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The Hindu Important News Articles & Editorial For UPSC CSE

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India's urgent efforts to reduce air pollution and aerosol emissions, particularly from coal-based power generation, may unintentionally accelerate warming in the short term due to the removal of aerosols that currently mask greenhouse gas (GHG)-induced warming.

- This trade-off highlights the complexity of climate science and policy, especially in regions like India where air quality and climate goals intersect.

India's critical efforts to tackle air pollution could worsen warming

Regions that cleaned their air in the late 20th century have experienced a greater increase in warming trends over time while more populated urban areas with low human development indices have experienced lower levels of warming – due to the masking effect of pollution

Neelima Vallangi

Rapidly reducing aerosol emissions, which are part of air pollution, without concurrently reducing greenhouse gas emissions could expose a large fraction of the world's most vulnerable people to a sudden acceleration of warming and extreme heat in highly polluted regions like India. Researchers warned as much in a study published in November 2024 in *Geophysical Research Letters*.

The analysis found regions that cleaned their air in the late 20th century have experienced a greater increase in warming trends over time, while more populated urban areas with low human development indices have experienced lower levels of warming – due to the masking effect of pollution.

According to Aditya Sengupta, a graduate researcher at the University of Melbourne and first author of the study, abruptly halting the emission of aerosols can also increase the rate of warming on shorter time scales.

The study is particularly relevant for India, which is currently struggling to improve air quality on one hand while trying to stave off the worst of climate change on the other.

Thermal power plants generate 70% of India's electricity by burning coal, which also releases sulphur that can go on to form reflective sulphate aerosols. AP

Greenhouse gases vs. aerosols

Global warming is caused by the build-up of greenhouse gases in the atmosphere and has been known to intensify temperature and rainfall extremes. Aerosols can counteract the impact of greenhouse gases to some extent.

This is because, while greenhouse gases trap heat and warm the earth's surface, aerosols such as sulphates and nitrates scatter solar radiation, preventing it from reaching the ground and rendering a cooling effect. Aerosols also affect the water cycle.

Greenhouse gases are also well mixed in the atmosphere. As a result, their effects, including knock-on ones on the climate, can be felt around the planet. On the other hand, the concentration of aerosols in the atmosphere varies by location and time. Greenhouse gases are also more long-lived – carbon dioxide can persist in the atmosphere without breaking down for centuries – whereas aerosols live for a few days to weeks at a time.

The consequences of changes in the atmosphere's aerosol load can thus be felt almost immediately.

Thermal power

According to Govindasamy Bala, professor at the Centre for Atmospheric and Oceanic Sciences at the Indian Institute of Science, Bengaluru, growing economies and industrialisation go hand in hand with aerosol and fossil-fuel emissions.

In India, thermal power plants generate roughly 70% of the country's electricity by burning coal, which contains some sulphur. "So before the flue gas [exhaust gas from the combustion process] is released to the atmosphere, you have to take out sulphur dioxide at the source to reduce air pollution," Mr. Bala explained.

Sulphate aerosols, which form through the oxidation of sulphur dioxide, are highly reflective and make up 50-60% of the overall aerosol composition in India, in addition to black carbon, dust, and other pollutants, according to Mr. Bala.

Invisible offset

"[O]ur numbers show, if it were not for aerosols, we would experience much greater warming over India," Krishna AchutaRao, dean and professor at the Centre for Atmospheric Sciences, IIT-Delhi, said.

According to him, India warmed by about 0.54° C between 1906 and 2005, with the estimated warming due to greenhouse gases being about 2° C and the cooling offset from other anthropogenic factors about 1.5° C. While most of the cooling is likely from aerosols released by human industrial activity, some cooling is also likely from irrigation, Mr. AchutaRao added.

According to the first-ever assessment of climate change over India published by the Ministry of Earth Sciences in 2020, the country's average temperature rose by around 0.7° C between 1901 and 2018, largely due to greenhouse gas-induced warming, but was partially offset by anthropogenic aerosols and changes in land use.To compare, overall long-term global warming is currently about 1.3° C above pre-industrial times.

Aerosols and rain

Aerosols' effects on rainfall are another matter. "In general, the temperature effect is fairly straightforward: remove aerosols, and it gets warmer," Mr. AchutaRao said. "With precipitation, things are further complicated."

According to Mr. Bala, the global mean cooling is about 0.6° C in the industrial period due to aerosols. But he said, citing a recent Intergovernmental Panel of Climate Change (IPCC) report, that "this cooling is unevenly distributed – in the northern hemisphere, it is 0.9° and in the southern hemisphere it is about 0.3° C. Because of this larger cooling in the northern hemisphere, the actual aerosol effect is a slight reduction in Indian monsoon rainfall."

> Achieving net-zero carbon emissions is not the end of the story, policymakers should focus on adaptation policies for vulnerable areas, particularly the Indo-Gangetic plains, where the highest aerosol loading is found

Many people would like to understand what aerosols emitted by India are doing to India, but the remote effects of aerosols are also important to consider, he added. For example, a May 2024 study published in *Proceedings of the National Academy of Sciences* reported that when China cut its aerosol emissions, extreme heat wave events in the Pacific Ocean, along the west coast of North America, got worse.

