

Sea Level Rise: Causes, Impacts and UPSC Relevance

Sea level rise is one of the most significant consequences of climate change, threatening coastal ecosystems, cities, agriculture and millions of people living in low-lying regions. For India, with its long coastline and densely populated coastal areas, sea level rise has important implications for **environmental security, disaster management, livelihoods and sustainable development**.

For UPSC aspirants, the topic is important for **GS Paper I - Geography, GS Paper III - Environment & Disaster Management, and current affairs**.

What is Sea Level Rise?

Sea level rise (SLR) refers to the long-term increase in the average level of the world's oceans relative to land.

It occurs due to both:

1. **Thermal expansion of seawater** as oceans warm.
2. **Addition of water to oceans from melting glaciers and ice sheets.**

Sea level is not rising uniformly everywhere. Local and regional sea levels are also influenced by **land subsidence, ocean currents, changes in winds and variations in gravitational effects**.

Major Causes of Sea Level Rise

1. Thermal Expansion

As ocean water absorbs heat from a warming atmosphere, it expands. This process, known as **thermal expansion**, contributes significantly to global sea level rise.

2. Melting Glaciers

Mountain glaciers are losing ice because of rising temperatures. Meltwater eventually reaches the oceans, contributing to sea level rise.

3. Melting Ice Sheets

The **Greenland and Antarctic ice sheets** contain enormous quantities of frozen

water. Their loss through surface melting and increased ice discharge can significantly increase global sea levels.

4. Land Subsidence

In some coastal regions, the land itself is sinking because of groundwater extraction, sediment compaction, natural geological processes or urban development.

Therefore:

Relative sea level rise = Global sea level rise + Local land-level changes

Why is Sea Level Rise a Major Concern? Coastal Flooding

Higher sea levels increase the risk of **permanent inundation and flooding**, particularly during high tides and storm surges.

Coastal Erosion

Rising sea levels can accelerate coastal erosion and threaten beaches, wetlands and settlements.

Saltwater Intrusion

Seawater can enter coastal aquifers and agricultural areas, affecting **freshwater availability and soil fertility**.

Extreme Events

A higher baseline sea level can make **cyclones and storm surges more destructive**, even when the intensity of the storm itself does not change.

Loss of Ecosystems

Mangroves, coral reefs, tidal flats and coastal wetlands are particularly vulnerable.

Sea Level Rise and India

India has a coastline of more than **7,500 km including its island territories**, making coastal climate risks highly significant.

Vulnerable areas include:

- Mumbai and other parts of the Maharashtra coast
- Gujarat coast
- Odisha and West Bengal
- Andhra Pradesh
- Tamil Nadu
- Kerala
- Lakshadweep
- Andaman and Nicobar Islands

The **Sundarbans**, for example, face a combination of sea-level rise, coastal erosion, cyclones and salinity intrusion.

Low-lying coastal cities are also vulnerable because climate risks can interact with **urban flooding, land subsidence and rapid urbanisation**.

Sea Level Rise and Indian Islands

India's island territories face particular challenges.

Lakshadweep consists largely of low-lying coral islands and is therefore vulnerable to coastal flooding, erosion and changes in freshwater availability.

The **Andaman and Nicobar Islands** face risks from coastal hazards, cyclones, ecosystem degradation and sea-level changes.

Sea Level Rise and Climate Change

Sea level rise is a **slow-onset climate hazard**, unlike sudden disasters such as earthquakes or flash floods.

However, its effects can accumulate over decades.

Climate change therefore requires two complementary approaches:

Mitigation → Reduce greenhouse-gas emissions

Adaptation → Prepare communities and infrastructure for unavoidable impacts

Measures to Address Sea Level Rise

Coastal Ecosystem Protection

Mangroves, wetlands, dunes and coral reefs act as natural barriers against waves and storm surges.

Climate-Resilient Infrastructure

Ports, roads, drainage systems and coastal settlements need to incorporate projected future sea levels into planning.

Coastal Zone Management

India's **Coastal Regulation Zone (CRZ)** framework seeks to regulate activities in environmentally sensitive coastal areas.

Early Warning Systems

Better forecasting and evacuation systems can reduce loss of life during cyclones and storm surges.

Managed Retreat

In highly vulnerable areas, relocation of settlements and infrastructure may become necessary where protection is technically or economically impractical.

UPSC Relevance

Prelims

Important concepts:

- Thermal expansion
- Glacial melt
- Ice-sheet loss
- Sea-level rise vs land subsidence
- Storm surge
- Coastal erosion

- Saltwater intrusion
- Mangroves and coastal wetlands

GS Paper I - Geography

Connect the topic with:

- Oceanography
- Coastal processes
- Climate systems
- Islands
- Coastal geomorphology

GS Paper III - Environment

Connect it with:

- Climate change
- Disaster management
- Coastal regulation
- Climate adaptation
- Ecosystem-based adaptation
- Climate-resilient infrastructure

Possible UPSC Mains Question

“Sea-level rise is a slow-onset climate hazard with potentially severe consequences for India’s coastal regions. Discuss its causes, impacts and adaptation strategies.”

A strong answer can follow:

Causes → Impacts → Indian vulnerability → Adaptation → Way forward

Conclusion

Sea level rise is not merely an environmental problem; it is a development, economic and security challenge. Its consequences can affect coastal populations, infrastructure, agriculture, freshwater resources and ecosystems.

For India, the way forward requires a combination of **climate mitigation, coastal ecosystem restoration, resilient infrastructure, scientific monitoring, disaster preparedness and sustainable coastal planning.**

For UPSC aspirants, sea level rise is best understood through the interconnected themes of **Climate Change + Oceanography + Coastal Geography + Disaster Management + Sustainable Development.**

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