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A lepidoptera hotspot, India is home to 8.25% of the world's butterflies, moths

Shiv Sahay Singh
KOLKATA

India is home to 13,703 species of lepidoptera – butterflies and moths – which is about 8.25% of the total lepidoptera found across the globe.

Scientists of the Zoological Survey of India (ZSI) have come out with a detailed "Catalogue of Lepidoptera (Butterflies & Moths) of India", which has been published in the peer-reviewed journal *Zootaxa*.

ZSI scientists Navneet Singh and Rahul Joshi took almost 12 years to complete the monumental work of cataloguing, field exploration, museum curation, and rigorous literature verification.

"There have been attempts to classify and catalogue lepidoptera for over 100 years. There are 13,703 species of butterflies and moths across 3,705 genera,



Of the 13,703 species of lepidoptera found in India, 12,286 are moths and 1,417 are butterflies. M. PERIASAMY

240 subfamilies, 102 families, and 31 superfamilies," Mr. Singh said.

Of the 13,703 species of lepidoptera, 1,417 are butterflies, and the remaining 12,286 are moths, Mr. Singh said.

The scientific work bridges critical taxonomic gaps that have persisted for more than 100 years, since the first historical attempts to document the region's insect fauna, a Press Infor-

mation Bureau release stated. "It firmly positions India among a select group of megadiverse nations possessing a fully updated, centralised, and authoritative baseline inventory of its butterfly and moth diversity," the release said.

Crucial role

Butterflies and moths play crucial roles in maintaining ecological equilibrium, serving as essential herbi-

vores, detritivores, and pollinators, while acting as vital food resources for birds, bats, and other insectivores, the ZSI scientists said.

"These catalogue volumes will serve as a vital national asset for biodiversity research, ecological monitoring, and global conservation strategies. Such comprehensive catalogues ensure these species are given an authoritative voice, a clear legal identity, and a permanent place in scientific history," Dhriti Banerjee, Director, ZSI, said.

Among the 13,703 species of lepidoptera, the scientists have identified and catalogued 2,205 species of Geometroidea, nocturnal pollinators taking over the "night shift" when daytime butterflies rest. These 2,205 species account for 8.8% of the world's known species in this superfamily.

- **Key Terms and Explanations**
 - **Lepidoptera:** Derived from the Greek words *lepis* (scale) and *pteron* (wing), this is an order of insects that encompasses all butterflies and moths. They are characterized by minute, overlapping scales on their wings that produce distinct colors and patterns.
 - **Taxonomy & Baseline Inventory:** Taxonomy is the science of naming, describing, and classifying organisms based on shared characteristics. A baseline inventory is an authoritative, verified record of species in a given geographical region, serving as a scientific benchmark for future ecological monitoring.
 - **Megadiverse Nation:** A designation given to a group of nations that house the majority of Earth's species and high numbers of endemic species. India is recognized as one of the 17 megadiverse countries worldwide, holding around 7% to 8% of recorded global species across flora and fauna.
 - **Nocturnal Pollinators:** Organisms that actively forage and transfer pollen during dusk and nighttime hours. While diurnal pollinators like honeybees operate during the day, nocturnal species ensure uninterrupted, round-the-clock plant reproduction.
 - **Bioindicators:** Species whose health, population density, and behavior reflect the overall health of an ecosystem. Insects like butterflies and moths are exceptionally sensitive to microclimatic shifts, habitat fragmentation, and chemical exposure, making them early warning systems for ecological degradation.
- **Main Arguments and Substantive Parts**
- **Core Thesis**
 - Establishing a centralized, scientifically peer-reviewed baseline catalogue of species diversity is a critical prerequisite for ecological conservation, legal protection, and environmental policy in megadiverse nations. Documenting national insect wealth bridges long-standing taxonomic gaps, secures biological sovereignty, and reveals the indispensable ecosystem services provided by overlooked invertebrate groups.
- **Key Statistical Composition**
 - India hosts a vast portion of global insect diversity, accounting for approximately 8.25% of all known Lepidoptera species worldwide.
 - **Total Documented Species:** 13,703 species distributed across 3,705 genera, 240 subfamilies, 102 families, and 31 superfamilies.
 - **Butterflies vs. Moths Asymmetry:** Moths constitute the overwhelming majority of Lepidoptera diversity in India, comprising 12,286 species (~89.7%), whereas butterflies represent 1,417 species (~10.3%).
 - **Geometroidea Diversity:** Moths under the superfamily Geometroidea alone account for 2,205 species in India, representing 8.8% of the global species count in this specific group.
- **Crucial Ecological Roles**
 - Lepidoptera are not merely aesthetic elements of wild landscapes; they form functional pillars in ecosystem maintenance:
 - **Dual-Shift Pollination Ecosystem:** While butterflies operate during daylight hours, nocturnal moths take over the "night shift." This ensures that continuous pollination services are delivered to wild plants and agricultural crops without temporal gaps.
 - **Trophic Layer Dynamics:** As primary consumers (herbivores) and detritivores, caterpillar larvae convert plant biomass into biological tissue. They serve as a foundational food supply for higher trophic levels, including insectivorous birds, bats, amphibians, and small mammals.
 - **Nutrient Cycling and Forest Health:** Larval feeding activity and frass (insect excrement) contribute to forest soil nutrient enrichment, driving decomposition cycles and regulating plant growth dynamics.
- **Taxonomic Significance**
 - Bridging over a century of fragmented historical records, systematic cataloguing offers pivotal institutional benefits:
 - **Legal Identity and Protection:** Providing precise taxonomy allows environmental enforcement agencies to identify, classify, and legally protect species under national legislation.
 - **Baseline for Climate Impact Tracking:** Documenting baseline populations enables researchers to measure range shifts, phenological mismatches, and extinction risks brought on by global warming.

