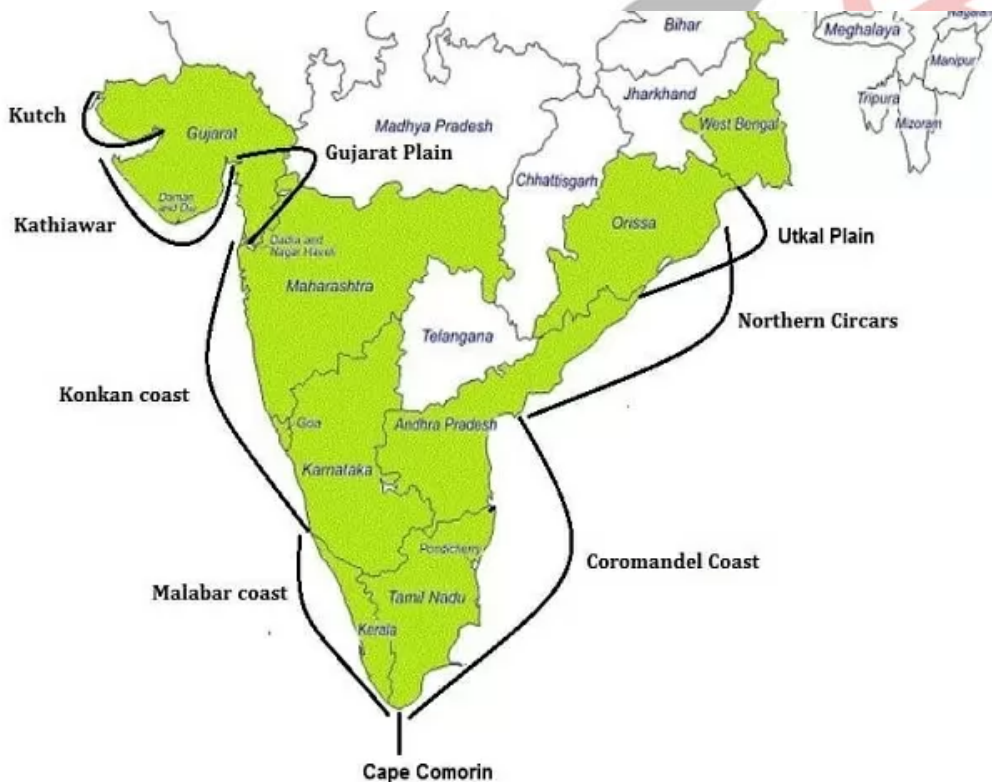
▪ **Mechanisms of Coastal Flooding:**

- **Overtopping:** Waves can breach barriers like seawalls or dikes, leading to flooding behind these defences.
- **Inundation:** High sea levels or extreme weather can flood low-lying coastal areas even without overtopping.
- **Backflow:** Storm surges or high tides can overwhelm rivers or drainage, causing water to flow back into coastal zones.

Overview of India's Coastal Landscape

- **India's coastline stretches 7,516.6 km**, with 6,100 km along the **mainland** and **1,197 km around its islands**, spanning 13 States and Union Territories.
- Among the states, Gujarat has the longest coastline (1,214.7 km), followed by Andhra Pradesh (973.7 km) and Tamil Nadu (906.9 km).
- The Andaman & Nicobar Islands hold the longest coastline among UTs at 1,962 km.
- **Vulnerable Areas:**
 - **Vulnerable Coastal States:** Coastal states like Odisha, Andhra Pradesh, Tamil Nadu, Kerala, West Bengal, Gujarat, and Maharashtra face heightened risks due to their geographic exposure and socio-economic conditions.
 - **Low-Elevation Flood Risks:** Regions with low elevation, such as the Sundarbans in West Bengal and Odisha's coastal plains, are particularly prone to coastal flooding.

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How does Global Warming Impact Coastal Region?

- **Sea-Level Rise:** As [global temperatures increase](#), glaciers and ice sheets melt, adding more water to the oceans and contributing to sea-level rise.
- **Increased Coastal Flooding:** Higher sea levels and stronger **storm surges** result in more frequent and intense coastal flooding, impacting infrastructure and habitats.

- **Erosion of Coastlines:** The combination of rising seas and more powerful storms accelerates erosion, causing the loss of beaches and wetlands that act as natural buffers.
- **Impact on Marine Ecosystems:** Changes in [ocean temperatures and acidification](#) due to increased CO₂ affect marine life, including coral reefs, fish populations, and biodiversity crucial to coastal economies.
- **Increased Storm Intensity:** Warmer seas contribute to more powerful tropical storms and hurricanes, resulting in destructive storm surges that threaten coastal communities.

