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All the topics of this UPSC IAS Edition are directly or indirectly important for the prelims & main examination. There are some topics which can be coded in answer writing of other topics in the main exam.

Prime Minister Narendra Modi being received by Bhutan Prime Minister Tshering Tobgay on Tuesday. PTI

All conspirators will be brought to justice, says Modi

Rahul Karmakar
THIMPHU

Prime Minister Narendra Modi on Tuesday said the conspirators behind Monday's car explosion near the Red Fort in Delhi that killed at least 13 people "will not be spared".

Addressing the people of Bhutan and 20 other countries who have converged for the 16-day Global Peace Prayer Festival (GPPF) in Thimphu, the Prime Minister stated that he had been in touch with all the agencies investigating the blast throughout the night.

'Conspiracy probe on'

"Our agencies will get to the bottom of this conspiracy, and the conspirators will not be spared," he said, speaking at the Changlimithang Stadium.

"All those responsible will be brought to justice," Mr. Modi said.

Mr. Modi landed in Thimphu, Bhutan's capital, on Tuesday morning on a two-day visit to participate in the 70th birthday celebrations of Jigme Singye Wangchuk, the Himalayan country's fourth King, revered as the Father of Bhutan.

He said participating in the GPPF was his commitment to Bhutan's royal family, the people, and all who believe in world peace. "But I came here with a heavy heart because of the lives lost in the Delhi blast. I can feel the pain of the affected people, and the entire country shares their grief," Mr. Modi said.

Prayers for blast victims

The Bhutanese leadership, including the fifth (current) King Jigme Khesar Namgyel Wangchuk and Prime Minister Tshering Tobgay, conveyed their condolences on the "tragic loss of precious lives" in the Delhi explosion, and offered special prayers for all those affected by the blasts.

"India has always stood by Bhutan. India has always supported Bhutan. Likewise, Bhutan stands firmly with India because we share a common destiny," King Jigme Khesar Namgyel Wangchuk said.

Mr. Modi's presence for a momentous day in Bhutan "speaks a million words" and "has deeply touched our people", he said.

(This correspondent is in Thimphu at the invitation of the Bhutan government)

SC issues notice to EC on pleas against SIR

Krishnadas Rajagopal
NEW DELHI

The Supreme Court on Tuesday interrogated Opposition parties, leaders, and NGOs for their negative portrayal of the Election Commission (EC)'s special intensive revision (SIR) of electoral rolls, including their claims that the exercise amounts to "citizenship screening" in disguise and threatens to disenfranchise lakhs of voters.

"You people want to project as if revision of electoral rolls is happening for the first time in this country! We also know the ground reality. A Constitutional functionary is undertaking an exercise... There can be some procedural deficiency. Those can be pointed out and rectified. You are saying as if the democratic process is being threatened... There is already an electoral roll, this is just a process to revise it," Chief Justice of India-designate Justice Surya Kant said.

The Bench issued notice to the EC on the petitions filed by the DMK and other pleas challenging the constitutionality of the exercise. It listed the case for hearing on November 26.

FULL REPORT ON
» PAGE 14

The infirmities in the SIR of electoral rolls

P.D.T. Achary

is a former Secretary General, Lok Sabha

The Special Intensive Revision of electoral rolls (SIR) ordered by the Election Commission of India (ECI) in 12 States and Union Territories (Tamil Nadu, Kerala, West Bengal, Uttar Pradesh, Madhya Pradesh, Rajasthan, Chhattisgarh, Goa, Gujarat, Puducherry, Andaman and Nicobar Islands, and Lakshadweep), where elections are due, has provoked strong protests from some State governments – some have challenged it in the Supreme Court of India. The SIR was conducted in Bihar earlier, beginning in June; the Assembly election has just been held in the State.

The Opposition had opposed the SIR in Bihar on various grounds which included the haste with which such a massive exercise was sought to be done. The Opposition challenged it in the Court on the ground that, *inter alia*, the ECI's power to conduct such an extensive revision after a summary revision done as recently as in 2024 was unconstitutional. Although the Court made some interim observations and directions to protect a voter's right, the constitutional issues have not been settled.

The ECI claimed, while justifying the SIR in Bihar, that the last SIR had been conducted in 2002-03 with demographic changes since then due to large-scale urbanisation, migration and death. Therefore, it was necessary to revise the roll comprehensively to reflect the latest demographic picture in the State.

The issue of timing

The ECI, no doubt, has the statutory right to conduct a comprehensive revision of the electoral roll. But the question as to why it should be done just a couple of months before elections to the Assembly has remained unanswered. The point is that intensive revision involves a massive exercise of enumeration which requires enumerators to visit every household and collect data, deal with claims and objections and decide appeals. In fact, between 2003 and 2024, there have been five general elections to the Lok Sabha and many elections in the States and Union Territories. But the ECI did not conduct an SIR anytime during this period, which is unexplainable. Therefore, it is intriguing why the ECI has chosen to conduct an SIR just before the Bihar elections and now a few months before the Assembly elections in Kerala, Tamil Nadu and West Bengal.

The preparation and the revision of the electoral roll in the country is dealt with under Section 21 of the Representation of the People (RP) Act, 1950. This section provides for the revision of the roll before the general election to the Lok Sabha or the State Assemblies and revision in "any year" if the ECI so directs.

Although the top court made interim observations and directions to protect a voter's right, the Election Commission of India's actions do raise questions

On revisions and voter citizenship

It also provides for a special revision in any constituency or a part of it on the direction of the ECI. A careful reading of this legal provision would reveal that the revision before the general election is mandatory and the other revisions are done as and when the ECI directs this; the reasons have to be recorded by the ECI for undertaking such revisions.

Further, a closer look at Rule 25 of the Registration of Electors Rules 1960 would show that revision of the roll done before the elections under Section 21(2)(a) is summary in character and the revision done under Section 21(2)(b) in 'any year' is an intensive revision. The intensive revision is akin to the preparation of a new roll.

Intensive revision, as the name implies, is a comprehensive, and hence time-consuming exercise. Therefore, it should be presumed that this exercise is delinked from the elections and is done in any year when there is no likelihood of a general election. Since the revision before the election is linked to the elections, it can be reasonably assumed that only a summary revision can be done before an election. So, the SIR of the rolls just a couple of months before the elections is not envisaged under the RP Act, 1950.

Another important issue which has come up in the context of the SIR is the nature of the documents which are sought by the ECI to prove the citizenship of voters. Under Article 326 of the Constitution, a voter has to be a citizen of India. So, the issue of citizenship becomes important at the time of enrolment of voters in the electoral list. The documents demanded by the ECI from applicants did not include Aadhaar as the ECI is of the opinion that Aadhaar is not a proof of citizenship.

The matter was settled by the Supreme Court, through an interim order, by directing the ECI to accept Aadhaar also as a document to establish the identity of the voter. As a matter of fact, the main question that arises here is what exactly the powers of the ECI are to determine which documents are necessary to prove the citizenship of Indians.

Citizenship is governed by Articles 5 to 11 of the Constitution and the Citizenship Act of 1955. Under these, Indian citizenship is acquired by birth, descent, registration and naturalisation. The point to note in the context of the SIR is that the law relating to citizenship is administered by the Ministry of Home Affairs and not the ECI. Article 326 says that only a citizen can be the voter, so the question of citizenship of the voter becomes crucially important when the electoral roll is prepared by the ECI which has the exclusive authority to prepare the roll for election to the Assemblies and Parliament. But how does the ECI determine citizenship? Or can the ECI specify the documents to prove the citizenship of voters?