Likewise, according to Mr. Bala's ongoing research, any substantial increase in aerosols over India could negatively affect the hydrological cycle and reduce the amount of monsoon rainfall. Understanding this process is an active area of study worldwide.

Net-zero not the end

Both aerosol pollution and greenhouse gas-related climate pollution are mainly due to large-scale industrial activity. Greenhouse gas-induced warming increases the risk of extreme heat, aerosols cause respiratory ailments, creating a compounding effect on vulnerable populations, Mr. Sengupta said.

The study has found that cutting both will also require policies to support already at-risk populations that will be affected by the sudden rise in warming in the short term.

"Achieving net-zero carbon emissions would not be the end of the story, and policymakers should focus on long-term adaptation policies for the vulnerable parts of India, particularly people residing in the Indo-Gangetic plains, where the highest aerosol loading is found," Mr. Sengupta added.But because aerosol distribution is highly regional, it is difficult to exactly predict how specific places in India will be affected when (and if) we clean up aerosols, Mr. AchutaRao said.

Experts suggested the surest step would be to develop better heat action plans. Delhi-based research organisation Sustainable Futures Collaborative recently reported that few of the heat action plans of nine cities – Delhi, Mumbai, Bengaluru, Faridabad, Gwalior, Kota, Ludhiana, Meerut, and Surat – included long-term action and that even those were poorly targeted. If and when aerosols are removed from the atmosphere, the heat stress in these cities could worsen.

"While cleaning the air might accelerate ongoing warming by unmasking the greenhouse gas-induced warming, it could be beneficial in terms of increased rainfall over India. These trade-offs should be considered when assessing the effects of aerosols on our complex climate system," Mr. Bala added.

That said, all the experts agreed the immediate benefits to human health from reducing air pollution far outweighed any adverse consequences due to higher heat or disrupted rainfall.

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Key Takeaways & Analysis

1. Aerosols vs Greenhouse Gases: Contrasting Roles

- Greenhouse gases (GHGs) like CO_2 trap heat and cause global warming.
- Aerosols (e.g., sulphates, nitrates, black carbon):
  - Scatter sunlight - cooling effect
  - Short-lived (days to weeks)
  - Regionally concentrated
  - Affect cloud formation and monsoon rainfall

2. India's Dilemma

- India generates - 70% of its electricity from coal, a major aerosol source.
- Sulphate aerosols formed from sulphur dioxide (SO_2) emissions account for 50–60% of India's aerosol load.
- If India rapidly reduces aerosol emissions without also reducing GHGs, it risks:
  - Sudden warming
  - Increased heat stress
  - Disrupted rainfall patterns

3. Warming Trends & Aerosol Masking

- Between 1906–2005, India warmed 0.54°C, but GHG warming was ~2°C.
- Aerosol masking offset ~1.5°C of that warming.
- Removal of aerosols would likely:
  - Worsen heat waves
  - Possibly increase rainfall but also affect monsoon timing

4. Impact on Rainfall & Monsoons

- Aerosols have regional climate effects, especially on the Indian monsoon.
- Aerosol cooling is stronger in the northern hemisphere (0.9°C) than the south (0.3°C), which can shift monsoon circulation.
- High aerosol loading in the Indo-Gangetic plain may reduce rainfall and disturb hydrological cycles.

5. Implications for Policy

- Removing pollution improves health but may cause climate stress in short term.
- Need for:
  - Long-term adaptation strategies
  - Heat action plans (currently lacking in most Indian cities)

- Better modelling of aerosol effects
- Synchronised reduction of both aerosols and GHGs

Quote: "Achieving net-zero carbon emissions would not be the end of the story…" – Aditya Sengupta

Prelims Pointers

Term	Explanation
Aerosols	Tiny particles suspended in the atmosphere; can cool (sulphates) or warm (black carbon) the Earth.
Flue Gas	Exhaust gas from industrial combustion processes, often contains SO_2.
Sequestered Warming	Hidden warming masked by aerosols, revealed when aerosols are removed.
Heat Action Plan	A public health strategy to reduce heat-related mortality and morbidity.

Conclusion

India stands at a critical juncture where air quality improvements, though essential, may expose its population to greater climate risks unless accompanied by GHG reductions and robust adaptation strategies. Policymakers must balance short-term public health with long-term climate resilience, particularly in urban and densely populated regions.

UPSC Mains Practice Question

Ques : While air pollution reduction is crucial for public health, it may accelerate warming. Discuss this paradox in the Indian context with reference to aerosol emissions.

On August 23, 2023, ISRO's Chandrayaan-3 made history by successfully landing near the moon's south pole. Aboard the Vikram lander was ChaSTE — Chandra's Surface Thermophysical Experiment, a first-of-its-kind instrument designed to measure in-situ thermal profiles of lunar soil.

- ChaSTE became the first probe in space exploration to successfully penetrate and collect subsurface thermal data from a celestial body, outperforming earlier missions from ESA and NASA that had similar objectives but failed due to deployment issues.

What is ChaSTE?