What are India's Initiatives for Coastal Management?

- **Managing Coastal Flood:** [MISHTI Initiative](#), a government-led initiative aimed at increasing the mangrove cover along the coastline and on saltpan lands.
- **National Centre for Sustainable Coastal Management:** It aims to promote integrated and sustainable management of the coastal and marine areas in India for the benefit and well-being of the traditional coastal and island communities.
- **Integrated Coastal Zone Management Plan:** It is a process for the management of the coast using an integrated approach, regarding all aspects of the coastal zone, including geographical and political boundaries, in an attempt to achieve sustainability.
- **Coastal Regulation Zone:** The [Coastal Regulation Zone](#) notification was issued in 1991 under the **Environmental Protection Act, 1986**, by the Ministry of Environment, Forest and Climate Change to regulate activities in coastal areas of India.
- **Solutions for Flood Management:**
 - **Storage Reservoirs:** These man-made structures retain water during periods of high flow and discharge it when flows are low.
 - **Embankments:** These are raised structures that confine the flow of water within a channel or along a bank.
 - **Flood Forecasting and Warning:** This system predicts potential floods using meteorological and hydrological data.
 - For instance, the [Central Water Commission \(CWC\)](#) runs a network of flood forecasting stations in India, providing daily updates and alerts on flood conditions.

What are the Challenges Related to Coastal Flooding?

- **Infrastructure Damage:** Coastal flooding severely damages infrastructure like roads, buildings, ports, and bridges, leading to high repair costs and disrupting transportation and communication systems in coastal areas.
- **Economic Losses:** Industries such as tourism, fisheries, and agriculture suffer due to flooding, with coastal regions facing direct losses from halted operations, reduced productivity, and damaged assets.
- **Loss of Biodiversity:** Flooding leads to habitat loss for coastal flora and fauna, impacting biodiversity. Wetlands, mangroves, and other critical ecosystems are particularly vulnerable, leading to reduced natural resilience against future flooding.
 - Saltwater intrusion from coastal flooding contaminates freshwater resources, affecting drinking water, agriculture, and local ecosystems.
 - Soil salinity also disrupts crop production, impacting food security in affected regions.
- **Displacement and Human Migration:** Persistent flooding can render areas uninhabitable, forcing communities to relocate.
 - This results in internal migration, strain on urban infrastructure, and potential social conflicts in destination areas.

What Strategies Can Protect Forests from Coastal Flooding?

- **Forest Resilience:** Forest managers should inventory species composition to prioritize forests that are most at risk, rather than applying blanket strategies.
 - Coastal habitats such as [Mangroves](#), [Coral Reefs](#) and lagoons are recognized as the best defence against sea storms and erosion, deflecting and absorbing much of the energy of

sea storms.

- For example, forests dominated by **loblolly pine** may need more urgent interventions due to their susceptibility to tidal flooding.
- **Localized studies:** Localised studies such as soil health and rainfall, are crucial to understanding the **site-specific** challenges that coastal ecosystems face and for assessing coastal forests' vulnerability to sea-level rise, not just flooding.
- **Dune Construction and Restoration:** Building or restoring sand dunes can act as a buffer against high tides and storm surges.
- **Species Selection:** Choosing salt-tolerant and flood-resistant tree species can help sustain forest health in flood-prone areas
- **Infrastructure and Engineering Solutions:** Exploring innovative engineering solutions like **seawalls, levees, and stormwater** management systems.

Drishti Mains Question:

Analyze the impact of rising sea levels on coastal tree species and discuss the implications for forest management and conservation strategies in the context of climate change.

UPSC Civil Services Examination Previous Year's Question (PYQs)

Prelims:

Q. La Nina is suspected to have caused recent floods in Australia. How is La Nina different from El Nino? (2011)

1. La Nina is characterised by an usually cold ocean temperature in the equatorial Indian Ocean whereas El Nino is characterised by unusually warm ocean temperature in the equatorial Pacific Ocean.
2. El Nino has an adverse effect on the south-west monsoon of India but La Nina has no effect on the monsoon climate.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Ans: (d)

Mains

Q. With reference to the National Disaster Management Authority (NDMA) guidelines, discuss the measures to be adopted to mitigate the impact of recent incidents of cloudbursts in many places of Uttarakhand. (2016)