The simple answer is that the ECI is not the authority which can specify the documents to prove citizenship. It can be done only by the Ministry of Home Affairs of the Government of India. In fact, the ECI can only verify the documents so notified by the government. It is legally not right for the ECI to say that it has the power to determine the citizenship question and to not accept a particular document for this purpose. But the problem is that the Ministry of Home Affairs has so far not notified any comprehensive list of documents which are required by voters to prove their citizenship. In fact, Article 326 impliedly requires the government to specify such documents. In the absence of such a list, the ECI arrogates to itself the power to specify the list of documents which voters should produce before it to prove their citizenship. How can the ECI exercise a power which is vested in the Home Ministry?

A key decision

It is not clear how many voters whose names were in the roll till 2024 were removed from the voters' list in Bihar after the SIR on the ground that they are not citizens because they could not produce any of the documents specified by the ECI. In this context, the Supreme Court's decision in *Lal Babu Hussein And Others v. Electoral Registration Officer And Others* (1995) is of crucial importance. It said: "In the second situation, since the name is already entered, it must be presumed that before entering his name the concerned officer must have gone through the procedural requirements under the statute".

Article 14 forbids any arbitrary action by the state or its agencies. Article 21 forbids the deprivation of the liberty of any person except in accordance with a fair and just procedure. The legal and constitutional authorities need to adhere to these constitutional directions.

Exploited workers, a labour policy's empty promises

Rejimon Kuttappan

is a forced labour investigator

In July, while probing instances of forced labour in the seafood industry on India's eastern coast, this writer met hundreds of women driven to desperation, peeling fish heads on cold tables without gloves, all for meagre wages as farming failed their families. Promised Employees' State Insurance (ESI) and Provident Fund benefits at the time of recruitment, they were reclassified as "daily wagers" a month before my visit. There was a modest wage hike, but they lost both benefits as the company stopped contributions. Vulnerable, they toil long hours –trapped in exploitation that has come to define forced labour – exposing the fragility of their legal safeguards in India's labour landscape.

Against this grim backdrop – where 11 million people endure modern slavery in India, the world's highest – the Bharatiya Janata Party-led government unveiled the draft Shram Shakti Niti 2025, which is claimed to be a "future-ready" policy cloaked in "ancient Indian ethos" from texts such as Manusmriti, but is blind to the brutal realities that workers face.

A case of 'employer ease'

Since late 2021, this writer has interviewed thousands of workers in steel factories, sandstone quarries, seafood plants, and textile mills (across west, northwest, east and south India) hired through middlemen on daily wages, without contracts and stripped of their rights. Paid off the payroll through contractors, these workers are denied legal benefits, languishing as part of the 90% informally employed workforce in India, as in a 2024 International Labour Organization (ILO) report.

This policy flouts labour laws, enables wage theft and erodes worker dignity, defying constitutional protections under Articles 14, 16, and 23. It is a cynical rebrand favouring cultural nostalgia and employer ease over justice for workers.

The policy introduces a portable Universal Social Security Account, merging Employees' Provident Fund Organisation, Employees' State Insurance Corporation, Pradhan Mantri Jan Arogya Yojana, e-SHRAM, and State boards for lifelong health, pension, maternity, accident, and life insurance across sectors – invoking Article 41 (right to work, education, and public assistance).

Yet, it dodges funding – no gig employer mandates or state matches – risking the e-SHRAM's paltry payouts. Digital IDs, in a situation of only 38% household literacy, result in the exclusion of women, senior citizens and low-literates, violating Article 15. Further, the absence of union safeguards affects bargaining. The initial phase must enforce offline access and tripartite funds, else this is a case of exploitation.

On the occupational safety front, the policy pledges strict enforcement of the 2020 Occupational Safety, Health and Working Conditions Code, with risk audits and gender-sensitive standards, honouring Directive 42 (state can make provision to secure just and humane conditions of work and for maternity relief) and ILO Convention 155 (women's care-role risks).

But the goal of "near-zero fatalities" by 2047 appears fanciful without penalties and given the reality of inspector shortages. Digital tools exclude informal workers, undermining equality; ignoring gig mental health, while union audits weaken Article 19.

The draft Shram Shakti Niti 2025 further exposes the gaps in India's labour landscape

Areas of concern

The hints that the Ministry of Labour and Employment (MoLE) will become an employment facilitator, by using the Artificial Intelligence (AI)-driven National Career Service (NCS) for job matching, credential checks, and skill alignment in Tier-II/III cities and micro and small medium enterprises, merging Skill India to tackle 91.75% graduate mismatches. Yet, absent AI bias safeguards risk caste- and gender-based Article 15 violations.

Ignoring the Wages Code minima for 12 million gig workers – where "flexibility" is a cover for abuse – and unclear transition benefits demand ethics audits and union-vetted algorithms to curb tech-driven inequality.

The policy targets 35% female labour participation by 2030 (from 33.7%) through affordable childcare, flexible gigs, equal pay and apprenticeships –aligning with Article 15's gender equity and the ILO Convention 195's mobility goals. However, without quotas, penalties or sufficient maternity support for informal workers, there can hardly be success. Overlooking youth mental health and caste-gender data gaps hides the unique challenges that Dalit women face, making union-led audits essential for true dignity and progress.

The policy's green-tech vision promotes AI-enhanced safety measures and reskilling opportunities for coal workers, aligning with the climate goals of Sustainable Development Goal 13 and the livelihood rights of Article 21. However, "just transitions" lack substance without income support or union involvement, risking violations of ILO Convention 29. Widening rural-AI gaps and urban-centric green jobs marginalise 400 million informal workers. Tripartite funding and Organisation for Economic Co-operation and Development (OECD) safeguards are essential to avert an exploitative eco-trap that undermines dignity.

The policy, which hints at convergence through Labour and Employment Policy Evaluation Index (LEPEI) dashboards, aims to realise Article 12's vision – of just governance – by linking the National Education Policy with Digital India. However, weak enforcement of the Digital Personal Data Protection Act risks enabling surveillance and undermining Article 19's freedoms.

Amid exploitation and digital optimism, the Shram Shakti Niti 2025 projects a "rights-driven, future-ready" vision for Viksit Bharat. But there are gaps beneath its ambitious rhetoric such as weak regulatory oversight, digital exclusion, unenforced penalties and a fragile adherence to ILO conventions. All these would only accelerate the decline of unions in an expanding gig economy.

It is about dignity, rights and justice

Without concrete funding and institutional safeguards, the promise of universal social protection may collapse under its own weight. For millions trapped in informal and forced labour, the policy's success will ultimately be measured not by its digital dashboards, but by its power to restore dignity, rights, and justice to India's working poor.

The 2025-47 rollout needs urgent pilots, with rights audits for accountability. There needs to be tripartite enforcement, offline access for digitally excluded workers, and transparent grievance redressal. Without these, there is the risk of symbolic rhetoric over justice for India's labouring millions.

When data became the first responder

Andhra handled Cyclone Montha with maturity in disaster governance

STATE OF PLAY

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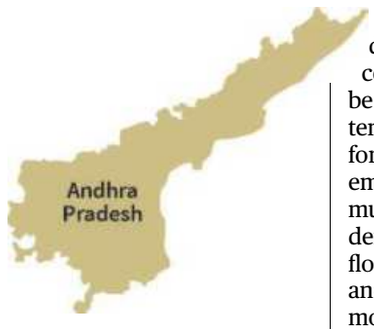
Andhra Pradesh displayed a new level of maturity in disaster governance while dealing with Cyclone Montha, which struck the State's coast between October 27 and 30. Drawing lessons from the past, Andhra Pradesh fought back with precision – guided by data, technology, and teamwork.