Feature	Description
Full form	Chandra's Surface Thermophysical Experiment
Function	Measures temperature at various depths of lunar regolith
Structure	10 thermal sensors, spaced ~1 cm apart
Mechanism	Rotating motor pushes the probe (vs hammering in past missions)
Depth achieved	10 cm into the lunar soil
Location	Near **Moon's south pole**, a region of high interest for water ice

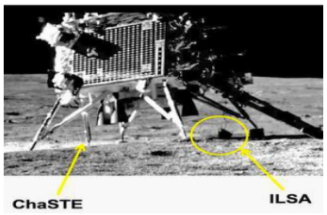
Scientific & Technological Significance

1. Understanding Moon's Thermal Properties

- Provides key data on thermal conductivity, temperature gradients, and regolith structure.
- Supports theories about presence of water ice near the lunar south pole.

2. Engineering Innovation

- Previous missions (ESA's MUPUS on Philae & NASA's HP3 on InSight) failed to deploy properly due to poor landings or insufficient soil friction.



This image shows the ChaSTE instrument. ISRO

Chandrayaan's ChaSTE takes the moon's temperature

Unnati Ashar

As the Vikram lander of Chandrayaan-3 touched down on the moon on August 23, 2023, a thermal probe tucked snugly in its panels slowly worked itself free and stretched its arms. Its motors started to whir, sending the little probe into the soil. Once the probe reached its intended depth, it clicked in place with a latch.

This is Chandra's Surface Thermophysical Experiment (ChaSTE) – the first instrument to measure temperatures *in situ* near the moon's south pole. Scientists used this data to report that water ice is more prevalent on the moon than expected.

ChaSTE also became the first mission to successfully penetrate the soil of a celestial body to deploy a thermal probe after two previous missions had fallen short. The ChaSTE probe features 10 temperature sensors spaced about 1 cm apart along its length, near the nose-tip. It uses a rotation-based deployment mechanism.

When its motor rotates, ChaSTE's probe needle pushes down until its tip touches the moon's surface. By monitoring the temperature from the sensor at the end of the probe, scientists can identify if it has touched the surface. As the probe continues to pierce, the soil offers more and more resistance. This requires the motor to exert greater force. That is how scientists confirm how far the probe has descended.

ChaSTE tunnelled into the soil to a final depth of 10 cm, then collected measurements throughout the Chandrayaan-3 mission until September 2, 2023.

ChaSTE became the first mission to successfully penetrate the soil of a celestial body to deploy a thermal probe after two previous missions had fallen short

On November 12, 2014, the European Space Agency's Philae lander, hitchhiking on the Rosetta spacecraft, landed on comet 67P/Churyumov-Gerasimenko. But it bounced – twice. Its Multi-Purpose Sensors for Surface and Subsurface Science (MUPUS) instrument onboard was designed to measure temperature by digging into the terrain. However, scientists couldn't deploy it due to the awkward landing. Philae found itself in on a desolate icy rock, 500 million km away.

The German-Polish team behind MUPUS got another chance when NASA's InSight robotic spacecraft landed on Mars on November 26, 2018. It carried a temperature-sensing instrument called the Heat Flow and Physical Properties Package (HP^3). It consisted of a self-hammering nail, nicknamed "The Mole," designed to penetrate 5 m below Mars's surface.

But the friction between the probe and the sand was too low for the mole to hammer itself down more than a few centimetres. After more than a year's action-packed struggle, the 35-cm Mole had finally descended fully into the Martian sand. But scientists couldn't get any temperature data. This was because HP^3's temperature sensors were not on the mole. They were attached to a tether that was supposed to trail The Mole as it burrowed through the sand.

"While both the instruments [MUPUS and HP^3] used a hammering device, the ChaSTE probe was pushed into the soil by a rotating device," Durga Prasad K., principal investigator of ChaSTE from the Physical Research Laboratory, Ahmedabad, said. It was the secret sauce that made all the difference.

(Unnati Ashar is a freelance science journalist. unnati_a@ymail.com)

- ChaSTE's success credited to its rotation-based deployment instead of hammering — more effective in loose lunar soil.

3. Global Recognition

- Demonstrates India's ability to design cutting-edge, reliable scientific payloads for interplanetary missions.
- Strengthens India's position in space research and planetary science.

Prelims Pointers

Term	Description
ChaSTE	Thermal probe onboard Chandrayaan-3 to measure sub-surface temperature
Vikram Lander	Part of Chandrayaan-3; deployed ChaSTE
MUPUS	ESA's thermal sensor on comet 67P (failed due to bounce)
HP3 "The Mole"	NASA's Martian heat probe (failed to burrow deeply enough)
ISRO	Indian Space Research Organisation – developer of Chandrayaan-3

Conclusion

ChaSTE's successful deployment and operation on the moon's south pole marks a milestone for ISRO and global lunar science. By achieving what other space agencies could not, India has once again proven its prowess in cost-effective, high-precision space exploration, setting the stage for future missions in planetary science and interplanetary resource exploration.

UPSC Mains Practice Question

Ques : Discuss the significance of the ChaSTE instrument onboard Chandrayaan-3 in advancing lunar science and technology.

Page 10 : GS 1& 3 : Geography and Disaster Management

On March 28, 2025, a magnitude 7.7 earthquake struck central Myanmar, about 20 km from Mandalay, near the Sagaing Fault, one of Southeast Asia's most active tectonic features. The earthquake was followed by strong aftershocks, notably a 6.4 magnitude tremor minutes later.

How did the Myanmar earthquake occur?

