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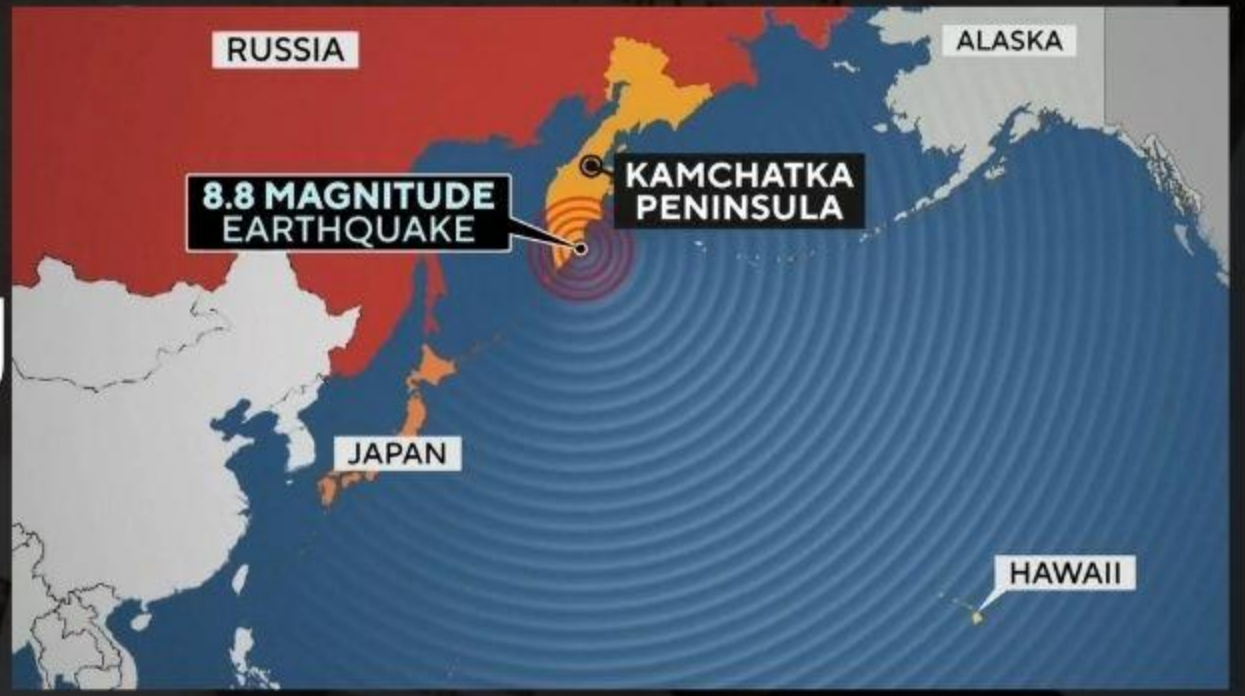
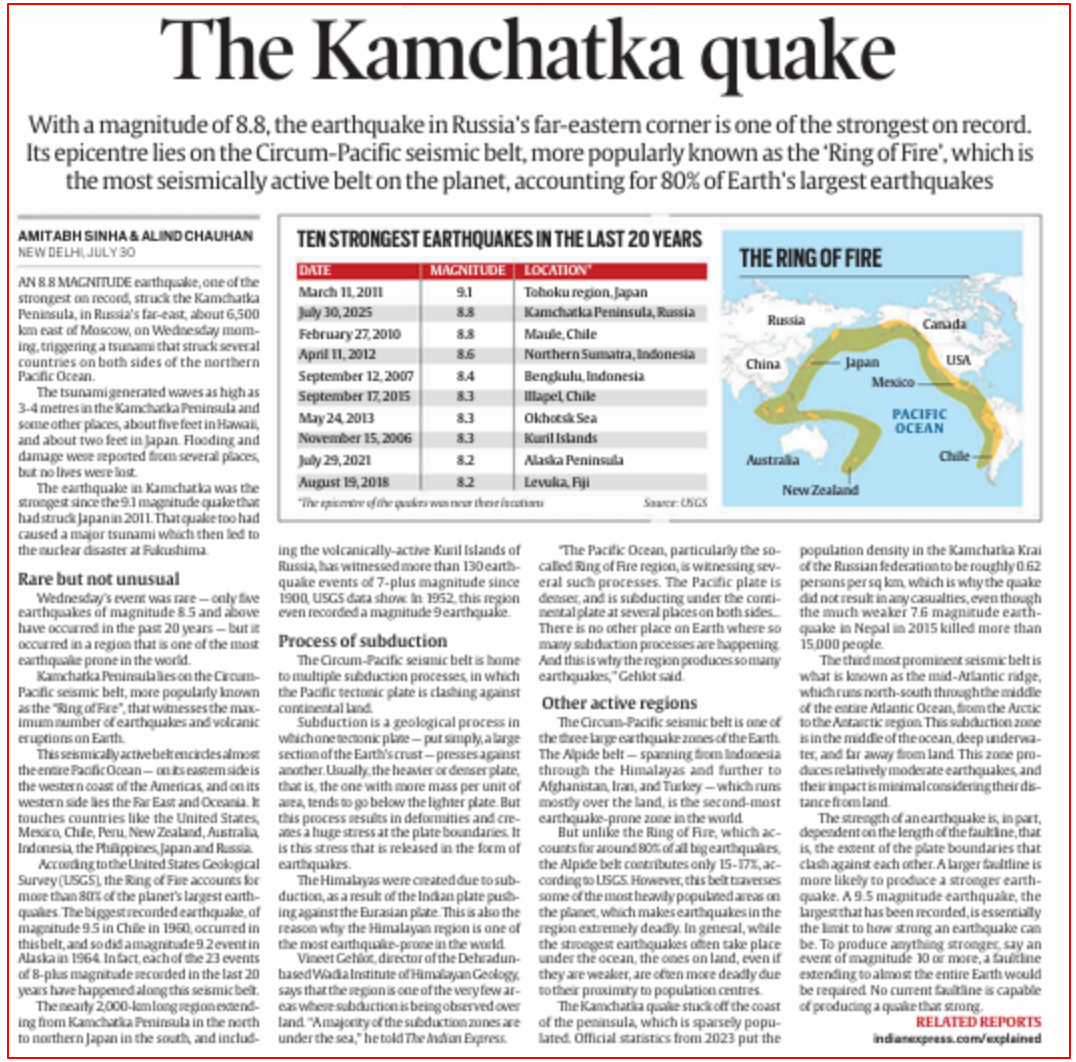
THE HINDU ANALYSIS