The coordinated and technology-driven response demonstrated how governance can evolve from reactive relief to proactive resilience. Instead of waiting for disaster to strike, Andhra Pradesh anticipated it – pre-positioning resources, keeping transformers ready, and ensuring uninterrupted road access for rescue and restoration.

Digital dashboards, predictive analytics, drone surveillance, and GIS tools replaced traditional paperwork and panic-driven coordination. Through the Andhra Pradesh Weather Forecasting and Early Warning Research Centre (AWARE 2.0) and the Real-Time Governance Society (RTGS), the government built a live, interconnected decision system linking departments from Police and Revenue to Health and Panchayat Raj. The RTGS-led Data Lake project aims to integrate all departmental data to improve efficiency, enable services such as digital document storage, and strengthen analytics-based decision-making.

AWARE 2.0's forecasts proved remarkably accurate, predicting wind speeds between 80 kmph and 100 kmph, closely matching the actual 87 kmph recorded. The system enabled 72-hour early alerts



and facilitated the evacuation of around 10,000 people from high-impact zones in Kakinada and Konaseema. Over 1.1 crore safety messages were sent to citizens, while more than 12,000 grievances were tracked and resolved in real time through the Manamitra citizen engagement platform. Generators, pumps, and heavy machinery were positioned in advance, ensuring immediate response capability. Power utilities deployed transformer repair teams in advance as well, while digital inventory systems tracked resource deployment to eliminate duplication and ensure that smaller mandals were not overlooked.

National Disaster Response Force and State Disaster Response Force teams were deployed in advance across the coastal belt. Critical equipment, from communication kits to high-capacity pumps, was stationed in vulnerable areas. Arterial roads were kept clear for emergencies. Digital inventory management allowed the government to track where every machine, transformer, and vehicle was located.

Now that is over, officials and experts agree that Cyclone Montha must not remain a one-off triumph, but serve as a blueprint for institutionalised resilience. Technology, while indispensable, cannot guarantee safety on its own. True resilience demands that preparedness become a daily practice. Schools and community buildings must be retrofitted as cyclone shelters; coastal regions reinforced with mangroves and embankments; and budgets must earmark funds for underground power cabling, flood-resistant embankments, and real-time sea-level monitoring.

Andhra Pradesh now has a strong operational blueprint, but sustaining it requires consistent investment and policy continuity. The private sector, too, has a role, by integrating disaster resilience into Environmental, Social, and Governance commitments through insurance coverage, climate-proof infrastructure, and corporate participation in local disaster planning.

Odisha's long-term transformation offers a reference. Since the devastation caused by the 1999 super-cyclone, the State has evolved a community-based preparedness model. Andhra Pradesh can emulate this model by empowering panchayats, decentralising disaster budgets, and embedding climate literacy across administrative levels.

While 'zero casualty' goals rightly focus on saving lives, fiscal planning must also prioritise long-term infrastructure resilience. Disaster mitigation funds should be directed toward strengthening power grids, communication networks, and transport corridors to withstand high-velocity winds and saline corrosion.

Cyclone Montha also exposed the broader ecological dimensions of vulnerability. Deforestation, mangrove loss, and unregulated coastal construction have eroded natural defences. Sustainable coastal planning and ecosystem restoration must, therefore, complement technological innovation.

India recorded the highest greenhouse gas emissions for 2024

However, in per capita terms, India's emissions remained less than half the global average

DATA POINT

The Hindu Data Team

In 2024, India registered the largest absolute increase in greenhouse gas (GHG) emissions among all countries compared to the previous year. India was the third largest overall emitter of GHGs in 2024, behind only China and the United States, in absolute terms. However, its per capita GHG emissions remained less than half the global average, highlighting the country's relatively low emissions intensity despite rapid absolute growth.

Worldwide, GHG emissions are on an increasing trend. In 2024, 57,700 metric tonnes of CO2 (MtCO2e) of anthropogenic GHG was emitted, the highest on record **(Chart 1)**.

Fossil CO2 emissions from burning coal, oil, and natural gas accounted for 69% of GHG emissions in 2024 **(Chart 2)**. Emissions from power generation were the largest single source for fossil CO2. This was followed by emissions from industrial combustion, transportation, and fuel production. Anthropogenic CH_4 (methane) emissions – emitted majorly during agricultural and waste management procedures – accounted for 16% of GHG emissions, the second largest share. Deforestation and land-use change also amounted significantly to this year's rise in emissions.

In 2024, India's per capita GHG emissions was 3 tCO2e, less than half of the global average of 6.4 tCO2e **(Chart 3a)**. However, India's per capita GHG emissions grew at 3.7% between 2023 and 2024, much higher than the global average of 0.04% increase **(Chart 3b)**.

The 57,700 MtCO2e worth of GHG emitted globally in 2024 was 1,500 MtCO2e higher than 2023. India contributed 165 MtCO2e to this rise, the highest among all nations. China stood second, contributing 126 MtCO2e **(Chart 4)**.

Carbon climb

The data for the charts were sourced from the United Nations Environment Programme (2025)'s 'Emissions Gap Report 2025: Off target – Continued collective inaction'

Chart 1: Total net anthropogenic greenhouse gas emissions by gas, 1990–2024

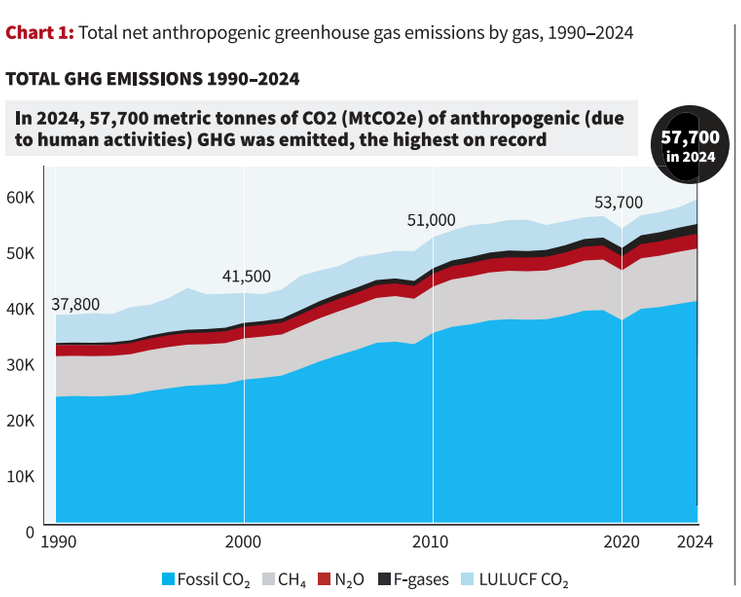


Chart 2: Total net greenhouse gas emissions by gas, sector, and fossil or non-fossil category in 2024

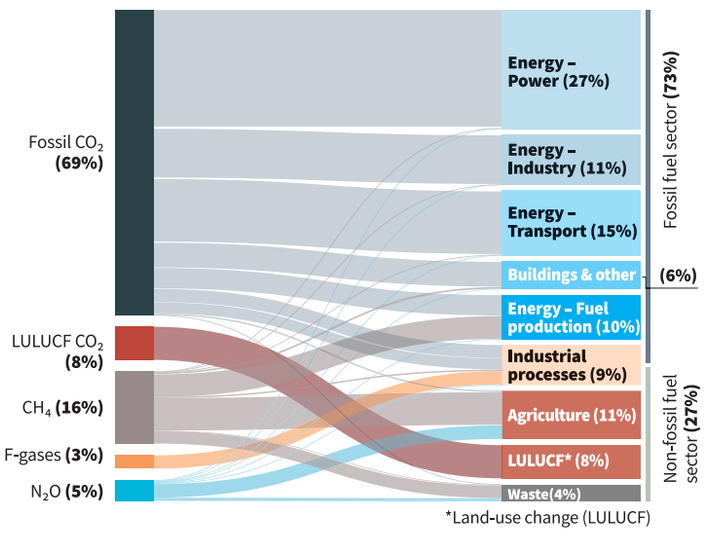


Chart 3A & 3B: Per capita greenhouse gas emissions of the six largest emitters (tCO2e/capita/year).