Has there been a history of earthquakes along the Sagaing fault? Has the earthquake caused damage in Bangkok as well? How did neighbouring eastern parts of India avoid any damage from the earthquake? Why is the plate boundary in Southeast Asia an active tectonic feature?

EXPLAINER

C. P. Rajendran

The story so far:

The powerful earthquake in Myanmar on March 28 had its source in central Myanmar, about 20 km from Mandalay, the country's second-largest city. Mandalay, located on the east bank of the Irrawaddy river, is close to one of the most seismically active faults in the region, called the Sagaing fault, named after a town not far from Mandalay on the river's opposite side. The earthquake of magnitude 7.7 struck around 12:50 pm local time, followed by several strong aftershocks, including one of magnitude 6.4, which occurred 11 minutes after the major event.

What effect did the quakes have?

The quakes were very devastating: they affected the entire region, left thousands of people dead, and destroyed many homes. The damage zone extended to Bangkok, the capital of neighbouring Thailand, which is about 1,000 km from the earthquake's epicentre.

However, the damage in Bangkok was minimal, confined to the complete collapse of a 33-storey high-rise under construction, and causing water from a swimming pool on the top of another high-rise building to overflow. However, these incidents were given much hype because of the city's place on the global tourism circuit. The outpouring of water from the rooftop pool was due to seismic seiches – oscillations in the water triggered by the passage of seismic waves through the area. Even though the building was located far from the earthquake's source, slower, long-period seismic waves can cause the top floors to sway more and amplify the seiches, as observed in this case.

The damage prediction models of the U.S. Geological Survey estimated that the total death toll in the region could reach well over 10,000. Mandalay itself is home to over 1.5 million people and was hit the hardest, with many buildings, including pagodas, mosques, and bridges, either partially damaged or completely collapsed. A review of the damage pattern reveals that much of the devastation was concentrated in the southern areas of the Sagaing fault because this region is sitting on a thicker pile of alluvium, deposited by the Irrawaddy, which amplifies the seismic energy, as compared to the northern parts of the fault. This also explains why China's southwest Yunnan Province, which is north of the fault, escaped earthquake-induced damage. The depth to the source of the 2025 earthquake on the Sagaing fault was only 10 km, which is another contributing factor for the heavy damage and a large felt area (area where the earthquake's shaking is felt).

The neighbouring eastern parts of India also escaped damage because the energy released by the earthquake dispersed in a north-south direction, following the trend of the fault.

Are quakes common in South Asia?

South Asia, including Myanmar, is highly prone to earthquakes due to its proximity to the complex assemblage of some of the largest tectonic features on earth, including the Himalayas, the Shillong Plateau, the Southern Indo-Burman Range, and the Andaman-Nicobar subduction zone. Originating from the collision of the Indian and the Eurasian Plates some 40 million years ago, the plate boundary in Southeast Asia is an active tectonic feature that generated one of the largest earthquakes in history, of magnitude 9.2, and a transcontinental tsunami in 2004.

Mass destruction: A damaged pagoda in the aftermath of the earthquake in Amarapura township, Mandalay, Myanmar, on April 2. AP

The tectonic stress accumulating on these plate boundaries is the cause of frequent seismic activity in the region. The earthquake of 1762 was also a great 'megathrust' earthquake of magnitude 8.5, with its epicentre located somewhere along the Arakan coast of Myanmar. This seismic event generated a tsunami in the northern Bay of Bengal and caused widespread soil liquefaction in the Chittagong areas of Bangladesh. The large thrust fault extends further north onto the Chittagong-Tripura fold belt, where several moderate earthquakes continue to occur. It is still not clear whether this part of the deformation front can generate future great earthquakes.

Southeast Asia is a tectonic museum that exhibits structures that host earthquakes of varying faulting mechanisms, occurring at depths ranging from as shallow as 5 km to 200-400 km. The deeper ones occur in the southern regions closer to Indonesia or the Indo-Burmese regions in the north, bordering the subduction front along the Indo-Eurasian plates. The 2025 Mandalay earthquake in Central Myanmar was sourced from within the continental part of the mountain range. In the tectonics of mountain building, such features develop when sediment piles up and rocks are scraped off from the subducting Indian plate, which get plastered onto the overriding Asian plate.

What is the geodynamic context of the Sagaing fault?

Because of the complex interplay of plate motions and the resulting geodynamics in the eastern margin of the Indian Ocean, the northeast-directed convergence of the India and Eurasia plates takes place in a slanted fashion rather than happening head-on. This oblique convergence of the plates causes the overall strain to become partitioned, with part of the deformation being perpendicular to the plate boundary and the other part occurring parallel within the interiors. The north-south running Sagaing fault forms the tectonic boundary between the Central Myanmar Lowlands and the Indo-Burman Range. An elongated micro-tectonic block that exists between the Indian plate and the Sagaing fault is commonly called the Burma plate or the Burma sliver. It owes its origin to the strain partitioning occurring at the subduction front.

Studies have revealed that this fault, with its subsidiary parallel structures, accommodates much of the strike-slip part of the oblique convergence, with a slip rate of 15-25 mm a year and an accumulated slippage of 100-700 km. The Sagaing fault accommodates about 50-55% of the overall plate motion in the region. Unlike the vertical motions of fault blocks along the frontal part of the convergence zone, where one tectonic block is pushed up on the other, the movement is horizontal on the Sagaing fault, with the blocks sliding past each other. The San Andreas fault in the western U.S. is another such example. Unlike thrust faults, where earthquakes originate at either shallow or deeper sources, earthquakes on strike-slip faults are almost always shallower (10-15 km).