- **Historical Evolution of the Issue**
 - **Colonial Era (Pre-1947):** Taxonomic documentation in India began primarily under British naturalists and imperial institutions like the Zoological Survey of India (established in 1916) and the Bombay Natural History Society (1883). These early efforts focused on collecting and classifying specimens for European museums. While foundational, the literature remained fragmented and lacked unified national baseline mapping.
 - **Post-Independence Transition (1947–1970s):** Following independence, field surveys expanded, but institutional attention shifted largely toward managing forest timber resources and big-game animals. Invertebrate taxonomy received limited state funding, creating significant taxonomic gaps that persisted for decades.
 - **Legislative Recognition (1972–1990s):** The enactment of the Wildlife Protection Act (WPA) in 1972 marked a major legal milestone. For the first time, select butterfly species (such as the Kaiser-i-Hind and Crimson Rose) were listed under Schedule I and II for legal protection. However, moths and lesser-known insect families remained largely absent from legal conservation frameworks.
 - **The Biological Diversity Act Era (2002):** Post-1992 Convention on Biological Diversity (CBD) developments led India to enact the Biological Diversity Act in 2002. This shifted the conservation paradigm toward protecting national sovereign rights over biological wealth, preventing biopiracy, and creating People's Biodiversity Registers (PBRs) at local levels.
 - **Modern Integrative Taxonomy (Present):** Recent decades have witnessed a transition toward unified national cataloguing. Leveraging field exploration, museum collection curation, literature verification, and DNA barcoding, taxonomy has evolved into an essential foundation for national climate resilience, ecological monitoring, and biodiversity accounting.
- **Way Forward**
 - **Elevate Invertebrate Priorities in National Policy:** Transition from megafauna-exclusive conservation toward habitat-level, multi-taxonic conservation strategies. Ensure state forestry programs explicitly include insect baseline monitoring in forest management plans.
 - **Mitigate Light Pollution (Photopollution):** Artificial Light at Night (ALAN) severely disrupts nocturnal moths, altering their navigational systems, mating patterns, and pollination efficiency. Implementing dark-sky corridors and low-impact street lighting in ecologically sensitive areas is a vital policy need.
 - **Expand Citizen Science and Digital Taxonomy:** Integrate molecular techniques (DNA barcoding) with crowd-sourced platforms (e.g., India Biodiversity Portal). Training citizen scientists accelerates the discovery of undescribed species, particularly across unexplored regions in the North-East and high-altitude Himalayas.
 - **Establish Agricultural Pollinator Corridors:** Encourage green belts, wildflower corridors, and organic farming buffers around agricultural fields. Restricting blanket pesticide sprays—especially neonicotinoids—safeguards both daytime butterflies and night-active moths, protecting long-term agricultural yields.
 - **Strengthen Legal and Institutional Enforcement:** Utilize updated baseline taxonomies to train customs officers, forest guards, and judicial officials. Fast-tracking forensic identification of illegal insect shipments helps dismantle transnational wildlife trafficking networks.