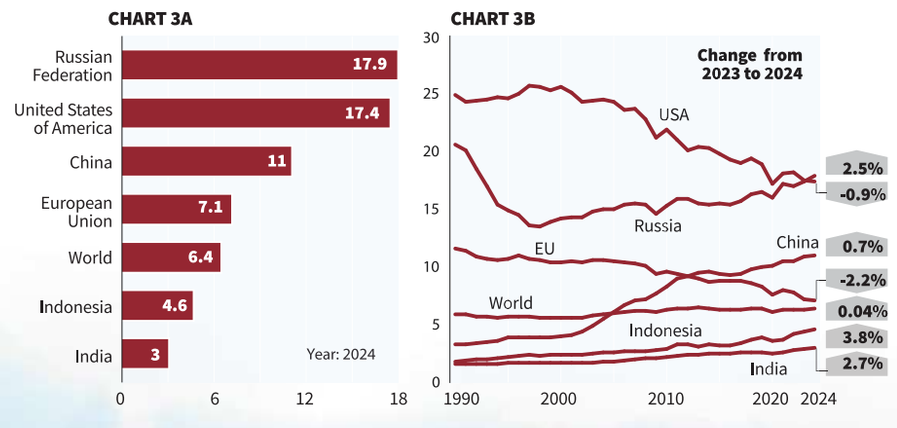
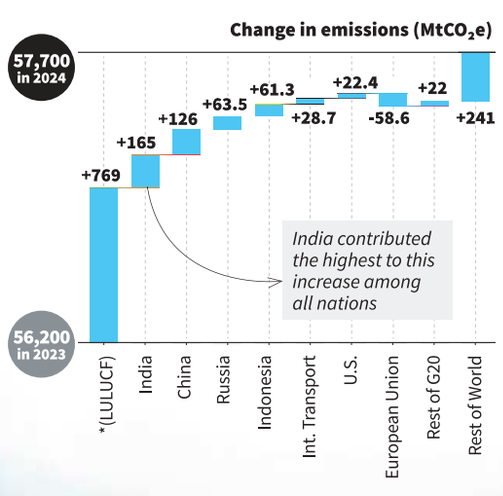


Chart 4: Contributions to the increase in GHG emissions in 2024 from 2023 levels of select actors



Text&Context

The share of Indians showing signs of high blood sugar

50 In per cent. An analysis of four million lab test reports by PharmEasy has revealed that one in two Indians tested showed high blood sugar levels, indicating widespread hyperglycaemia. Among those tested who had high blood sugar, 51.9% were men and 45.43 % were women. PTI

What do forensic experts do after blasts?

What is the primary job of forensic experts in cases of blasts or explosions? How do they determine whether an explosion was intentional or accidental? What are some of the tests they conduct on the samples they collect from the site? Do multiple divisions of a forensic science laboratory collaborate?

EXPLAINER

Shamim Haque Mondal

The story so far:

On November 10, New Delhi witnessed a massive explosion near the Red Fort complex. An i20 car parked at the signal of the complex exploded, destroying several nearby cars, buses, and the people inside them. As of now, 13 people have been confirmed dead.

What do forensic experts do?

Experts of the Explosives Department of the Delhi Forensic Laboratory visited the scene within half an hour along with police personnel. The primary job of forensic experts in such situations is to observe and analyse the cause from a scientific perspective. They collect necessary samples and arrange for quick laboratory tests so that the cause of the accident can be found, or the identities of the people involved in the crime can be verified in a science-based manner.

It is worth noting that various media houses often report that forensic members collect samples from the site, which is partly accurate; the site does provide a wealth of information for any skilled forensic expert. However, an explosion is different from other crimes; here everything is shattered in an instant. Explosions generate intense pressure and heat, causing everything at the scene to burn to ashes, thereby complicating the work of experts. Despite the challenges, they persist in their efforts. Locard's principle states that a criminal will leave something at the scene and bring something when he arrives; both are equally important as evidence in forensics. Thus, there must be a sample linking the suspect to the scene, from which it could be possible to guess the intensity of the explosion, the source, and what kind of explosives were used.

Photographers are also present and take pictures of the site from different angles, and experts make a sketch of it, which serve as a guideline for various stages of analysis. Along with this, various burnt pieces (which experts call debris), broken parts of the car, carbon powder, etc. are collected from the scene. These samples are then analysed by explosives experts in the laboratory using spectroscopic and chromatographic techniques to determine the type of chemicals used.

Probing: Forensic technicians work at the site of the explosion in New Delhi, on November 10. REUTERS

During the on-site inspection, it is necessary to figure out if any piece of electronic gadget has been found, because in remote-controlled explosions, an auto-timer, the best activation technique, is usually used. However, no timer or electronic circuit has been found in the Delhi incident.

What kind of tests are done?

After gathering and analysing the initial data, experts then try to reconstruct the crime scene to better understand the explosion's timing. For this, experts use Fourier Transform Infrared Spectroscopy (FTIR) and Attenuated Total Reflectance-FTIR (ATR-FTIR). In these tests, forensic experts analyse the spectrum of the absorbed light to find out how the collected samples interact with infrared light.

The chemical composition of explosives is detected using field-specific Raman spectroscopy. Advanced Scanning Electron Microscopy (SEM) is used to analyse the morphology of the fragments found after the explosion, while Energy Dispersive X-ray (EDX) techniques are used for fundamental analysis of the residues. Scientists also use thermal analysis to determine information about explosives, such as chemical activity and stability.

Additionally, fire is an important factor in any explosion – how it spreads, how far it spreads, and the total loss caused by fire all depend on statistical data. That's why experts use laser-based scene mapping, flashpoint testing, etc. to try to determine the source of the fire and the presence of any combustible material that caused it to spread so much. Therein they decide whether it was an accident or an intentional explosion.

Are only explosives experts involved?

In the current incident, the role of the vehicle is crucial. Therefore, CCTV footage of the car needs to be thoroughly examined to find out whether anyone got in or got down in order to form an idea about the attacker. A cyber-forensic expert is necessary to achieve this.

Again, experience says that in any accident, especially in the case of organised heinous crimes like explosions, the engine number and the chassis (the metal frame of a vehicle onto which the other parts fit) number of the cars are changed before they are used for the crime purpose, so it is necessary to find out the actual engine number and chassis number of the car with the help of 'thermochemical examination,' which is popularly known as etching. Typically, the investigating agency employs a forensic physicist for this. Moreover, DNA analysis of the body parts found at the crime scene is a must, as their families are waiting.

Therefore, in the event of an explosion, multiple divisions of a forensic science laboratory must collaborate to assist investigators in solving the crime and to ensure that the scientific analysis of various evidence is presented before a court of law.

Shamim Haque Mondal is a researcher in the Physics Division, State Forensic Science Laboratory, Kolkata.

THE GIST

- Experts of the Explosives Department of the Delhi Forensic Laboratory visited the scene within half an hour along with police personnel.
- Fire is an important factor in any explosion — how it spreads, how far it spreads, and the total loss caused by fire all depend on this statistical data. That's why experts use laser-based scene mapping, flashpoint testing, etc. to try to determine the source of the fire and the presence of any combustible material that caused it to spread so much.
- In the event of an explosion, multiple divisions of a forensic science laboratory must collaborate to assist investigators in solving the crime.

