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CLIMATE CHANGE AND GLOBAL WARMING- FUTURE IMPACTS AND REMEDIAL MEASURES REVIEW ARTICLE

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ABSTRACT

Climate change and global warming have emerged as major environmental challenges of the twenty-first century. Recent years have witnessed noticeable changes in climatic conditions, including increasing temperatures, frequent and intense heat waves, irregular rainfall, floods, droughts, melting glaciers and ice sheets, sea-level rise, coastal erosion and changes in extreme weather events. These changes are closely associated with increasing atmospheric concentrations of greenhouse gases, particularly carbon dioxide released through fossil-fuel combustion, deforestation, industrial activities and land-use change. Methane, nitrous oxide and fluorinated gases also contribute to climate forcing. The consequences extend beyond temperature increases and affect water resources, agriculture, biodiversity, human health, infrastructure and the economy. Sea-level rise is a major concern for low-lying coastal regions. India, with its extensive coastline and densely populated coastal areas, is particularly vulnerable. This article reviews recent climate changes, their major causes, projected impacts, sea-level rise, Indian and Chennai-specific vulnerability, and major mitigation and adaptation measures. Effective responses require rapid emission reduction together with ecosystem restoration, climate-resilient infrastructure, early-warning systems and long-term land-use planning.

1. INTRODUCTION

Climate change refers to long-term changes in temperature, rainfall patterns, atmospheric circulation, sea level and other components of the Earth's climate system. Although Earth's climate has changed naturally throughout geological history, the present warming trend is predominantly associated with human activities and increasing greenhouse-gas concentrations. The source material identifies human activities, principally greenhouse-gas emissions, as the dominant driver of current global warming.

Climate change is not simply a temperature problem. It involves interacting changes in the atmosphere, oceans, cryosphere, land surface and biological systems. Consequently, warming can influence rainfall, ice loss, sea level, extreme events, ecosystems and human systems simultaneously.

What Climate Science Says About a Warming World — and India's Coastline

Could global warming really put the entire planet underwater? It's a question that sounds like science fiction, but it points to a real and important phenomenon: polar ice loss and sea-level rise. The short answer is reassuring in one sense and sobering in another — the Earth will not become one giant ocean, but the changes already under way are reshaping coastlines, threatening major cities, and altering life for hundreds of millions of people, particularly along India's coast.

This article explains what actually happens when ice melts, why some regions — including Chennai, Mumbai, and Kolkata — face far greater risk than others, what is driving climate change more broadly, and what can realistically be done about it.

Not all polar ice behaves the same way, and the distinction matters enormously.

Would the whole Earth go Underwater?

Floating Sea Ice vs. Land Ice

Floating sea ice, such as much of the ice covering the Arctic Ocean, is already displacing seawater — much like an ice cube in a full glass. When it melts, it contributes very little to sea-level rise.

Land-based ice, by contrast — the vast ice sheets sitting on Greenland and Antarctica — is the real concern. When this ice melts, the water is added to the ocean for the first time, and sea level rises as a direct result.

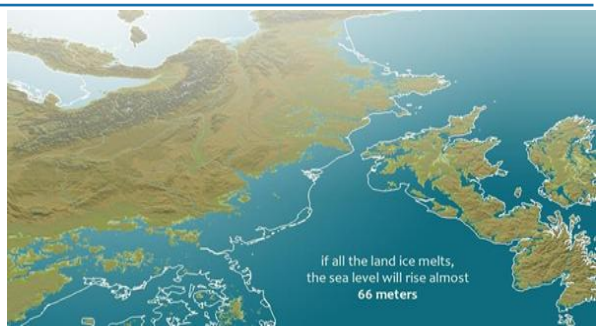

Fig 1. *Shows if all land-based ice on Earth melted, global sea level would eventually rise by roughly 65–66 metres — but the planet would not be fully submerged.* A Slow-Motion Process, Not a Sudden Flood

How Much Would Sea Level Actually Rise?

According to NASA, if all the ice in Greenland and Antarctica melted completely, global sea level would eventually rise by around 65 metres (about 215 feet). Greenland's ice alone holds enough water to raise sea level by roughly 7 metres.

shape of the coastline — river deltas, low coastal plains, and many major cities would be submerged or severely affected, while highlands remain untouched.

A Slow-Motion Process, not a Sudden Flood

This is perhaps the most important point of all: a complete melt of Greenland and Antarctica is not something that could happen within a few years or decades. Ice sheets are enormous, and their response to warming plays out over centuries to millennia — a timescale the IPCC stresses when discussing large, multi-metre sea-level changes.