A GLOBAL LEPIDOPTERA HOTSPOT: INDIA'S INSECT WEALTH (UPSC / APSC INTEGRATED PREPARATION)

Statistics & Global Context.



Authored by ZSI Scientists
after nearly 12 years,
bridging 100+ year
taxonomic gaps.

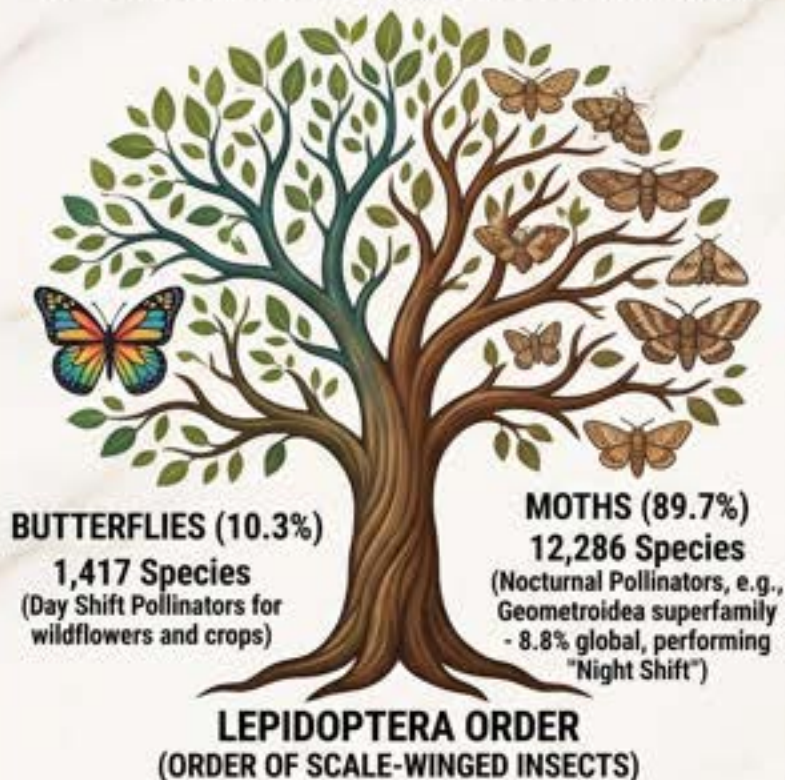
INDIA'S LEPIDOPTERA INVENTORY

13,703
TOTAL SPECIES



8.25%
of Global
Lepidoptera
Species

The Overwhelming Majority & Complexity.



TAXONOMIC COMPLEXITY (ZSI Catalogue):
3,705 Genera, 240 Subfamilies, 102 Families.



Key Ecosystem Roles & Multidimensional Analysis.

POLLINATION ECOSYSTEM SERVICES (DAY vs NIGHT SHIFTS)



Diurnal and Nocturnal
shifts provide essential
continuous pollination
services.

TROPHIC LAYER DYNAMICS & FOOD WEB FOUNDATION



Energy flow from
primary consumers
to higher levels.

GLOBAL & LEGAL SIGNIFICANCE (MULTIDIMENSIONAL ANALYSIS)

- SOCIAL**
 - Ecotourism
 - Green Livelihoods
 - Community Awareness
- POLITICAL**
 - Federal Pride (State Butterflies)
 - Center-State Coordination
- LEGAL**
 - WPA 1972 Schedules
 - Biological Diversity Act (ABS)
- ETHICAL**
 - Combat Vertebrate Blindness
 - Intergenerational Equity
- INTERNATIONAL**
 - GBF Targets (30x30)
 - CITES Compliance
- ECONOMIC**
 - Agri-Productivity
 - Biomimicry for Photovoltaics

WAY FORWARD

Mitigate Photopollution, Establish Pollinator Corridors,
Expand Citizen Science Platforms.