Why do astronauts wear pressurised suits?

Why is it mandatory to wear IVA suits during ascent and descent of the spacecraft?

Unnikrishnan Nair S.

Space is the vast area beyond the earth's atmosphere, filled with stars, planets, and galaxies. In this airless environment, one of the most critical differences from life here is the absence of atmospheric pressure.

Why is pressure important?

The atmosphere is a thick layer of gases held around the earth by its gravity. It protects us from harmful solar radiation, keeps temperatures stable, and provides gases to respirate. The atmospheric pressure presses down on our bodies with about 20 tonnes of force, but we don't feel it because our bodies have evolved to push back with equal force, balancing it out. As we go higher, the atmosphere gets thinner and its pressure drops.

When a human body is suddenly exposed to vacuum, a sequence of sudden lethal effects occur, including ebullism (boiling of bodily fluids at low pressure), decompression (rapid loss of atmospheric pressure in a spacecraft), and lack of oxygen (hypoxia). The absence of atmospheric pressure causes gases to expand rapidly in the lungs and tissues, leading to loss of consciousness in seconds and death in a few minutes.

How are astronauts protected?

Astronauts wear special suits during space travel for their safety. Extra-vehicular activity (EVA) suits or spacesuits are for walks and work outside the spacecraft, like fixing external components and conducting maintenance. They have 12-14 layers and serve as a personal spacecraft, protecting its wearer against the vacuum of space, extreme temperatures, radiation, and space debris. Each EVA suit weighs 100-130 kg. Likewise, intra-vehicular activity (IVA) suits are worn inside the spacecraft and include a flight suit and a pressure suit. A flight suit is a general-purpose garment worn by pilots and astronauts, primarily for fire resistance, and protection against environmental conditions like temperature extremes or low pressure at high altitudes. A pressure suit is a specialised garment designed to protect against the extremely low pressure environment of high altitudes or space. It provides full-body pressurisation, oxygen supply, and thermal regulation, making it more robust than a standard flight suit. The pressure suit weighs about 8-10 kg and has two or three major layers, depending on the model.

In 1961, Yuri Gagarin, the first human to go to space, wore a specialised IVA suit called SK-1. The U.S. and Russia have developed eight to 10 IVA suit designs.

Is wearing an IVA suit mandatory?

In the tragic Soyuz 11 mission in 1971, three cosmonauts died when returning to the earth. When the crew's descent module separated from the orbiting module, a vent valve meant to balance cabin pressure opened too early at about 168 km altitude. It didn't close properly, causing the air to rush out quickly, suffocating the cosmonauts. The disaster led to major safety changes in the Soviet space program, including bringing in a mandate to wear IVA suits during ascent and descent. These phases are dynamic and under exigency may involve high G-forces, sudden loss of cabin pressure, extreme heat, and vibrations, all of which pose serious risks.

Which IVA suit does Gaganyaan use?

In Gaganyaan, India's first human spaceflight mission, the 'gaganyatris' will be using the Russian Sokol KV2 suit manufactured by Zvezda. The suit consists of two layers: an inner pressure bladder made of rubberised polycaprolactam to remain airtight, and an outer restraint layer of white nylon canvas for structural support and protection. Many astronauts have worn the Sokol suit and it has been involved in more than 128 Soyuz crewed missions. While the Sokol suit provides vital assurance, it also underscores a key phase in India's space journey: leveraging global expertise while pursuing the goal of indigenous human spaceflight capability.

Unnikrishnan Nair S. is Former Director, VSSC; Founding Director, HSFC.

THE GIST

- The atmosphere is a thick layer of gases held around the earth by its gravity. It protects us from harmful solar radiation, keeps temperatures stable, and provides gases to respirate.
- A pressure suit is a specialised garment designed to protect against the extremely low pressure environment of high altitudes or space.
- In Gaganyaan, India's first human spaceflight mission, the 'gaganyatris' will be using the Russian Sokol KV2 suit manufactured by Zvezda.

KEYWORD

What's the status of the rare earth hypothesis?

Findings from the Kepler and James Webb Space Telescope suggest that while earth-sized planets in habitable zones are not as rare as once thought, the conditions necessary for complex life may still be uncommon

Vasudevan Mukunth

The rare earth hypothesis was proposed in a 2000 book by palaeontologist Peter Ward and astronomer Donald Brownlee. It argues that while simple, microbial life may be common in the universe, complex, multicellular life is likely uncommon. The idea is rooted in a particular place in the universe meeting a chain of successive conditions.

While we often talk about life as ranging from simple (e.g. bacteria and yeast) to complex (e.g. humans and octopuses), life itself is a complex phenomenon and the product of many factors falling in place. Studying these factors on the earth itself has been an arduous and even now an unfinished task; and looking for them on planets located several light years away remains extraordinarily fraught. Scientists studying the possibility of life on other planets have busied themselves with particular aspects over time. Some focus on planetary ingredients such as a rocky world with surface water in the habitable zone of the host star. Other scientists have been concerned with system-level architectures such as giant planets in particular places in the universe. Still others have been looking into long-term climate regulation and a persistent atmosphere. And so on.

Since 2000, we have accumulated significantly more data about exoplanets and planetary science. And the big picture that has emerged is mixed: several conditions required for life look less restrictive than scientists once feared whereas many others look harder to meet than scientists had hoped.

An illustration which shows a hycean world — an exoplanet with a liquid water ocean beneath a hydrogen-rich atmosphere — orbiting a red dwarf star. REUTERS

Understanding a planet

Let's consider how often potentially habitable earth-sized planets occur. Studies based on early data from the NASA Kepler telescope (2009-2018) suggested that a significant fraction of sun-like stars in the Milky Way galaxy hosts small planets receiving starlight comparable to what the earth receives. One study even found that roughly a fifth of sun-like stars may harbour earth-sized planets in their habitable zones, although the data had many uncertainties.

More recent work has concluded, based on Kepler data, that there's a non-negligible rate at which rocky planets occur in the habitable zones of stars called GK dwarfs. These and similar findings have concluded that worlds of roughly the right size at roughly the right distance from a suitable star are not rare, thus weakening the most sweeping claim in the hypothesis. The question has thus shifted from 'where a planet is' to 'what a planet is like'. In the solar system, Mercury is too close to the sun to host earth-like life whereas Pluto is too far away. But while both the earth and Venus are in the sun's habitable zone, Venus's atmosphere renders it deadly for earth-like life.

One important open issue is whether small planets around cool, active M-dwarf stars can retain their atmospheres and surface water over billions of years. Modelling studies have indicated that planets that spend millions of years exposed to intense stellar radiation – like that M-dwarf stars are known to emit – tend to lose water and build up false-positive oxygen atmospheres.

Say intense ultraviolet radiation from an M-dwarf star breaks up water molecules on the planet: $H_2O \rightarrow H^+ + OH^-$. Further breakdown leads to O and H atoms accumulating in the atmosphere. Over time, the H escapes to space more easily than O, and the O atoms left behind pair up to form O_2. If there aren't enough surface 'sinks' that can absorb this oxygen fast enough – the way rocks and oceans do on the earth – the O_2 will accumulate. When a telescope looks at this planet and finds an excess of oxygen in its atmosphere, scientists may think the planet's surface has photosynthesis, which is how the earth's atmosphere has lots of oxygen. But it's actually due to the M-dwarf star's radiation.