Classified as a typical ridge-trench transform fault, the Sagaing fault system runs 1,400 km between the spreading centre under the Andaman Sea in the south to the eastern Himalayan bend in the north. It has a long history of earthquakes. Moderate and occasional strong earthquakes of magnitudes 7 and above are common in central Myanmar, where six strong quakes of 7.0 magnitude or more struck between 1930 and 1956 along the Sagaing fault or on adjacent structures. Analyses of historical earthquakes have revealed that about half of the Sagaing fault has ruptured in the last few decades. Thus, the 2025 earthquake is not a surprise event but a part of the earthquakes occurring sequentially on this structure to release the accumulating stresses from the ongoing active plate interactions.

What does the Mandalay earthquake portend?

Historical records support the occurrence of an earthquake in 1839, called the Ava earthquake, that killed more than 500 people in central Myanmar. This event may have originated on one of the segments of the Sagaing fault with a hypothesised magnitude of 7.8. Equally interesting is the earthquake of 1927, reportedly felt strongly north of Yangon, Myanmar's largest city with a current population of more than four million people. Records also indicate that an earthquake occurred in 1946, possibly on the Sagaing fault north of Mandalay and with a magnitude of 7.7, like that of the 2025 temblor.

The historic city of Bagan in Central Myanmar, densely packed with religious monuments, has also been subjected to several damaging earthquakes. The latest one to hit this town was in 2016.

Science helps us understand the processes behind earthquakes and provides approximate locations of future earthquakes and their possible magnitudes. The Sagaing fault is not merely a scientific curiosity: it has a tragic impact on the millions who live with the restless fault beneath their feet. Myanmar is struggling to cope with the aftermath of the latest earthquake, with a rising death toll and extensive damage to infrastructure, both complicated by the ongoing civil war.

The 2025 Mandalay earthquake should serve as a warning to India. As the country most prone to earthquakes in South Asia, India should introduce scientifically tested safety measures and procedures to mitigate the impact of earthquakes.

C.P. Rajendran is an adjunct professor at the National Institute of Advanced Studies, Bengaluru. This article benefited from the paper by Yu Wang et al., published in JGR Solid Earth on March 15, 2014.

THE GIST

- The Myanmar quakes were very devastating; they affected the entire region, left thousands of people dead, and destroyed many homes. The damage zone extended to Bangkok, the capital of neighbouring Thailand, which is about 1,000 km from the earthquake's epicentre.
- Classified as a typical ridge-trench transform fault, the Sagaing fault system runs 1,400 km between the spreading centre under the Andaman Sea in the south to the eastern Himalayan bend in the north. It has a long history of earthquakes.
- The historic city of Bagan in Central Myanmar, densely packed with religious monuments, has also been subjected to several damaging earthquakes. The latest one to hit this town was in 2016.

Key Details & Analysis

Why and How Did the Earthquake Occur?

- Originated along the Sagaing Fault, a strike-slip fault where tectonic blocks slide past each other horizontally.

- The epicentre was shallow (10 km deep), amplifying ground shaking.
- The Sagaing Fault accommodates about 50–55% of the plate motion between the Indian and Eurasian plates.
- Oblique convergence (not head-on) between the Indian and Eurasian plates causes strain to be partitioned, leading to strike-slip motion along the fault.

Has the Sagaing Fault Had a History of Earthquakes?

- The Sagaing Fault has experienced numerous strong earthquakes:
  - 1839 Ava Earthquake (magnitude - 7.8)
  - 1927 and 1946 quakes (magnitude 7.7)
  - Six major quakes between 1930–1956
  - 2016 earthquake damaged Bagan, a UNESCO heritage site

Impact on Bangkok

- Although - 1,000 km from the epicentre, Bangkok experienced:
  - Collapse of a 33-storey under-construction building
  - Seismic seiches (oscillation of water due to seismic waves) in rooftop pools
- Minimal structural damage, but media hype due to Bangkok's international prominence

Why Did Eastern India Escape Damage?

- The energy released traveled mostly in a north-south direction, aligned with the Sagaing fault's orientation
- Eastern India lies to the west of the fault - Less seismic wave impact
- Contrast with Yunnan Province (China) which is north of the fault and also escaped heavy damage due to being on more stable geological formations

Tectonic Context of Southeast Asia

- Region is a tectonic hotspot, influenced by:
  - Indian–Eurasian Plate collision
  - Indo-Burman Range
  - Andaman Subduction Zone
  - Himalayas & Shillong Plateau
- Past massive events:
  - 2004 Indian Ocean Earthquake & Tsunami (Magnitude 9.2)
  - 1792 Arakan Coast Earthquake (Magnitude 8.5)

Why Is This a Warning for India?

- India shares tectonic continuity with Myanmar and is highly earthquake-prone
- Need for:
  - Strict enforcement of building codes
  - Early warning systems
  - Community preparedness programs

UPSC Mains Practice Question

Ques : How do geological factors like soil type and depth of the earthquake affect the damage caused by seismic events? Illustrate your answer with reference to the 2025 Mandalay earthquake.