31 JULY 2025



8.8 MAGNITUDE EARTHQUAKE IN RUSSIA

The Kamchatka Quake



The Kamchatka quake

With a magnitude of 8.8, the earthquake in Russia's far-eastern corner is one of the strongest on record. Its epicentre lies on the Circum-Pacific seismic belt, more popularly known as the 'Ring of Fire', which is the most seismically active belt on the planet, accounting for 80% of Earth's largest earthquakes

AMITABH SINHA & ALIND CHAUHAN
NEW DELHI, JULY 30

AN 8.8 MAGNITUDE earthquake, one of the strongest on record, struck the Kamchatka Peninsula, in Russia's far-east, about 6,500 km east of Moscow, on Wednesday morning, triggering a tsunami that struck several countries on both sides of the northern Pacific Ocean.

The tsunami generated waves as high as 3-4 metres in the Kamchatka Peninsula and some other places, about five feet in Hawaii, and about two feet in Japan. Flooding and damage were reported from several places, but no lives were lost.

The earthquake in Kamchatka was the strongest since the 9.1 magnitude quake that had struck Japan in 2011. That quake too had caused a major tsunami which then led to the nuclear disaster at Fukushima.

Rare but not unusual

Wednesday's event was rare — only five earthquakes of magnitude 8.5 and above have occurred in the past 20 years — but it occurred in a region that is one of the most earthquake prone in the world.

Kamchatka Peninsula lies on the Circum-Pacific seismic belt, more popularly known as the "Ring of Fire", that witnesses the maximum number of earthquakes and volcanic eruptions on Earth.

This seismically active belt encircles almost the entire Pacific Ocean — on its eastern side is the western coast of the Americas, and on its western side lies the Far East and Oceania. It touches countries like the United States, Mexico, Chile, Peru, New Zealand, Australia, Indonesia, the Philippines, Japan and Russia.

According to the United States Geological Survey (USGS), the Ring of Fire accounts for more than 80% of the planet's largest earthquakes. The biggest recorded earthquake, of magnitude 9.5 in Chile in 1960, occurred in this belt, and so did a magnitude 9.2 event in Alaska in 1964. In fact, each of the 23 events of 8-plus magnitude recorded in the last 20 years have happened along this seismic belt.

The nearly 2,000-km long region extending from Kamchatka Peninsula in the north to northern Japan in the south, and including the volcanically-active Kuril Islands of Russia, has witnessed more than 130 earthquake events of 7-plus magnitude since 1900, USGS data show. In 1952, this region even recorded a magnitude 9 earthquake.

Process of subduction

The Circum-Pacific seismic belt is home to multiple subduction processes, in which the Pacific tectonic plate is clashing against continental land.

Subduction is a geological process in which one tectonic plate — put simply, a large section of the Earth's crust — presses against another. Usually, the heavier or denser plate, that is, the one with more mass per unit of area, tends to go below the lighter plate. But this process results in deformities and creates a huge stress at the plate boundaries. It is this stress that is released in the form of earthquakes.

The Himalayas were created due to subduction, as a result of the Indian plate pushing against the Eurasian plate. This is also the reason why the Himalayan region is one of the most earthquake-prone in the world.

Vineet Gehlot, director of the Dehradun-based Wadia Institute of Himalayan Geology, says that the region is one of the very few areas where subduction is being observed over land. "A majority of the subduction zones are under the sea," he told *The Indian Express*.

"The Pacific Ocean, particularly the so-called Ring of Fire region, is witnessing several such processes. The Pacific plate is denser, and is subducting under the continental plate at several places on both sides... There is no other place on Earth where so many subduction processes are happening. And this is why the region produces so many earthquakes," Gehlot said.

Other active regions

The Circum-Pacific seismic belt is one of the three large earthquake zones of the Earth. The Alpide belt — spanning from Indonesia through the Himalayas and further to Afghanistan, Iran, and Turkey — which runs mostly over the land, is the second-most earthquake-prone zone in the world.