On the other hand, some planets around M-dwarf stars can keep their air for a long time, even if most can't. If the star's magnetic outflows – streams of charged particles blown off the star by its magnetic field – are weak or shaped in such a way that they don't hit the planet hard, and if the planet is farther out and cooler, its atmosphere will be eroded more slowly. A strong planetary magnetic field can also deflect a part of the stellar wind, while a massive planet with ongoing volcanic activity can replace some of the lost gases.

These are all system-specific conditions that require a specific mix of star activity, magnetic fields, orbit, planet mass, rotation, and internal heat. When they line up well, a planet can retain its atmosphere for billions of years. However, such planets are in the minority because M-dwarf stars often produce strong flares and many close-in planets lack strong magnetic shields.

Scientists can directly test these observations today. Using NASA's James Webb Space Telescope (JWST), astronomers have started measuring the heat emitted from nearby rocky exoplanets. In TRAPPIST-1c, which is located near the inner edge of its system's habitable zone 40.7 lightyears away, the JWST has ruled out a thick atmosphere rich in carbon dioxide. Previously, scientists using JWST data had also found that the innermost planet, TRAPPIST-1b, likely lacked a substantial atmosphere.

These are only two worlds in one system, yet they show that earth-sized isn't synonymous with earth-like. Scientists still need more measurements of cooler, more temperate planets to understand how often atmospheres survive where earth-like life could plausibly persist.

Climate stabilisation

Another pillar of the rare earth hypothesis is long-term climate stabilisation. On the earth, the weathering of continental rocks and the recycling of carbon between the earth's interior and the atmosphere have buffered the climate over geologic time. Many researchers have linked this buffering to plate tectonics, which subduct a carbonated crust and build new surface rocks. This said, the interiors of planets behave in different ways. Rocky planets can have one stiff shell that barely moves, long quiet times broken by short bursts of crust movement or plate-like tectonics (as on the earth). A planet can even switch between these modes over time. Some models also show that without modern plate tectonics, a planet might still keep a habitable climate by balancing volcanism (which adds gases), weathering (removes gases), burial (traps materials), and crustal foundering (sinks the crust). Scientists don't have consensus either: while plate tectonics could help maintain a stable climate that in turn can support complex life, it may not be strictly required for life to begin.

The role of giants

A third line of debate is the role of giant planets like Jupiter. The old intuition was that Jupiter 'shields' the earth by deflecting comets and asteroids. Subsequent studies have complicated this story, however. Depending on a giant planet's mass and orbit, scientists have found that it can reduce or increase the flux of impactors to the inner system and it can also deliver water-rich bodies early on. In other words, there seems to be no universal 'filter' on this front; it all depends on the system's architecture. This conclusion has weakened the claim that a Jupiter-like planet is a necessary precondition for complex life on a rocky planet in the same system.

Thus, on the question of finding small, temperate planets, many scientists today argue that the occurrence rate of earth-sized planets in the habitable zones of sun-like stars is non-zero and may be a few tens of percent, per Kepler data, depending on the definitions and extrapolations. That undermines the notion that the earth's basic orbital and size configuration is vanishingly uncommon. On the other hand, on the question of planets' ability to retain atmospheres, have long climate cycles, be able to avoid catastrophic events, and so on, the data has become more sobering. The results keep open the possibility that truly earth-like surface environments supporting complex biospheres are less common than the count of earth-sized planets in the habitable zone would suggest.

Not definitive

Two more threads bear on the rare versus common debate. First, a recent effort to place an upper limit on the number of earth-like planets emphasised that a lot hinges on atmospheric processes that scientists can't yet survey at scale. Second, searches for technosignatures – signs of technology made by extra-terrestrial life, especially things nature is unlikely to produce on its own – have sharpened the limits on the prevalence of civilisations whose activities emit radio waves (such 'radio-loud' activities on the earth include broadcasting for TV and radio and air traffic control). Multi-year surveys of thousands of stars by the Breakthrough Listen project haven't found any convincing signals so far. While not detecting something doesn't prove that it's absent, it sets upper limits on how common it could be in the cosmos.

Taken together, the rare earth hypothesis remains plausible for complex life but it can't be said to be demonstrably true. At this juncture, three developments could change the picture: (i) if scientists detect atmospheres on rocky, temperate planets, preferably around sun-like stars, showing gases consistent with active surface water cycles; (ii) if scientists place stronger better constraints on tectonic regimes on exoplanets (even indirectly), indicating whether long-term climate stabilisers are widespread or rare; and (iii) scientists detect biosignatures or technosignatures. The first steps are already underway. Extremely large ground telescopes currently under construction as well as future space missions are aimed squarely at planets with temperate atmospheres.

Until their observations mature, however, a fair summary seems to be: while microbial life could be common, long-lived ecosystems straddling land and ocean and capable of producing complex life may still be scarce. This seems to be as far as the data can take us today.

From Page One

SC says SIR is not the first voter list revision; Opposition says it's being done in haste now

Krishnadas Rajagopal
NEW DELHI

The Supreme Court on Tuesday interrogated Opposition parties, leaders, and NGOs for their negative portrayal of the Election Commission's special intensive revision (SIR) of electoral rolls, including their claims that the exercise amounts to "citizenship screening" in disguise and threatens to disenfranchise lakhs of voters.

"You people want to project as if revision of electoral rolls is happening for the first time in this country! We also know the ground reality. A Constitutional functionary is undertaking an exercise... There can be some procedural deficiency. Those can be pointed out and rectified. You are saying as if the democratic process is being threatened... There is already an electoral roll, this is just a process to revise it," Chief Justice of India-designate Justice Surya Kant said, addressing Tamil Nadu's ruling party, the Dravida Munnetra Kazhagam (DMK), and leaders from West Bengal.

In progress: Booth-level officials distribute enumeration forms as part of the SIR on the Mousuni Island in West Bengal. AFP

Tamil Nadu and West Bengal are among the 12 States and Union Territories included in the second phase of the SIR exercise, announced on October 28, covering 51 crore voters.

Hasty process

Senior advocate Kapil Sibal, representing the DMK and some West Bengal MPs, took on the challenge from the Bench, responding that revisions have indeed happened in the past, but pointing out that the process in those instances was careful and long, taking almost three years.

"Now, the EC wants it done in a month... Ultimately, lakhs of people are going to be excluded from the voter list," he replied.

The enumeration stage for SIR 2.0 will continue till December 4 and the EC will release the draft electoral rolls on December 9. The final electoral rolls will be published on February 7, 2026.

The senior counsel said that only 61.43% enumeration forms have been given out in Tamil Nadu so far, during seven days of distribution till November 10. Of these, only 4,713 forms have been digitised. "If this is taken into account, lakhs of forms cannot be digitised before the date of publication of the draft electoral roll. Hence, there is imminent danger of lakhs of voters losing their franchise," Mr. Sibal argued.

Mr. Sibal termed the current SIR a "farcical exercise", referring to the EC's inexplicable inclusion of an "extract of the electoral roll of Bihar SIR with reference to July 1, 2025" in its list of 13 types of documents that could be submitted as proof of identity during scrutiny in the second phase of the SIR .

"An extract of the electoral roll of the Bihar SIR has been added as the 13th document. What has the Bihar SIR got to do with elections in Tamil Nadu was not made clear. This has become a cause of confusion in the minds of the electors as well as parties in Tamil Nadu and other States... " Mr. Sibal said.

The Bench issued notice to the EC on the petitions challenging the constitutionality of the SIR.

Advocates Prashant Bhushan and Neha Rathi, appearing for the NGO Association for Democratic Reforms, suggested alternative measures to weed dead and duplicate voters from the electoral rolls.

Mr. Bhushan said the EC had a de-duplication software which can be run to identify duplicate names. Likewise, gram sabhas or panchayat sabhas could be organised to identify voters who had migrated or were dead.