India's digital payments ecosystem continues to expand rapidly, with the Unified Payments Interface (UPI) at the forefront. As per the India Digital Payments Study by Worldline, UPI recorded a 42% year-on-year growth in transaction volume and 31% growth in value in the second half of FY24.

Key Highlights

Parameter	H2FY24 Figures	YoY Growth
UPI Transactions Volume	93.23 billion	42%
UPI Transactions Value	₹130.19 trillion	31%

Major Sectors Driving Usage:

- Grocery stores, restaurants, pharmacies, and government services:
  - Accounted for 68% of volume
  - Accounted for 53% of transaction value

Analysis & Implications

1. Deepening Financial Inclusion

- UPI's growth reflects India's digital public infrastructure success.
- Facilitates cashless economy and boosts formal financial inclusion.

2. Support for Small Businesses

- High usage in everyday transactions (kirana stores, eateries) shows UPI's penetration in informal sectors.
- Reduces reliance on cash, ensures better revenue tracking.

3. Government Services on UPI

- Increasing use in paying utility bills, taxes, and public fees shows adoption in citizen-government interface.
- Aligns with the Digital India mission.

'India logged 93.2-bn UPI transactions in H2FY24'

The Hindu Bureau
BENGALURU

India's UPI transactions volumes surged 42% year-on-year during the second half of FY2024, reaching 93.23 billion, according to 'India Digital Payments study released by Worldline, a payment services provider.

The UPI transaction value surged 31% YoY to ₹130.19 trillion, it reported.

Grocery stores, restaurants, pharmacies and government services accounted for 68% of the transaction volume and 53% of total transaction value, as per the study.

4. India as Global Leader in Digital Payments

- UPI is being considered for international collaborations (e.g., Singapore, UAE, France).
- Could boost soft power and fintech exports.

Prelims Pointers

Term	Explanation
UPI	Real-time interbank payment system developed by NPCI.
NPCI	National Payments Corporation of India, promotes retail digital payments.
Digital Public Infrastructure (DPI)	Platforms like UPI, Aadhaar, and DigiLocker that enable digital service delivery.
Worldline	Global payments services provider that authored the study.

Conclusion

The 93.2 billion UPI transactions in H2FY24 highlight the growing adoption of secure, fast, and low-cost digital payments in India. As UPI continues to drive everyday commerce and public services, it cements India's status as a global leader in digital innovation.

UPSC PrelimsPractice Question

Ques :"With reference to Unified Payments Interface (UPI), consider the following statements:

1. UPI is developed by the National Payments Corporation of India (NPCI).

2. UPI enables instant money transfer only between accounts of the same bank.

3.UPI is based on the Immediate Payment Service (IMPS) platform.

Which of the statements given above is/are correct?

A. 1 and 2 only

B. 1 and 3 only

C. 2 and 3 only

D. 1, 2 and 3

Ans : b)

With Prime Minister Narendra Modi likely to visit Sri Lanka soon, experts are urging India to seize the current geopolitical and economic climate to finalize a "stronger" Free Trade Agreement (FTA) with Sri Lanka. This push comes at a time when Sri Lanka is stabilising post its 2022 economic crisis and is governed by a relatively India-friendly NPP-JVP coalition.

'India must use window of opportunity to finalise 'stronger' FTA with Sri Lanka'

T. Ramakrishnan
CHENNAI

With Prime Minister Narendra Modi planning to visit Sri Lanka shortly, economist-writer Razeen Sally, who served as an adviser to Ranil Wickremesinghe during 2015-17 when the latter was Prime Minister of Sri Lanka, has called upon India to use the "window of opportunity available now" to finalise a "stronger" bilateral free trade agreement (FTA) with the neighbour.

In an interview with *The Hindu* on Tuesday evening, the 60-year-old academician, who had stints at the London School of Economics (LSE) and National University of Singapore (NUS), said the present Janatha Vimukthi Peramuna-led National People's Power (NPP) government "is sympathetic to India and much less defensive vis-à-vis India than [those of the governments led by] the Rajapaksas." Besides, there "is a change in the climate of opinion which is favourable to India", as a result of what the country did during the 2022 economic crisis in Sri Lanka.

Closer ties

The proposed FTA could "cover services; allow freer movement of some classes of workers and overcome protectionist blockages in both countries – which are, I think, more on the Sri Lankan side," the economist said, adding that closer relationship between the two neighbours "should not upset other powers – China and the U.S. – which have stakes in Sri Lanka."

Emphasising that "it is not the job" of India to provide dollars of aid to Sri Lanka "in perpetuity," Mr. Sally, however, renewed that the call for economic integration of the island-nation with southern States of India, an argument, which Mr. Sally himself admitted, was being made for over a generation.

> The National People's Power government is sympathetic to India and much less defensive vis-à-vis India than the Rajapaksas
> **RAZEEN SALLY**
> Economist

In 2003, Mr. Wickremesinghe, then Prime Minister, while delivering a lecture in Chennai, floated the idea of building a bridge linking Rameswaram in Tamil Nadu with Talaimannar in the Northern Province of Sri Lanka as part of his larger vision of regional economic integration, encompassing his country and the southern region of India.