But unlike the Ring of Fire, which accounts for around 80% of all big earthquakes, the Alpide belt contributes only 15-17%, according to USGS. However, this belt traverses some of the most heavily populated areas on the planet, which makes earthquakes in the region extremely deadly. In general, while the strongest earthquakes often take place under the ocean, the ones on land, even if they are weaker, are often more deadly due to their proximity to population centres.

The Kamchatka quake struck off the coast of the peninsula, which is sparsely populated. Official statistics from 2023 put the population density in the Kamchatka Krai of the Russian federation to be roughly 0.62 persons per sq km, which is why the quake did not result in any casualties, even though the much weaker 7.6 magnitude earthquake in Nepal in 2015 killed more than 15,000 people.

The third most prominent seismic belt is what is known as the mid-Atlantic ridge, which runs north-south through the middle of the entire Atlantic Ocean, from the Arctic to the Antarctic region. This subduction zone is in the middle of the ocean, deep underwater, and far away from land. This zone produces relatively moderate earthquakes, and their impact is minimal considering their distance from land.

The strength of an earthquake is, in part, dependent on the length of the faultline, that is, the extent of the plate boundaries that clash against each other. A larger faultline is more likely to produce a stronger earthquake. A 9.5 magnitude earthquake, the largest that has been recorded, is essentially the limit to how strong an earthquake can be. To produce anything stronger, say an event of magnitude 10 or more, a faultline extending to almost the entire Earth would be required. No current faultline is capable of producing a quake that strong.

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TEN STRONGEST EARTHQUAKES IN THE LAST 20 YEARS

DATE	MAGNITUDE	LOCATION*
March 11, 2011	9.1	Tohoku region, Japan
July 30, 2025	8.8	Kamchatka Peninsula, Russia
February 27, 2010	8.8	Maule, Chile
April 11, 2012	8.6	Northern Sumatra, Indonesia
September 12, 2007	8.4	Bengkulu, Indonesia
September 17, 2015	8.3	Illapel, Chile
May 24, 2013	8.3	Okhotsk Sea
November 15, 2006	8.3	Kuril Islands
July 29, 2021	8.2	Alaska Peninsula
August 19, 2018	8.2	Levuka, Fiji

*The epicentre of the quakes was near these locations
Source: USGS

Kamchatka Earthquake 2025

- A powerful 8.8 magnitude earthquake struck off the coast of **Russia's Kamchatka Peninsula,** leading to widespread tsunami warnings across the Pacific.
- The quake, centered 119 km southeast of **Petropavlovsk-Kamchatsky** at a shallow depth of 19.3 km, was initially reported as 8.0 but later upgraded.
- It was followed by a strong 6.9 aftershock. This marks the strongest global quake since Japan's devastating 9.0 magnitude earthquake in March 2011 that triggered the **Fukushima nuclear disaster.**

Understanding Earthquake Magnitude and Measurement

- The 8.8 magnitude **earthquake off Kamchatka** is classified as a great earthquake, a rare event globally.
- According to the US Geological Survey (USGS), earthquakes of this scale release immense energy — with each whole-number increase in magnitude corresponding to roughly 31.6 times more seismic energy.
- For instance, the Kamchatka quake released over **30 times more energy than Myanmar's 7.7 magnitude** quake in March 2024.
- While **"magnitude"** refers to the measured energy released by an earthquake, "intensity" describes the perceived shaking at specific locations.
- Earthquake movements are recorded using a **seismograph**, which tracks the relative motion between the Earth's surface and a suspended mass to determine seismic activity.

Kamchatka: A High-Risk Seismic Zone

- The Kamchatka Peninsula in Russia's Far East is one of the world's most earthquake-prone regions.
- This 1,250-km landmass has witnessed several powerful quakes in recent history — including those in 2020, 2006, 1959, 1952, and 1923 — many of which triggered tsunamis.

Frequent Earthquakes Fuelled by Tectonic Plate Movements

- The region's high seismic activity is due to the subduction of the Pacific Plate beneath the Okhotsk microplate.
- Subduction is a geological process where a denser tectonic plate slides beneath a lighter one, causing stress at plate boundaries.
- This stress, when released, results in earthquakes.
- The Himalayas were formed by the Indian plate pushing under the Eurasian plate through subduction, making the region highly earthquake-prone.

Pacific Ocean's Ring of Fire

- The Kamchatka Peninsula is part of the Pacific Ocean's Ring of Fire, a horseshoe-shaped **belt of intense seismic and volcanic activity** encircling the Pacific Plate.

- Stretching over 40,000 km, this zone marks the boundaries of multiple tectonic plates — including the Eurasian, North American, Indian, Australian, and others — making it one of the **most geologically active regions on Earth.**

- The Ring of Fire spans more than 15 countries, including Russia, Japan, Indonesia, the US, Chile, and the Philippines, all of which **frequently experience earthquakes, volcanic eruptions, and tsunamis** due to constant tectonic movements.

Tectonic Forces Behind the Ring of Fire

- The intense seismic and volcanic activity in the Ring of Fire is driven by constant tectonic plate movement.

- Plates frequently slide past, collide, or subduct beneath one another.