The court listed the case for hearing on November 26.

Don't use COP30 to change Paris deal 'architecture': India

Country says the parties 'must remain committed to and guided by equity'; it urges the Brazil COP Presidency to make a special call to the Parties to submit their National Adaptation Plan

Jacob Koshy
NEW DELHI

India made its opening statement at COP30 in Belem, Brazil, underlining that the climate conference ought to be stressing "adaptation", and the 10th anniversary of the Paris Agreement, signed in 2015, should not be used to "change the architecture" of that consensus.

This "architecture" refers to the agreed-upon principle of "common but differentiated responsibilities (CBDR)", which means that all countries must do their bit to curb fossil fuel emissions but without compromising on national economic-development priorities.

Common cause: Attendees walking in front of the main entrance to the COP30 UN Climate Change Conference in Belem, Brazil. AFP

Dwindling finance

With the withdrawal of the United States from the Paris Agreement and developed countries agreeing to mobilise only $300 billion – and not the demanded $1.35 trillion annually – by 2035 as "climate finance" (to cope with unfolding climate disasters as well as move away from fossil fuels), developing countries, including India, saw this as a reneging on agreed commitments.

"We must remain committed to and guided by equity and common but differentiated responsibilities. The cornerstone principles of the Convention and its Paris Agreement signed all of us to the CBDR in Brazil back in 1992. We must reaffirm our strongest commitment to the principles here, not attempt to sideline and ignore them," India delegation member Suman Chandra said as part of a collective of Like-Minded Developing Countries (LMDC) on Tuesday.

'Architecture' refers to the principle of 'common but differentiated responsibilities'

"Over the next two weeks, we must stay true to the cause and advance adaptation, which is among the most important issues for us. The [Brazil COP] Presidency must make a special call to the Parties to submit their National Adaptation Plan in line with national priorities and progress," she added.

The LMDC is a large collective that represents nearly half of the world's population, and consists of China, India, Pakistan, Indonesia, Bangladesh, Cuba, Egypt and several others.

India is yet to submit its National Adaptation Plan and the updated Nationally Determined Contribution, which specifies steps to curb fossil fuel emission by 2035, to the United Nations.

"We are not here to point fingers, but the facts speak for themselves. We cannot simply bypass the roadblocks and the impediments to implementation," Ms. Chandra added.

"Developed countries need to reach net zero much earlier than projected. They should invest significantly more in negative emission technologies," Tanmay Kumar, Secretary, Environment Ministry and part of the India delegation, said on behalf of a joint statement by another grouping called BASIC (Brazil India China South Africa). The LMDC had pushed for including a discussion on the responsibility of developed countries on the COP30 agenda but in the larger spirit of "consensus" was moved to a separate negotiating track by COP30 President André Corrêa do Lago.

SC judge: imported ideas may not save endangered species

Krishnadas Rajagopal
NEW DELHI

Supreme Court judge Justice P.S. Narasimha on Tuesday said many environmental law principles imported from the West such as "inter-generational equity" are anthropocentric and would hardly be of any assistance in protecting an endangered species from extinction.

Justice Narasimha made these oral observations while hearing a petition filed by M.K. Ranjitsinh on the conservation of the dying species of the Great Indian Bustard, which is being bred in captivity, and the Lesser Florican.

Senior advocate Shyam Divan, appearing for the petitioner, said there were 70 bustards in captivity and 150 in the wild. Lesser Floricans number 70.

"That is all... Captive breeding may be successful with the Great Indian Bustard, but it is not showing success with the Lesser Florican. Extinction is not an option for these two species," he said.

'Biblical roots'

Justice Narasimha said principles such as inter-generational equity had "Biblical" roots, with humans at the top.

The Great Indian Bustard

The judge referred to how, 13 years ago, a *amicus curiae* in the red sanders conservation case, had urged the Supreme Court to consider the "intrinsic worth" of an endangered species rather than its "instrumental value to human beings".

He criticised principles such as inter-generational equity which "pre-supposes the higher needs of human beings and lays down that exploitation of natural resources must be equitably distributed between the present and future generation". The judge said the court, in its judgment in the red sanders case, had accepted his submissions on the need to take an ecocentric approach, which "obliges every citizen to have compassion for all living creatures", in biodiversity law.

States ruled by non-BJP parties insist on wider consultation on draft labour policy and codes

The Hindu Bureau
NEW DELHI

Issues such as the draft labour policy and the implementation of four Labour Codes came up for discussion at the two-day National Conference of Labour & Employment and Industry Ministers and Secretaries of States and the Union Territories that began here on Tuesday.

The Union government said the meeting was aimed at accelerating the implementation of key labour policies and initiatives, decent employment generation, and social security initiatives.

Inaugurating the event, Union Labour Minister Mansukh Mandaviya said the government had placed the citizen at the heart of every policy. Highlighting

The Union Minister launched a mobile app for connecting building and construction workers with employers

the importance of the newly launched Pradhan Mantri Viksit Bharat Rozgar Yojana (PMVBRY), with an outlay of nearly ₹1 lakh crore to create 3.5 crore jobs, he asked the States to align their employment programmes with this national mission for maximum synergy and impact.

Non-BJP-ruled States such as Kerala demanded wider consultation with the States, trade unions and other stakeholders before implementing the new draft labour policy and the four Labour Codes.

Talking to *The Hindu*, Kerala Labour Minister V. Sivankutty said he demanded that the Centre consult all trade unions and the States on the draft labour policy. "I informed the meeting about certain reservations the State has about implementing the four Labour Codes. Wider consultations should be held with workers and their representatives before implementing the policy and the codes," he said.

Labour app

Mr. Mandaviya launched a Digital Labour Chowk app for connecting construction workers with employers. The meeting discussed the draft Private Placement Agency (Regulation) Act to establish uniform rules for placement ecosystem, bringing transparency to recruitment.

ISRO conducts crucial safety tests on main parachutes for Gaganyaan crew

The Hindu Bureau
BENGALURU

The Indian Space Research Organisation (ISRO) recently conducted an important test on main parachutes for the Gaganyaan Crew Module.

The test was conducted at the Babina Field Firing Range (BFFR) in Uttar Pradesh's Jhansi on November 3 as part of the ongoing series of Integrated Main Parachute Airdrop Tests (IMAT) for the qualification of parachute system for Gaganyaan mission.

For the Gaganyaan Crew Module, the parachute system comprises a total of 10 parachutes of four types. The descent sequence begins with two apex cover separation parachutes that remove the protective cover of the parachute compartment, followed by two drogue parachutes that stabilise and decelerate the module. "Upon release of the drogues, three pilot parachutes are deployed to extract three main parachutes, which further slow down the Crew Module to ensure a safe touchdown. The system is designed with redundancy – two of the three main parachutes are sufficient to achieve a safe landing," the space agency said. The main parachutes of the Gaganyaan mission deploy through a step-by-step process known as reefed inflation. "In this process, the parachute first opens partially, which is called reefing, and then fully opens after a predetermined period of time, known as disreefing. This process is carried out using a pyro device," it added. In the recent test, ISRO demonstrated one of the extreme scenarios – delay in the disreefing between the two main parachutes successfully, thereby validating the system for its maximum design conditions. The test evaluated the system's structural integrity and load distribution under asymmetric disreefing conditions, which is one of the most critical load scenarios expected during actual mission descent.A simulated mass equivalent to the Crew Module was dropped from an altitude of 2.5 km using the Indian Air Force's IL-76 aircraft. The parachute system deployed as planned and the sequence was executed flawlessly, and the test article achieved a stable descent and soft landing, validating the robustness of the parachute design.