Huge potential

Acknowledging that "the political roadblock among certain sections of Sri Lanka is Tamil Nadu," Mr. Sally emphasised that "geography essentially tells you what the advantages are. There exists huge potential for closer links between Sri Lanka and individual States – government to government, business to business, and business to government." He added: "We are talking of Tamil Nadu and three or four other States that are economically doing very well."

To a question whether the current government was receptive to the idea of Sri Lanka's integration with the supply chain of south India, Mr. Sally replied that "it is up to groups outside the government – business and civil society – to make the case and find people in the government to champion the case.

On the political and economic situation in Sri Lanka, the economist, with both British and Sri Lankan roots, said the ruling NPP-JVP formation "has become the principal force" in the country with no effective Opposition in the political landscape. So far, there had been no corruption charges against it.

Economic situation

On the economic front, the stabilisation package, worked out by the previous Wickremesinghe government and the Central Bank of Sri Lanka, in line with the IMF [International Monetary Fund] programme, had gotten Sri Lanka out of an economic crisis. "But. it has not put Sri Lanka on the path of recovery." The current government had to "go beyond the IMF reforms", and the country should grow faster to pay its debts, which would become due in 2027, apart from generating extra revenue for other requirements.

However, if Sri Lanka stuck to only the IMF reforms, the country might "drift along at a fairly low level of economic growth, sowing the seeds for the next economic crisis."

Key Takeaways from the Analysis

1. Current Political & Economic Climate in Sri Lanka

- The NPP-JVP government is less defensive toward India, unlike the Rajapaksa regime.
- There is no strong opposition, and the current ruling party has no corruption charges so far.
- The IMF-backed stabilisation programme helped avert a collapse but hasn't ensured long-term growth.
- Sri Lanka must go beyond IMF reforms to prevent another crisis post-2027 debt deadlines.

2. Why This Is a Strategic Opportunity for India

- Pro-India sentiments in the current Sri Lankan government create a favourable negotiation climate.
- India's timely assistance during the 2022 crisis improved goodwill.
- There's growing regional recognition of India's stabilising role in South Asia.

3. What Should the FTA Encompass?

- Trade in services
- Freer movement of skilled workers
- Reduction of protectionist barriers, especially on Sri Lanka's side

- Deeper economic integration with southern Indian States like Tamil Nadu, Kerala, Andhra Pradesh, and Karnataka

4. Tamil Nadu Factor

- Some political apprehensions in Sri Lanka stem from concerns over Tamil Nadu's role, due to ethnic and political history.
- However, geography and economic logic favour integration between Sri Lanka and southern India.
- Mr. Sally highlights the role of civil society and business groups in driving cross-border cooperation.

5. India's Role and Strategic Interests

- India should not aim to provide endless aid, but rather focus on sustainable economic engagement.
- A strong FTA would reinforce India's Act East and Neighbourhood First policies.
- Deepening ties with Sri Lanka helps counterbalance China's influence, especially in infrastructure and ports.

UPSC Mains Practice Question

Ques : What are the risks of relying solely on IMF-driven reforms for economic recovery? Examine in the context of Sri Lanka. **(250 words)**

Digital child abuse, the danger of AI-based exploitation

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Recently, the Department for Science, Innovation and Technology of the British Government, along with the AI Safety Institute (now called the AI Security Institute), released the first-ever International AI Safety Report 2025 (updated February 18, 2025). It flags the imminent risk of the generation, the possession, and the dissemination of child sexual abuse material (CSAM) with the help of Artificial Intelligence (AI) tools. Additionally, the United Kingdom is making the first legislative attempt to target the threats posed by AI tools that can generate CSAM. CSAM refers to material (audio, video, and images) that depicts a sexually explicit portrayal of a child. In a similar vein, the World Economic Forum, in a 2023 paper, highlighted how generative AI can create life-like images, especially of children. Moreover, the Internet Watch Foundation, in its report released in October 2024, underscored the proliferation of CSAM on the open web. The Government of India must amend existing laws to address the emerging threats and ensure long-term effectiveness.

Recent developments

The upcoming U.K. legislation will make it illegal to possess, create, or distribute AI tools that can generate CSAM. Moreover, it will be illegal to possess paedophile manuals that may guide individuals in using AI tools to generate CSAM. This marks a progressive shift from an 'accused-centric' and 'act-centric' to a 'tool-centric' approach in dealing with these abhorrent crimes.

The existing laws focus entirely on 'who' has done 'what', placing less or no emphasis on the 'tool/medium' used to commit the said 'act.' For instance, the Protection of Children Act 1978 criminalises taking, distributing, and possessing an indecent photograph or pseudo-photograph of a child. Furthermore, the Coroners and Justice Act 2009 criminalises the possession of a prohibited image of a child, including non-photographic materials. In contrast, the proposed law outlaws even the possession and use of such AI tools, making it deterrent and holistic. Second, it will enable enforcement authorities to apprehend offenders at the preparation stage itself. Third, it can curb the initial rippling effect caused by the spread of CSAM on the mental health of children. Fourth, it addresses the legislative gap concerning CSAM generated as purely AI imagery, which was previously restricted to the images of an 'actual child.'