- When rough plate edges get stuck while the rest of the plate continues moving, stress builds up until it suddenly releases, causing an earthquake — as seen in the recent Kamchatka quake and tsunami.

India Needed Structural Transformation

Needed: New drivers of growth

Limits of trade as a pathway to prosperity are evident. To become a developed country by 2047, India needs new economic ideas

ISHAN BAKSHI

RECENT DEVELOPMENTS INIMICAL to India's economic interests, such as China's curbs on the export of rare earths and fertilisers, and the reported withdrawal of engineers and technicians working on Foxconn's iPhone plants, raise the question: How should India respond? Any immediate response will most likely be geared towards ensuring that supply chain disruptions are minimal. Beyond that, however, there is a larger question. Will shifts in the global order, changes to the trading architecture and the weaponisation of trade, the growing economic imbalance between India and China and Delhi's economic and strategic realities, be the trigger for much-needed and far-reaching changes in the policy architecture? Will they spawn a new development compact, one that places growth and development front and centre?

Looking back, growth has not always been the top priority. Post-independence, the overriding objective was to ensure the stability of the Union. Partition and the integration of princely states created the ground for veering towards a strong Centre that promised stability. The constraining impulses of the Constitution also flow from this intent. To ensure that the compact held, deals were struck with various pressure groups over the decades. A strong Centre also complemented the overly centralised planning model adopted by governments in matters of economic policy. Sluggish growth over the years did not prompt a rethink of either approach or priorities. While some pro-business policy changes were introduced in the 1980s, increasing economic efficiency was not the predominant objective. As Dani Rodrik and Arvind Subramanian have argued, these changes were less about the economy and more about "garnering political support from nascent business groups".

This framework, however, did not deliver prosperity. Growth was anaemic and poverty was widespread. The crisis in 1991 created the space for a new compact where growth became the overriding objective. Economist Stefan Dercon has argued that the policy shift in the 1990s was a decisive step towards a development bargain. Dercon views development bargain as a commitment by those who wield power — the country's political and economic elite — "to shape politics, the economy and society to strive for growth and development".

This bargain — formalised at a time when the political system was transitioning away from a period of one-party dominance to an era of coalitions where power was less concentrated at the Centre — had buy-in from parties across the political spectrum. With a broad consensus on the nature of policies to be pursued, subsequent governments stayed the course. The NDA government under Atal Bihari Vajpayee doubled down on the reforms push, and the UPA under Manmohan Singh trod along the path while adding a slew of welfare programmes to ensure the stability of the compact.

This period coincided with the high noon of globalisation — a time when the rising tide of global trade lifted all boats. The pace of poverty decline accelerated and new pathways to upward mobility emerged. Investment activities gathered steam, exports surged, capital inflows soared and millions moved out of agriculture. While growth did slow down sharply during the UPA's second term, in large part due to policy transition, steps were taken during its initial years to arrest the decline.

In the run-up to the 2014 election, the overriding concern was to shore up the economic momentum. The BJP's rise to power was largely on the back of a promise to provide good governance and ensure high growth and development. The shift from a coalition era to one where a single party commanded a full majority was also taken as a sign that the pulls and pressures from allies would no longer be a hindrance in fulfilling the compact, which could now be pursued aggressively. The first few years of the new government did see crucial steps being taken to reward the loyal. There was also a continuity in ideas — ideas that were birthed in earlier governments such as inflation targeting and GST found resonance.

Somewhere along the way, however, the growth impetus weakened. The pandemic made matters worse. And as inequality rose and pathways for upward mobility shrivelled, the compact shaped by the political class pivoted towards populism. Cash transfers, tax giveaways and other populist schemes became the norm across political parties and governments as short-term electoral considerations took precedence over longer-term economic benefits. Few fresh ideas were articulated to reinforce the compact. Perhaps the Production-Linked Incentive Scheme and the sustained strategy of promoting a handful of private firms as national champions can be considered new ideas. Even then, the limits of both were apparent.

This weakening of the consensus around the compact comes at a time of significant changes in the global order. In the Trumpian era, trade, a pathway for many nations — from Bangladesh to Vietnam — to climb the ladder of prosperity has become acausality. At the time, when the tailwinds of "hyper" globalisation are no longer available, a strategy to rely just on trade deals with the developed world, but not seek deeper integration with countries at the heart of global supply chains, will limit the gains that are being envisaged. Alongside, the rapid adoption of AI will impact large swathes of IT jobs. Considering that the IT sector has provided millions with pathways to upward mobility — the great Indian middle class grew on the back of this sector — a new driver of growth are needed.

This new reality is at odds with hopes that the country will become a developed nation by 2047. That goal, in any case, is a tall order, if the economic history of the world is anything to go by. Only a handful of countries have managed to ascend to the high-income category. And even if India manages to sustain its growth over the coming two decades — per capita income has grown at 5.7 per cent in dollar terms over the past 10 years — then average income would be just shy of $18,000 in 2047. The question is whether this or higher growth can be achieved.

Growth does not miraculously endure. It isn't easy to sustain the momentum over such long periods without a development bargain and without an elite compact. Unless that happens, the goal of becoming a developed country will remain elusive.

ishan.bakshi@expressindia.com

Context

- Recent developments such as **China's restrictions on rare earth exports** and the withdrawal of Western chipmakers from China have reignited debates on India's economic direction and overdependence on trade-led growth.