For the Gaganyaan Crew Module, the parachute system comprises a total of 10 parachutes of four types. Photo: X/@isro

Scientists map neural pathway linking stress to enhanced fears

Stress's benefits for the species come at the cost of long-term changes in defensive responses; for instance, it can exaggerate how you respond to a threat; if someone were attacked in a dark street, they could become afraid of any dark environment, like in movie theatres. This is called stress-enhanced fear learning

Reeteka Sud

In every living being through history, stress from a perceived threat has automatically and immediately triggered an avalanche of reactions.

'Fight or flight' is an example of the choices these life-forms have confronted. Every bodily function that is not essential for survival is moved to the sidelines as the being prepares to respond. All available resources are diverted to extricating oneself from the threatening situation. In this sense, stress has been good for the body and for the species.

Fear response

But it comes at a cost. Stress can also cause long term changes in defensive responses. For starters, it can exaggerate how you respond to a threat. If someone were attacked in a dark street, they could become afraid of any dark environment, like in movie theatres. This is called stress-enhanced fear learning.

Stress can also induce a fear of objects and situations unrelated to the original threat. This is called a stress-enhanced fear response (SEFR).

SEFR has been connected to anxiety disorders, phobias, and post-traumatic stress disorder (PTSD). The question of why this connection exists recently prompted scientists at the University of Texas, Austin, and the University of California, Los Angeles, to closely investigate it in a mouse model.

They found that they were able to induce SEFR in the mice when they were confronted with new cues unrelated to a stressor. This then prompted the team to design careful experiments to identify the precise brain regions and mechanisms driving such behaviour, paving the way for better clinical treatments for conditions like PTSD.

Experimental setup

The team confined lab mice in a conditioning chamber, an aluminium box with a clear door and about a foot long on each side. The control group animals were undisturbed while the stress group was administered a mild electrical footshock (1 mA) at random intervals.

Then the team gave the mice context exposure: the two groups were placed in the same chamber but received no footshock this time. For mice that had received the shocks earlier in a similar chamber, their surroundings sufficed to trigger a freeze response, i.e., they became completely immobile yet hyper-alert.

Freezing is not a conscious choice and happens automatically.

Out in the wild, mice are prey animals, so their self-preservation repertoire includes freezing, fleeing, and simply hoping to avoid detection (e.g., from a predator flying overhead). In the conditioning chamber, the confinement only induced the freeze response.

Next, the team placed these mice in a different chamber, i.e. exposed them to a new context, where they received new stimuli in the form of brief sounds. Even here, the mice displayed a heightened freeze response – an example of unlearned fear and thus of SEFR at work.

Curiously, the stress group mice froze only after they heard the audio tones, not otherwise. It was a sign that the stress mice hadn't generalised the freeze response.

Learned fear behaviour allows us to respond appropriately to cues, but stressful or traumatic experiences can ratchet this response up in response to both learned and unlearned fears, as with PTSD. AEDRIAN SALAZAR/UNSPLASH

Follow the light

How does the brain develop unlearned fear?

The scientists peered into the brains of the stress group mice looking for a particular protein called c-fos. This protein is the "time to get to work" signal for brain cells. They found a part of a brain region called the paraventricular thalamus (PVT) expressing high amounts of c-fos after the audiotone test, but only in mice that received both the footshock on day 1 and the audio tone test later.

If the animals had not faced the footshocks on day 1 or had received the shocks but no audio tone test after, the amounts of c-fos didn't change. In other words, increases in c-fos in the PVT were specific to the unlearned fear response.

Freezing isn't a conscious choice and happens automatically. In the wild, mice are prey, so their self-preservation repertoire includes freezing and fleeing. In the conditioning chamber, the confinement only induced the freeze response

The PVT is named thus because it is a part of the thalamus and is localised around ("para") the third ventricle, one of the cavities inside the brain. The thalamus is a somewhat egg-shaped structure located roughly at the middle of the brain. All information coming into the brain first comes here and is then relayed to other regions for interpretation and response.

The research team suspected that the unlearned fear response stemmed from the PVT being activated, and sought a way to confirm this independently.

When the cells in any brain region prepare to act, they use calcium ions to signal to their neighbours to get ready. So the team injected a calcium-sensing protein genetically modified to light up when it detected calcium. Their observations confirmed that neurons in a part of the PVT were getting activated when the unlearned fear response was on show.

They also showed that when the activity in these neurons was blocked, the stress group mice did not develop the freezing response when exposed to the audio tones.

Remarkably, however, this blocking action didn't change the stress-enhanced fear learning in these mice, proving that the activation of PVT neurons was specific to SEFR.

When more is too much

The experiments by the international team showed that unlearned fear is caused by increased activity in PVT neurons. This is why the team's study is fascinating: the findings highlight that PVT fine-tunes different defensive responses differently.

For example, learned fear behaviour is adaptive, allowing us to respond appropriately to environmental cues. But stressful or traumatic experiences can ratchet this response up manifold in response to both learned, like in the dark movie theatre, and unlearned fears, as with PTSD.

In fact, unlearned fear responses have been particularly difficult to treat because scientists did not fully understand their causes. The new finding, of specific activity in the PVT neurons, may now lead them to new avenues to clinically treat symptoms.

(Reeteka Sud is a neuroscientist by training and senior scientist at the Centre for Brain and Mind, Department of Psychiatry, NIMHANS, Bengaluru. reeteka@gmail.com)

THE GIST

Fight or flight exemplifies the stress response. Every bodily function not linked to survival is moved to the sidelines. All available resources are diverted to extricating oneself from the threatening situation. In this sense, stress has been good for the body and the species

SEFR has been connected to anxiety disorders, phobias, and PTSD. Scientists were able to induce SEFR in mice and design experiments to identify the brain regions driving such behaviour, paving the way for better treatments for conditions like PTSD

Observations confirmed that neurons in the PVT activated when the unlearned fear response manifested. When it was blocked, the stress group didn't develop the freezing response. However, this blocking action didn't change SEFR, proving that activation of PVT neurons was specific to SEFR

BIG SHOT

Say hello to the Milky Way's most active star-forming region, as captured by the James Webb Space Telescope. Called the Sagittarius B2 molecular cloud, it's located only a few hundred light years from the galaxy's central supermassive black hole. NASA, ESA, CSA, STSCI

QUESTION CORNER

All plastics are not the same

Q. Why can we recycle only some kinds of plastics?

A: 'Plastics' is an umbrella term for various materials with some similar properties. Each type of plastic has a different polymer structure and set of additives. These differences decide how a piece of plastic behaves when it is heated, ground down, and remade, which is why only some kinds can be recycled in practice. Thermoplastics like the PET in water bottles and HDPE in milk jugs soften when heated and harden when cooled. This property allows them to be melted, filtered, and reshaped with limited damage, so they are widely collected. Thermosets like the many epoxy resins and some rubber parts form permanent chemical bonds when they're first made. They crack rather than melt when heated, so they can't be recycled by normal heat-based methods.

Even among thermoplastics, recycling depends on purity. Labels, food residues, dyes, fillers, flame retardants, and plasticisers change how the melt flows and weakens the final product. Multilayer packaging combines different polymers (for example, PET, polyethylene, and aluminum) to keep food fresh, but these layers are hard to separate, so the item is often not recyclable.

Collecting, sorting, washing, and remelting also cost money, so recycling happens only when there is a steady demand for the recycled pellets. Bottles and jugs have large and cleaner waste streams and established buyers whereas many films, foams, and mixed plastics don't. Newer chemical recycling methods can in principle break polymers to simpler molecules, but they are energy-intensive and not yet broadly deployed.

Recycling happens only when there is a steady demand for the recycled pellets. STICKERIT/UNSPLASH