The Government of India must amend existing laws to address emerging threats

On whether India is future ready

According to the National Crime Records Bureau (NCRB) Report 2022, cybercrimes against children have substantially increased compared to the previous year's statistics. Moreover, the National Cyber Crime Reporting Portal (NCRP), under the aegis of the Cyber Crime Prevention against Women and Children (CCPWC) scheme, recorded 1.94 lakh child pornography incidents as of April 2024. In 2019, the NCRB signed a memorandum of understanding with the National Centre for Missing and Exploited Children (NCMEC), USA to receive tip-line reports on CSAM. As of March 2024, 69.05 lakh cyber tip-line reports have been shared with the States and Union Territories concerned. The statistics underscore the gravity of CSAM as a serious threat to a child's right to life and dignity in India.

Presently, Section 67B of the IT Act 2000 punishes those who publish or transmit material in electronic form depicting children in sexually explicit acts. Furthermore, Sections 13, 14, and 15 of the Protection of Children from Sexual Offences Act, 2012 (POCSO) prohibit using children for pornographic purposes, storing child pornography in any form, and using a child for sexual gratification. Additionally, Section 294 of the Bharatiya Nyaya Sanhita penalises the sale, distribution, or public exhibition of obscene materials, while Section 295 makes it illegal to sell, distribute, or exhibit such obscene objects to children. However, the existing legislative framework lacks adequate safeguards to deal with the AI-generated CSAM.

A plan to follow

The existing legislative and policy framework in India needs to adapt to futuristic challenges, by making suitable changes. First, as proposed by the NHRC Advisory in October 2023, the definition of 'child pornography' under the POCSO Act must be replaced with the phrase 'CSAM' to make it expansive. Second, the term 'sexually explicit' under Section 67B of the IT Act must be defined to enable the real-time identification and blocking of CSAM. Third, the definition of 'intermediary' under the IT Act must expressly include Virtual Private Networks, Virtual Private Servers, and Cloud Services to impose statutory liability on them to comply with the CSAM-related provisions in Indian laws. Fourth, statutory amendments are needed to integrate the risks arising from emerging technological advancements. Fifth, the Government of India must pursue the adoption of the UN Draft Convention on 'Countering the Use of Information and Communications Technology for Criminal Purposes' by the UN General Assembly. Notably, the Ministry of Electronics and Information Technology proposed the Digital India Act 2023, currently in pipeline, to replace the two-decade-old IT Act. Therefore, and lastly, the proposed Digital India Act must draw inspiration from the U.K.'s upcoming legislation to include the provisions specifically targeting AI-generated CSAM.

Paper 03:Science and Technology

UPSC Mains Practice Question:The misuse of Artificial Intelligence tools in generating Child Sexual Abuse Material (CSAM) highlights a critical gap in India's legal and institutional frameworks. Examine the need for legal reforms to address AI-driven exploitation of children. Suggest a policy roadmap for India to counter this threat.

Context :

The release of the International AI Safety Report 2025 by the U.K.'s Department for Science, Innovation and Technology, in collaboration with the AI Security Institute, has flagged a new dimension of child sexual abuse — the use of AI tools to generate Child Sexual Abuse Material (CSAM). The U.K. is also preparing landmark legislation to combat this evolving threat, highlighting the need for India to adapt its legal and policy frameworks.

Key Highlights

- AI-generated CSAM: Artificial Intelligence can now generate lifelike images, including of children, which could be used for sexually exploitative purposes. These are difficult to trace and fall in legal grey areas, especially when no real child is involved.
- Tool-centric approach: The U.K. legislation will outlaw the possession, creation, or distribution of AI tools that can generate CSAM — a shift from punishing just the actor to targeting the enabling technology.
- Mental health and ripple effects: The unchecked spread of CSAM severely impacts child victims and contributes to long-term psychological harm.

India's Current Framework

- Section 67B, IT Act 2000: Penalizes publishing or transmitting sexually explicit content involving children.
- POCSO Act, 2012: Prohibits use, storage, or display of child pornography.
- Bharatiya Nyaya Sanhita Sections 294 & 295: Penalize obscene content and its sale to children.
- Cyber Tip-line Reports: As of March 2024, over 69 lakh reports received via MoU with NCMEC (USA), showing the magnitude of the crisis.

Gap Identified: No explicit provisions to deal with AI-generated CSAM, non-photographic depictions, or paedophile manuals using emerging technologies.

Recommendations for India

1. Expand Terminology:
    - Replace "child pornography" with CSAM in POCSO to broaden the scope and align with global standards.
2. Clarify Legal Language:
    - Define "sexually explicit" in Section 67B to include AI-generated, lifelike, or non-photographic imagery.

3. Update Intermediary Liability:
    - Amend the IT Act to explicitly include VPNs, VPS, and Cloud Services under the definition of intermediaries.
4. Strengthen Enforcement:
    - Enable pre-emptive policing by penalizing even the possession or use of tools that can potentially create CSAM.
5. Incorporate in New Legislation:
    - Ensure the upcoming Digital India Act 2023 incorporates specific clauses on AI-driven exploitation.
6. Global Cooperation:
    - Actively push for the UN Draft Convention on ICT misuse for criminal purposes, ensuring global consensus on AI and cyber exploitation.

Way Forward

The intersection of AI and child exploitation poses an unprecedented threat that requires a multi-stakeholder approach, involving legal reforms, technological safeguards, international cooperation, and public awareness. India must take proactive steps not only to address current cyber threats but also to future-proof its legal and institutional frameworks.