India’s Development Trajectory Must Diversify Beyond Trade-Led Growth

- India’s current growth model largely relies on exports, especially in services. However, global trade is witnessing a deceleration post-2010s due to rising protectionism, technological fragmentation, and strategic decoupling.

- Global tensions, e.g., US-China rivalry, expose the fragility of a trade-centric development model. India’s integration into global value chains (GVCs) may remain constrained due to geopolitics and structural limitations.

Structural Challenges in India’s Growth Model

- Unlike China and East Asian economies, India has struggled to build a strong industrial base or create large-scale employment via manufacturing.

- Post-1991 liberalization yielded pockets of prosperity, but core issues like informal employment, underemployment, and agrarian distress remain persistent.

- India continues to face inefficiencies in governance, public service delivery, and state capacity, which hampers equitable and sustainable growth.

Socioeconomic Impacts of a Limited Growth Model

- Trade and capital-intensive growth have failed to generate mass employment, leading to wealth concentration and rising rural-urban divides.
- Education, healthcare, and skill development are not keeping pace with population needs, limiting upward mobility for large sections of the population.

Reorienting India's Development Path

- Investment in public health, education, and nutrition is critical to build a healthy, productive workforce capable of supporting long-term growth.
- Greater institutional efficiency, decentralization, and fiscal empowerment of state governments are necessary to implement grassroots-level reforms.
- India must promote industrial deepening through targeted support to MSMEs, green energy sectors, and domestic R&D innovation.
- Sustainable and well-planned urbanization can become a driver of job creation and economic clustering, as seen in global examples.

Police Reforms

India's police must get out of Dirty Harry's shadow

K. Ashok Vardhan Shetty

is a retired IAS officer and a former Vice-Chancellor of the Indian Maritime University, Chennai

It is time for a policing reset where human dignity and professionalism replace fear, coercion and the illusion of quick justice

Imagine a crime scene, where two detectives arrive. The first person is Sherlock Holmes, who is calm, meticulous and relentlessly logical. He sees what others overlook, asks things that others miss, and lets logic and evidence guide every step. He knows that the truth cannot be extracted by force and that it must be uncovered through careful, patient investigation.

The other person is Dirty Harry, gruff, impatient and contemptuous of rules. He does not investigate; he intimidates. He does not gather evidence; he extracts confessions. For him, justice is about speed, not accuracy, even if it leaves behind broken bodies and ruined lives.

These are not just fictional characters. They represent two conflicting visions of policing in India. The question is this. In the fight against crime, do we want a Sherlock Holmes or a Dirty Harry in our police stations?

A culture of impunity

The custodial death of Ajith Kumar, a 27-year-old temple guard, in June, in Tamil Nadu, is a grim reminder of the perils of the Dirty Harry-style of policing. The case (which involved missing jewellery from a car) happened just months after the Tamil Nadu Police Commission had recommended, among other things, a series of reforms to curb custodial torture.

According to a 2023 Lok Sabha reply, 687 people had died in police custody across India between 2018-19 and 2022-23, which is an average of two to three deaths every week. The data showed that these States had the highest numbers – Gujarat (80), Maharashtra (80), Madhya Pradesh (50), Bihar (47), Uttar Pradesh (41), West Bengal (40), and Tamil Nadu (36).

Official figures conceal more than they reveal. Many custodial deaths are quietly labelled as suicides, accidents, or sudden illnesses. Torture often occurs off the record – beyond lockups and CCTV surveillance. In Ajith Kumar's case, it reportedly happened in police vans, abandoned buildings, a village tank bed, and in a cow shed behind a temple.

Custodial violence overwhelmingly targets the daily-wage worker, the migrant, the slum dweller, the Dalit, and the tribal. So, torture is not just bad policing. It is structural injustice that reflects and reinforces the entrenched hierarchies of caste, class and power.

Torture persists due to inadequate training especially for the public-facing constabulary that makes up 90% of the police force alongside poor infrastructure, pressure to deliver quick results, and weak institutional oversight. Disciplinary action is rare and criminal convictions rarer still.

More troubling is societal tolerance of custodial violence, which normalises the abuse, turning crime into the routine and impunity into unofficial policy.

In *D.K. Basu* (1996), the Supreme Court of India had laid down detailed safeguards against custodial torture. In *K.S. Puttaswamy* (2017), it reaffirmed dignity and bodily autonomy as fundamental rights. Yet, torture remains rampant. The Law Commission of India's 273rd Report (2017) urged Parliament to enact a standalone anti-torture law, but no such law exists. India has yet to ratify the United Nations Convention Against Torture. In 2025, India was ranked a "high-risk" country in the Global Torture Index – a searing indictment we can no longer ignore.

On research and real world examples

The case against torture is not just moral or legal. It is scientific. Torture is often mythologised as a necessary evil – the quick fix when time is short and lives are at stake. Films and television shows often portray a suspect cracking under pressure, revealing the truth just in time. But decades of scientific research and real-world evidence tell a very different story.