India produces smart scientists but is struggling to retain them

Research flourishes when ideas compete but suffers when people compete for proximity to power; many of India's laboratories continue to operate within rigid hierarchies that would appear strange in leading scientific institutions elsewhere in the world

Riju Bhargava

Recent reports of nearly 120 scientists resigning from the Indian Space Research Organisation (ISRO) have rightly raised concerns. The ISRO has been a symbol of India's scientific aspirations and such an exodus cannot be dismissed as an ordinary episode of employee turnover.

Resignations have occurred over the years but the scale of recent departures conforms as with the question of why some of India's brightest scientific minds are electing to leave institutions without dreams of joining.

The phenomenon is not unique to ISRO. Similar stories have emerged from laboratories under the Council of Scientific and Industrial Research (CSIR), premier autonomous institutes, and several government-funded research organisations. Often these departures are hard to notice as part of a larger pattern but now they seem one scientist at a time – yet together they point to a deeper issue besetting of national ambition.

Real main reasons

The most obvious explanation is salary but it is not sufficient. Scientists who have spent decades building their expertise and reputation rarely leave only because another organisation is offering a higher paycheck. Many of those that are resigning are also in the latter half of their careers, and generally unwilling to risk financial and professional stability. So, what they want is something even greater: professional dignity, freedom of thought, and the freedom to work on their topics of choice.

Several researchers – many of whom are unwilling to go on record for fear of repercussions – in private characterise these institutions as places where bureaucratic power is increasing at the expense of that of science, and where it is becoming more risky to question authority. The tragedy is that while Indian science inherited world-class institutions, it also retained a colonial administrative mindset.

Research flourishes when ideas compete but suffers when people compete for proximity to power. Many of India's laboratories continue to operate within rigid hierarchies that would appear strange in leading scientific institutions elsewhere in the world. Young scientists often learn quickly that survival depends less on asking bold scientific questions than on understanding invisible administrative boundaries. In some institutions, even simple acts of professional equality are viewed as breaches of etiquette. Respect, instead of being earned through scholarship and mentorship, is demanded through designation.

A class system in order to be creative, for example, a doctoral student should be able to



Representative image of the National Institute of Animal Health (NIAH) in Hyderabad. India is spending a historically unprecedented, but otherwise still insufficient, amount of money on scientific research. (A. Srinivas)

challenge a senior scientist's hypothesis without fearing that his or her long-term career will be adversely affected. A young investigator should feel confident enough to question established ideas. The world's best research environments are the best because they allow just such interaction.

Attend an international scientific conference in Europe or the Americas and you will often witness something remarkably ordinary. Nobel laureates standing to the same criteria as graduate students, and young scholars openly questioning senior scientists during presentations. They are respectful – and the seniors know that – but that respect flows from intellectual contributions rather than via communal protocols.

However, many Indian scientific gatherings continue to have a hierarchical rather than academic culture. Distinguished guests receive VIP badges, exclusive dining arrangements, and special hospitality while students and junior participants are treated as an entirely different class. Such symbolism is not harmless: it reinforces a hierarchy that has little place in science. Science has never progressed but more someone occupied a larger office or enjoyed a separate lunch. Let us foster the many little interactions; they could make a big difference.

Speaking up

Equally worryingly, scientists rarely speak openly about unhealthy workplace cultures because the recipients are remarkably small. Today's reviewers may become tomorrow's selection committee members. Today's director may influence tomorrow's funding decisions.

Several researchers – many of whom are unwilling to go on record for fear of repercussions – in private characterise some institutions as places where bureaucratic power is increasing at the expense of that of science.

Occasionally, some disturbing information emerges, including allegations of harassment, vindictive administrative actions, and attempts to publicly discredit accomplished scientists. Whether every allegation withholds scrutiny is for due process to determine – but the mere perception is immediately damaging.

In a result, many talented researchers are now moving to private research organisations, emerging deep-tech companies, universities abroad, and/or international collaborations where scientific autonomy has more room than administrative intrusion. India's growing innovation ecosystem benefits from this movement to some extent but it is not a zero-sum: our national laboratories lose institutional memory and experienced mentors.