Even so, both ice sheets are already losing mass today, as confirmed by continuous satellite observation. Current scientific projections fall far short of the 65-metre extreme:

Time horizon	Projected global sea-level rise
By 2050	≈ 0.18 – 0.23 m
By 2100	≈ 0.28 – 1.01 m
By 2150	≈ 0.37 – 1.88 m
By 2300	Potentially several metres under very high warming
Complete Greenland + Antarctic melt	≈ 65 m, over far longer timescales

The practical concern, in other words, is not a hypothetical 65-metre wall of water — it is the much smaller rises already in

motion, which are enough to intensify flooding during storms, cyclones, and unusually high tides

Which Places are Most at Risk?

Sea-level rise does not need to submerge a city outright to cause serious harm. Even half a metre to a metre of rise can sharply increase flooding during cyclones and storm surges — and some regions are far more exposed than others.

India's Most Vulnerable Coastlines

India's coastline includes some of the world's most exposed geography, particularly its river deltas, which are flat and only slightly above sea level. The regions of greatest concern include:

- The Sundarbans and the Ganges–Brahmaputra delta
- The Kolkata region
- Mumbai and its surrounding low-lying coastline
- Chennai and coastal Tamil Nadu
- Kochi and parts of Kerala
- Coastal districts of Odisha, Andhra Pradesh, and Gujarat

not uniform worldwide — gravity, ocean circulation, and land movement mean local sea level can rise faster or slower than the global average.

Chennai: A Case Study in Coastal Vulnerability

Chennai is a useful example precisely because it is a low-lying coastal city, but its risk unfolds gradually rather than all at once:

Sea-level rise	Likely effect on Chennai
+1 m	More frequent coastal flooding during cyclones and high tides; saltwater intrusion into groundwater begins.
+2 m	Considerably more frequent flooding; drainage problems in low-lying coastal neighbourhoods and backwaters.
+5 m	Coastline moves substantially inland; some areas become difficult to inhabit without major protection.
+10 m	A catastrophic hypothetical scenario with extensive inundation of low-lying areas; higher ground remains safe.

India would not disappear — but its coastline, and the millions of people living along it, would be transformed.

The realistic sequence of impact tends to follow a pattern: more frequent high-tide flooding, worsening storm-surge damage, rising groundwater salinity, and — eventually, in the worst-affected pockets — the need for relocation or major coastal defences.

Fig.2: Rising heat, drought, stronger storms, wildfire, and melting ice are interconnected symptoms of the same underlying trend: human-driven climate change.

Why is this Happening?

unequivocally caused global warming. That warming, in turn, drives the ice loss, sea-level rise, and extreme weather described above.

The Greenhouse Gases Behind the Trend

Gas	Major sources
Carbon dioxide (CO_2)	Coal, oil, natural gas, cement production, deforestation
Methane (CH_4)	Agriculture, livestock, rice cultivation, landfills, oil and gas
Nitrous oxide (N_2O)	Fertilizers and agriculture
Fluorinated gases	Refrigeration and industry
Water vapour	Mainly a feedback effect that increases as the atmosphere warms

CO_2 from fossil-fuel combustion remains the dominant driver, compounded by land-use change and unsustainable patterns of consumption and production.

Why the Change Feels More Noticeable Now

Several reinforcing factors explain why climate impacts feel more pronounced today than in previous decades:

- Co_2 persists in the atmosphere for a long time, so decades of emissions accumulate.
- Fossil fuels still dominate electricity, transport, industry, and buildings worldwide.
- Deforestation reduces the planet's capacity to absorb CO_2 while releasing stored carbon.
- Urbanisation creates heat islands, as concrete and asphalt absorb and retain heat.
- Agriculture — especially livestock, rice cultivation, and fertilizer use — adds methane and nitrous oxide.
- Feedback loops reinforce warming: melting ice exposes darker surfaces that absorb more heat, and drying vegetation raises wildfire risk, releasing yet more CO_2.

What the Future May Hold

The future of the climate is not predetermined — it depends heavily on how quickly greenhouse-gas emissions are reduced. The IPCC is clear that continued emissions will drive further warming, while deep and rapid cuts can slow that trajectory.

Area	Possible future change
Temperature	More frequent and intense heat waves
Rainfall	More irregular and intense precipitation
Floods & drought	Increased risk, often in the same regions at different times
Agriculture	Crop stress and shifting growing seasons
Glaciers & sea level	Continued retreat and continued rise
Coastal areas	More flooding, erosion, and infrastructure damage
Health & economy	Heat stress, climate-sensitive disease, rising disaster losses

every additional increment of warming increases risk.

Can the Situation Still Be Controlled?

Yes — but action needs to be rapid. Because of inertia in the climate system, some further warming and sea-level rise cannot be avoided even with immediate emission cuts. What remains firmly within human control is the magnitude of change still to come. The IPCC states plainly that limiting warming requires reaching net-zero CO_2 emissions, with the reductions made this decade especially consequential.