In *Why Torture Doesn't Work: The Neuroscience of Interrogation* (2015), neuroscientist Shane O'Mara explains that torture impairs the brain's prefrontal cortex and hippocampus, the very regions essential for memory and clarity. Victims become disoriented, incoherent, and cognitively impaired; they will say anything, even lie, just to end the pain.

Experience bears this out. During the Algerian War (1954-62), French forces used torture extensively, only to find that much of the intelligence gathered from Algerian insurgents was useless or led to dead ends. In 2007, the International Committee of the Red Cross found that detainees from CIA "black sites" had confessed only to end their suffering, producing false or unusable information. In the United States, the Innocence Project used DNA evidence to overturn over 375 wrongful convictions, many based on coerced confessions. In Ajith Kumar's case, the victim 'confessed' to hiding jewels in a cowshed – not because it was true, but because he wanted the beatings to stop.

The CIA's now-infamous "enhanced interrogation techniques" – waterboarding, stress positions, sleep deprivation – were debunked in the U.S. Senate Intelligence Committee Report (2014). The 525-page partially redacted summary (from a 6,700-page report), based on classified CIA documents, concluded that these methods failed to yield actionable intelligence against al Qaeda. Worse, the time wasted chasing false leads had diverted attention from actual threats. So, what works? According to a Netflix documentary "American Manhunt: Osama bin Laden", the vital lead (the courier who led the U.S. to bin Laden) was uncovered through good, old-fashioned detective work – non-coercive intelligence gathering, surveillance, and methodical analysis.

After the wrongful conviction of six men in the 1974 Birmingham pub bombings, the U.K. abandoned confession-based policing. It adopted the PEACE model (Preparation and Planning, Engage and Explain, Account, Closure, and Evaluation) that focused on building rapport and trust with a suspect, open-ended questioning, active listening, and video recording of the interviews. This model reduced false confessions, improved conviction accuracy and restored public trust. Countries such as Norway, Canada and New Zealand have adopted it with similar success. The European Committee for the Prevention of Torture (CPT) has endorsed it.

Post-9/11, the High-Value Detainee Interrogation Group (HIG), a joint initiative of the FBI, the CIA, and the Department of Defence, undertook extensive research on interrogation techniques. Its peer-reviewed studies confirmed that non-coercive, rapport-based methods consistently outperformed torture in producing accurate, timely, and actionable intelligence.

In Norway, far-right terrorist Anders Breivik, who killed 77 people in 2011, was interrogated without threats or coercion. The police's calm, professional approach led to a full confession and valuable insights into extremist networks, demonstrating that even the most heinous crimes do not justify abandoning legal principles. In the U.S., Najibullah Zazi, who plotted the 2009 New York subway bombing, cooperated with the FBI after being treated with respect. His detailed disclosures helped dismantle a wider terror network.

Holmes, not Harry

The core issue is that this is not a debate about policing. It is a test of our democratic maturity. The law must protect the most vulnerable, not brutalise them. Every custodial beating is not just a wound on the body of a citizen. It is a stain on the soul of the state. India must immediately ratify the UN Convention Against Torture and enact a standalone anti-torture law. All States should embed the PEACE model into police training, and declare zero tolerance for custodial abuse. When Sherlock Holmes's methods succeed in reality – not just in fiction – why should India cling to Dirty Harry's shadow?

Context

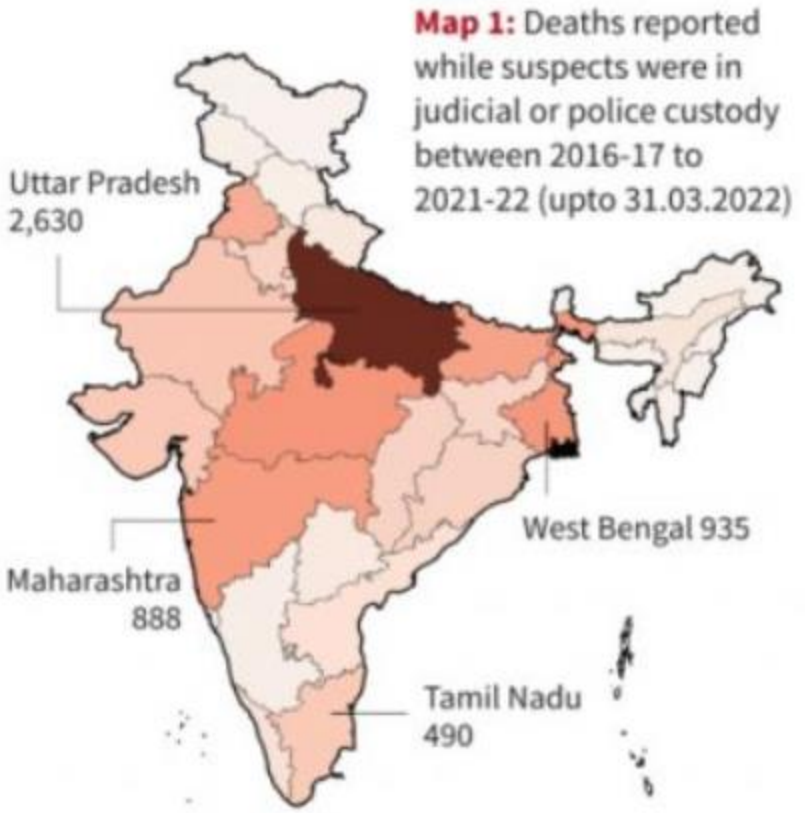
- The custodial death of Ajith Kumar in Tamil Nadu in June 2025 has sparked renewed calls for police accountability and anti-torture legislation in India.