India is spending a historically unprecedented, but otherwise still insufficient, amount of money on scientific research. Excellent skills are now needed for such research missions, including those involving semiconductor, quantum technologies, artificial intelligence, biotechnology, and spaceflight. But whereas buildings can be built in a few months and, with adequate funds, sophisticated instruments can be bought, building an environment that

holds great scientists is a very long process, often taking decades.

Crucious effort

Today, India must increase administrative transparency in scientific institutions, and install robust systems to redress grievances concerning workplace harassment and mentoring-based leadership training to ensure a leadership free from command.

In parallel, we need a conscious effort to break free of the colonial hierarchy that remains in the daily life of institutions. Respect should not disappear from scientific workplaces but it differs fundamentally from unquestioning deference.

India has repeatedly demonstrated that its scientists possess extraordinary capability. Our achievements in space exploration, vaccines, supercomputing, mathematics, biotechnology, and engineering stand as testimony to that talent. The challenge today is not producing brilliant scientists – our universities and institutions have figured that out. The challenge is to ensure those scientists can still flourish after they enter India's laboratories.

If we fail to reform workplace culture, the next generation may simply leave our public institutions. That will be an immeasurable loss. Science has always advanced through ideas that challenged power – not by power that silenced people or ideas.

Dr. Riju Bhargava is Dean, Academic Affairs, Gordon City University, Bangalore, and an adjunct faculty member at the National Institute of Advanced Studies, Bangalore. rijubhargava@gmail.com

THE GIST

Recent reports of nearly 120 scientists resigning from the Indian Space Research Organisation (ISRO) have rightly raised concerns.

Many talented researchers are now moving to private research organisations, emerging deep-tech companies, universities abroad, and/or international collaborations where scientific autonomy has more room than administrative intrusion.

India must increase administrative transparency in scientific institutions, and install robust systems to redress grievances concerning workplace harassment and mentoring-based leadership training.

- **Key Terms and Concepts**

- **Scientific Brain Hemorrhage (Deep Talent Attrition):** Unlike basic brain drain—which refers to students leaving a country for higher studies—this occurs when mid-career and senior scientists, after decades of state-funded training, resign from national laboratories to join private industry or international institutions due to workplace friction and stifled autonomy.
- **Bureaucratic Feudalism in Academia:** An organizational hierarchy where administrative rank, age, and proximity to political power supersede scientific merit, empirical truth, and peer review. In this system, respect is demanded through administrative designations rather than earned through scholarship.
- **Deep-Tech Research Ecosystem:** High-technology fields such as Quantum Computing, Semiconductor Fabrication, Artificial Intelligence, and Advanced Aerospace. These sectors require continuous, long-term capital investment alongside high human capital, where losing experienced mentors disrupts multi-decade technology roadmaps.
- **Institutional Memory:** The collective knowledge, historical experience, and procedural expertise accumulated within a research organization. When senior scientists leave abruptly, this memory dissipates, forcing junior scholars to rebuild foundational processes from scratch.
- **Command-and-Control Leadership:** A rigid, top-down administrative style derived from classical civil service protocols. While useful for maintaining order in routine administration, it limits open inquiry, risk-taking, and scientific dissent.

- **Core Themes and Structural Issues**

- The fundamental challenge in national scientific institutions is not merely a lack of infrastructure or funding, but a deep-seated workplace culture clash between modern scientific inquiry and inherited bureaucratic structures.

- **The Misconception of Compensation**

- A common assumption is that scientists resign from public institutions primarily for higher salaries in private industry or abroad. However, evidence shows that for mid-to-late career researchers, financial stability is usually already established. The primary driver of exit is the loss of **professional dignity, intellectual freedom, and autonomy** to pursue original research without administrative interference.

- **The Bureaucratic Mismatch**

- National research organizations often operate under rigid civil service rules designed for revenue collection or public administration rather than creative exploration.
 - **Protocols over Peer Review:** Administrative etiquette, ceremonial deference, and power dynamics often take precedence over scientific debate.
 - **Suppression of Intellectual Dissent:** Younger investigators and doctoral candidates frequently hesitate to challenge a senior scientist's hypothesis, fearing that administrative retaliation could jeopardize their grants, promotions, or future tenure decisions.