Mitigation: Preventing Further Change

- Shift from coal, oil, and gas toward solar, wind, hydro, and other low-carbon energy.
- Improve energy efficiency through better appliances, lighting, motors, buildings, and smart grids.
- Electrify transport — electric vehicles, public transit, rail, and cycling infrastructure.
- Protect and restore forests instead of clearing them.
- Modernise agriculture through efficient fertilizer use, better irrigation, and soil-carbon management.
- Reduce waste through the reduce–reuse–recycle–recover cycle, cutting landfill methane.

Adaptation: Preparing for What Cannot Be Avoided

Even with strong emission cuts, some climate change is already locked in, making adaptation essential:

- Floods: restore wetlands, expand storm-water drainage, protect floodplains, strengthen early warning.
- Coasts: map flood risk, restore mangroves, build flood-resistant infrastructure, and plan relocation where protec-

tion is impractical.

- **Heat waves:** heat-action plans, cooling centres, urban tree cover, cool roofs, adjusted working hours.
- **Drought:** rainwater harvesting, groundwater recharge, drip irrigation, drought-resistant crops.
- **Agriculture:** heat-, drought-, and flood-tolerant crop varieties, precision irrigation, weather advisories.

Building Resilience: A Coastal Protection Roadmap for India

India already has a foundation to build on: the Indian National Centre for Ocean Information Services (INCOIS) has produced coastal-vulnerability maps for cities including Chennai, Mumbai, and Kolkata, and the Survey of India has demarcated a hazard line that accounts for flooding, sea-level rise, and shoreline change. A phased, decades-long strategy could look like this:

Phase 1 (2026–2035): Know the Risk, Stop Making It Worse

Map every coastal settlement using high-resolution elevation data; create a national coastal risk-zone classification; restrict new construction in the highest-risk zones; protect mangroves, wetlands, and dunes; and upgrade cyclone and flood early-warning systems.

Phase 2 (2035–2050): Protect the People

Develop city-specific protection plans for Mumbai, Chennai, Kolkata, Kochi, Surat, and Visakhapatnam — combining raised roads, flood gates, pumping stations, and wetland restoration rather than a single nationwide design. The guiding principle: not every location needs a seawall, and some are better served by natural buffers.

Phase 3 (2050–2075): Prepare for Permanent Change

Classify communities into those that should be protected permanently, those that can adapt through modified housing and drainage, and those that will need gradual, planned relocation — complete with new housing, livelihoods, schools, healthcare, and transport, rather than forced displacement after a disaster.

Phase 4 (2075–2100): Long-Term Coastal Transformation

By this stage, each settlement's outlook should be reassessed continuously against one question: can this community be safely protected for the next century? If yes, invest in protection and adaptation; if no, relocate gradually rather than repeatedly rebuilding after each flood.

Natural Defences and the Hidden Threat of Saltwater

Mangrove forests reduce wave energy, slow water, limit erosion, and protect communities — making mangrove restoration one of the highest-value investments available. Sea-level rise also threatens fresh water directly, as saltwater intrudes into groundwater and agricultural soil, reducing crop yields. Vulnerable districts need freshwater storage, rainwater harvesting, groundwater monitoring, and — where appropriate — desalination and salt-tolerant crops.

Coastal cities also face a compounding "three-water prob-lem": heavy monsoon rain, swollen rivers, high tides, and storm surge can all arrive at once, overwhelming drainage that was designed for the sea alone. Effective coastal protection therefore has to include river and urban drainage management, not just seawalls.

What individuals and families can Do??

Preparedness is not only a matter of national policy. Families in vulnerable coastal areas benefit from keeping emergency drinking water, basic medicines, a torch, a power bank, important documents, emergency food, and a battery-powered radio on hand, along with knowledge of the nearest cyclone shelter. Ahead of a cyclone or flood, the guidance is simple: do not wait until water enters the house — follow official warnings and evacuate early. For anyone buying or building in a coastal area, checking elevation and flood history — and asking what the risk might look like 30 to 50 years from now — is essential.

CONCLUSION:

A Connected Chain of Consequences

Climate change is best understood not as a single temperature problem but as a connected chain of cause and effect: rising greenhouse gases drive higher global temperatures; that warms oceans and melts glaciers and ice sheets; sea levels rise and atmospheric circulation shifts; rainfall patterns change; heat waves, floods, droughts, and cyclones intensify; and agriculture, water supplies, health, biodiversity, and economies all feel the effects in turn.

delay increases future losses and makes adaptation harder. Humanity cannot stop climate change immediately, but it can strongly influence how severe it ultimately becomes. For India, and for coastal regions everywhere, the most effective strategy combines rapid emission reduction, ecosystem restoration, climate-resilient infrastructure, early-warning systems, and careful, forward-looking land-use planning.

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