Systemic Nature of Custodial Violence

- According to a 2023 Lok Sabha reply, 687 custodial deaths occurred between 2018–19 and 2022–23, with states like **Gujarat, Maharashtra, and Tamil Nadu** topping the list. Many deaths are misreported as suicides or accidents, masking the scale of abuse.

- **Marginalised Groups as Victims** Custodial torture disproportionately targets daily-wage workers, Dalits, Adivasis, and migrants, reflecting entrenched hierarchies of caste and class. Torture thus becomes not just a policing issue, but a manifestation of structural injustice.

- With 90% of the police force comprising constables **lacking adequate training, coupled with institutional apathy** and pressure for swift results, disciplinary action remains minimal and convictions almost nonexistent.



Legal and Institutional Deficit

- The Supreme Court in ***K. Basu v. State of West Bengal (1996)*** laid down procedural safeguards, and in ***K.S. Puttaswamy (2017)*** upheld the right to bodily autonomy. Yet, compliance remains weak.

- The **Law Commission's 273rd Report (2017)** recommended a standalone anti-torture law. However, no such legislation has been enacted, and India has not ratified the United Nations Convention Against Torture (UNCAT).

- In 2025, India was ranked as a **"high-risk" country** in the Global Torture Index, indicating international concern over persistent custodial abuse and state inaction on accountability.

- A mature democracy must ensure that **policing upholds constitutional values.**

- The use of Sherlock Holmes–like evidence-based methods must replace Dirty Harry–style brutality rooted in impunity and secrecy.

Restoring Mangroves

Restoring mangroves can turn the tide on India's coastal security

In spite of mounting threats to mangroves, India is also the epicentre of a number of inspiring efforts to protect and revive mangrove ecosystems; with the right mix of stewardship, scientific support, and policy attention, they are showing that mangroves can not only survive, but also thrive

Priya Ranganathan

Across India's coasts, from the languid channels of the Sundarbans delta to Mumbai's stifled creeks, mangroves form a barrier between land and sea. These coastal forests are critical in India's pursuit of climate resilience, biodiversity conservation, and the empowerment of coastal communities.

However, in the face of urban expansion, climate change, and development, how are India's mangroves surviving – and who is protecting them?

Mangroves matter

Mangrove swamps are forested wetlands characterised by trees that can tolerate saline water. They serve as natural barriers, protecting coastal communities from cyclones, tidal surges, and erosion. During natural disasters like the 2004 Indian Ocean tsunami and recurring cyclones in the Bay of Bengal, mangroves have been known to attenuate damage to coastal infrastructure and biodiversity and have saved thousands of lives.

Their role in biodiversity conservation is significant as well. Mangroves provide breeding and nursery grounds for fish, crustaceans, molluscs, and migratory birds. These salt-tolerant forests also store significant amounts of blue carbon (the carbon captured by marine and coastal ecosystems), helping mitigate climate change by trapping carbon dioxide from the atmosphere in their roots and soil.

The mangroves of India cover more than 4,900 sq. km, including estuaries, deltas, and the coasts of West Bengal, Odisha, Tamil Nadu, Gujarat, and Karnataka, among other States. For coastal communities, especially traditional fishers and honey gatherers, mangroves are intimately linked to livelihoods and cultural practices.

Yet they are increasingly threatened by urban expansion, aquaculture, pollution, and changing climate patterns. This isn't the case in India alone: around the world, more than half of all mangrove ecosystems are at risk of collapse by

Mangrove swamps are forested wetlands characterised by trees that can tolerate saline water. They serve as natural barriers, protecting coastal communities from cyclones, tidal surges, and erosion. DIVYANSHU PANWAR

hectares between 2021 and 2024 – and has been leading coastal ecosystem recovery in India. In early 2017, the M.S. Swaminathan Research Foundation in Chennai, in collaboration with local village committees and the Tamil Nadu Forest Department, began a project to restore 115 hectares of degraded

Efforts to restore mangroves in Tamil Nadu have seen remarkable progress. Once severely degraded by shrimp farming, pollution, and altered hydrology, the State's estuaries are witnessing a steady comeback

Shoreline Habitats and Tangible Incomes scheme, which was launched on World Environment Day 2023.Under this scheme, Gujarat has planted more than 19,000 hectares of mangroves in two years, surpassing the Central government's planned five-year target of 54,000 hectares.

CONTEXT

- India has witnessed notable mangrove restoration efforts across **Tamil Nadu, Gujarat, and Maharashtra**, aimed at enhancing coastal resilience and biodiversity amid rising climate and urban threats.

Mangroves and Coastal Ecosystem Conservation

Ecological Significance

- Mangroves are intertidal forests found in tropical and subtropical tidal areas.
- They serve as natural buffers against cyclones, tsunamis, and tidal surges.
- Act as breeding and nursery habitats for fish, crustaceans, and birds.
- Trap and store significant amounts of *blue carbon* in biomass and soil.