- **Small Ecosystems and the Fear of Repercussions**

- Because the high-end research network within any single nation is relatively compact, senior scientists often hold multiple roles—acting simultaneously as lab directors, grant reviewers, selection committee members, and policy advisors. This concentration of authority creates a deterrent against reporting administrative overreach or toxic workplace practices, as challenging the system can damage a scientist's career prospects.

- **Infrastructure Expansion versus Cultural Stagnation**

- State funding for advanced technological missions—such as quantum computing, supercomputing, and spaceflight—has reached historic highs. High-end equipment and modern laboratories can be acquired relatively quickly with adequate funding. However, physical infrastructure alone cannot generate breakthrough discoveries if the workplace culture discourages creative risk-taking, collaborative mentorship, and open intellectual debate.

- **Historical Evolution of R&D Governance**
- **The Visionary Phase (1940s–1950s)**
 - In the immediate post-independence era, state leadership placed strong faith in science as an engine for national development. Early research bodies—such as the Council of Scientific and Industrial Research (CSIR), the Atomic Energy Commission (AEC), and the Tata Institute of Fundamental Research (TIFR)—were established under scientific pioneers like Homi Bhabha and Shanti Swaroop Bhatnagar. These leaders enjoyed direct access to top political leadership, allowing them to bypass traditional administrative red tape and build flexible, autonomous institutions.
- **Expansion and Bureaucratization (1960s–1980s)**
 - As the public research network grew into a large state apparatus encompassing defense, space, agriculture, and industrial laboratories, institutional structures were increasingly aligned with standard civil service rules.
 - Hierarchical ranks, formal channels of communication, and standardized evaluation metrics were introduced.
 - While this brought organizational order, it gradually replaced informal, peer-driven academic culture with bureaucratic procedures.
- **Post-Liberalization and the Globalized Research Market (1990s–2000s)**
 - With economic liberalization, foreign universities and multinational corporate R&D centers expanded rapidly. Indian institutions faced their first major wave of outward scientific migration. While gross R&D expenditure stagnated at around 0.6% to 0.7% of GDP, foreign labs offered non-hierarchical work environments, state-of-the-art facilities, and competitive research grants.
- **The Modern Deep-Tech Era (2010s–Present)**
 - Today, government support for advanced technology missions has surged, accompanied by initiatives such as the Anusandhan National Research Foundation (ANRF) designed to boost research funding. However, the unexpected resignation of senior scientists from top labs highlights a growing divide: while state investment in equipment and physical capital has grown rapidly, workplace administration remains bound by rigid, legacy frameworks.
- **Strategic Way Forward**
- **Administrative De-Bureaucratization**
- **Specialized Scientific Management Cadre:** Modern scientific institutes should be managed by professional scientific administrators rather than generalist bureaucrats.
- **Procurement and Operational Autonomy:** Streamline equipment procurement and travel approvals, decoupling research laboratories from rigid civil service purchasing frameworks.
- **Independent Grievances and Institutional Ombudsman**
- **Autonomous Ombudsperson Offices:** Establish external, independent oversight boards to investigate allegations of harassment, administrative overreach, and career suppression without reporting directly to institute directors.
- **Protection of Whistleblowers:** Safeguard junior scientists and researchers who report misconduct, ensuring their funding, tenure track, and publication credits remain protected during reviews.
- **Transitioning from Command to Mentorship Leadership**
- **Leadership and Management Training:** Scientific excellence does not automatically confer management skills. Senior scientists appointed to administrative roles should undergo leadership training focused on mentorship, team building, and conflict resolution.
- **360-Degree Performance Evaluations:** Expand director and department head evaluations to include anonymous feedback from doctoral students, postdocs, and junior faculty regarding workplace environment and mentorship quality.