Climate Resilience Role

- During the 2004 Indian Ocean tsunami and cyclonic events in the Bay of Bengal, mangroves significantly mitigated damage and saved lives.
- Reduce coastal erosion and salinisation of coastal agricultural lands.

Livelihood and Cultural Relevance

- Integral to the sustenance of traditional fisherfolk and honey gatherers.
- Support ecotourism and small-scale fisheries in coastal belts.

Restoration Efforts Across States

Tamil Nadu Initiatives

- **Green Tamil Nadu Mission** and other coastal schemes have nearly doubled mangrove cover from 4,500 to over 9,000 hectares between 2021–2024.
- Restoration in Muthupettai Estuary and Kazhipattur region focused on community engagement, canal dredging, and removal of invasive species.
- Use of native species like *Avicennia marina* and *Rhizophora*.

Maharashtra (Mumbai) Project

- Partnership of Amazon's Right Now Climate Fund, Hasten Regeneration, and BMC to revive mangroves at Thane Creek.
- Introduction of **trash booms** to prevent plastic inflow.
- Plan to plant 3.75 lakh saplings and support women through employment.

Gujarat's Lead Role

- Under **MISHTI** (Mangrove Initiative for Shoreline Habitats & Tangible Incomes), Gujarat has planted over 19,000 hectares in two years.
- Surpassed Central targets using scientific coastal mapping.
- Accounts for 23.6% of India's mangrove cover.

NISAR Satellite

ISRO-NASA satellite placed in orbit, to map Earth in detail

ISRO's launch vehicle GSLV-F16 carrying NISAR, the first joint India-US satellite, lifts off from Sriharikota, Wednesday. *PTI*

ANONNA DUTT
NEW DELHI, JULY 30

IN ITS most significant launch since the Moon-landing Chandrayaan-3 in 2023, the Indian Space Research Organisation (ISRO) on Wednesday placed NISAR satellite, a first-of-its-kind collaborative project between India and the US, into its intended orbit.

NISAR, which stands for NASA-ISRO Synthetic Aperture Radar, is the most powerful Earth observation satellite to be put in space, the result of over one decade of research and development by the space agencies of India and the US.

The uniqueness of the satellite lies in the fact that it carries two Synthetic Aperture Radars (SARs) of different frequencies that are designed to work together to produce some of the most detailed images of the Earth ever captured from space. SARs are imaging equipment that use the non-visible microwave radiation to create pictures of the Earth from space. Never before have two SARs been mounted on a single satellite.

The NISAR satellite flew on a GSLV rocket launched from Sriharikota Wednesday evening. The satellite was deposited in the Sun Synchronous Polar Orbit (SSPO), about 747 km from the Earth, within 19 minutes of the launch. This was the first time

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• ISRO-NASA satellite placed in orbit, to map Earth in detail

that ISRO used its powerful GSLV rocket to drop a satellite in the SSPO. Usually, the PSLV rocket is used to access these orbits, but NISAR satellite was too heavy to be handled by PSLV. In fact, at 2,392 kgs, NISAR is the heaviest Earth observation satellite ever.

"This is the first mission to SSPO using the GSLV. Therefore, several analysis and studies were carried out to make it a grand success, including cryogenic upper stage corrections and a host of mission simulations. The vehicle performance today was as expected and predicted," ISRO Chairman V Narayanan said after the launch. This was ISRO's first successful launch since Narayanan took over as chairman in January. Two earlier launches this year were unsuccessful.

NISAR is meant to take high-resolution pictures of the Earth, which will be useful for a wide range of research activities, including in climate change, disaster management, agriculture, forestry and urban planning. The two SARs, working in tandem, can map the terrain in minute detail, and, by repeating their observations in a cyclic fashion, can capture the changes happening at as small a scale as one centimetre.

Narayanan said the satellite was injected just 2 km off the planned orbit. This was a very small difference and much less than the margin of error with which this satellite can perform, he said.

After the injection into orbit, a key event would be the unfurling of a 12-metre foldable antennae. The unfurling will be a slow process to ensure that the delicate system is not damaged during the process. It will start 10 days later and will happen over the next eight days.

To further prepare for the scientific observations, the satellites will complete deployment and testing of all parts over the next 90 days and then carry out calibration and validation over the next five months.

Science Minister Jitendra Singh, who witnessed the launch over video in Delhi because of the ongoing Parliament session, said this was another major achievement of the Indian space establishment, after the spaceflight by Shubhanshu Shukla on the Axiom-4 mission last month.

"This is another collaborative mission with NASA that comes quick on the heels of the ISS mission with astronaut Shubhanshu Shukla. It is one of the biggest collaborations between leading space agencies. Today, we are in a position to be equal partners with NASA, which started much before our space programme," he said.

NISAR satellite would map the entire globe every 12 days, providing a series of detailed images that can have various applications ranging from predicting disasters, helping in rescue efforts afterwards, developing new models for earthquakes and volcanic eruptions, and most importantly studying the impacts of climate change. The mission life of the satellite is five years.

Thank you

Address

B-47, Main Road Shivalik Enclave, Block-B, Shivalik Colony, Malviya Nagar, New Delhi-110017

Phone Number +91 8178833167