INDIA PRODUCES SMART SCIENTISTS BUT STRUGGLES TO RETAIN THEM: A MULTIDIMENSIONAL ANALYSIS

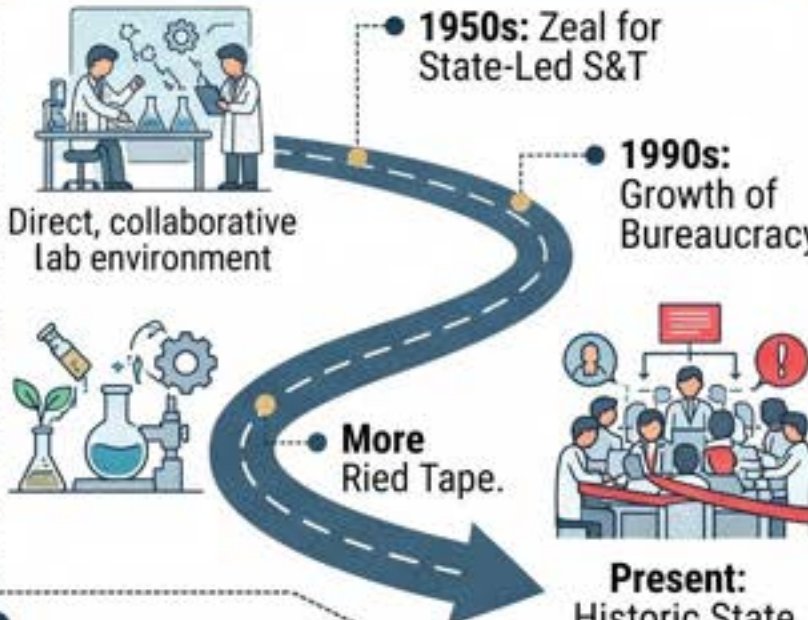
I. KEY TERMS & CORE CAUSES



Talent attrition vs. **Ideas**

- Not Salary, But **Dignity & Choice**
- **Deep-Tech** and The **Freedom to Challenge Ideas**
- Loss of **Institutional Memory & Mentorship.**

II. THE EVOLVING CHALLENGE (GS 3)



- 1950s:** Zeal for State-Led S&T
Direct, collaborative lab environment
- 1990s:** Growth of Bureaucracy
More Rigid Tape.
- Present:** Historic State Spending, Cultural Bottlenecks.

III. MULTIDIMENSIONAL ANALYSIS (GS 2, 3, 4)



- Social:** Culture of Deference over Debate
- Ethical:** Vindictive Actions & Harassment
- Political:** Historic State Spending
- Economic:** Private/Foreign Movement for Better Culture.
- International:** (No specific text)
- Legal:** (No specific text)

IV. LINKAGES & PYQs

Syllabus Linkages

GS 2: Statutory/Regulatory Bodies; Role of Civil Services.
GS 3: S&T Developments; Indigenization.
GS 4: Workplace Ethics; Emotional Intelligence.

Selected PYQs

Mains 2017: Changing Pattern of Public Expenditure.
Mains 2018: Formal vs. Moral Authority.

- Synthesize these aspects for comprehensive answers.

V. WAY FORWARD: PRACTICAL SOLUTIONS



- Establish Meritocratic Culture over Hierarchical Deference.
- Robust Grievance Systems for Workplace Issues.
- Shift from Command-and-Control to Mentoring Leadership.
- Transparency and Thought Freedom.

Why are govt. schools shutting down?

Which States have witnessed the highest number of closures? How has school rationalisation affected children's access to education? Who bears the biggest burden of government school closures? Can the Centre step in to reverse the trend? Why has the Right to Education Act fallen short?

EXPLAINER

G. Ramakrishnan

The story so far:

A recent NITI Aayog report said some 94,000 government schools were closed over the past decade, an average of 25 a day, contributing to a 2.26 crore decline in government school enrolment. The government schools' share of total enrolment has fallen from 71% in 2005 to 49.24% in 2024-25.

Why are government schools shutting down?

School closures are happening across States on the grounds of rationalisation. The National Education Policy 2020 advocates such rationalisation but without endangering the concept of neighbourhood schools.

School closure numbers cannot be explained away as gradual demographic drift, urban migration and so on. Rather, it is a coordinated administrative decision taken in states where the poorest and most rural children have the least capacity to compensate for a school that has vanished.

Which States are among the worst affected?

Uttar Pradesh, Madhya Pradesh and Jammu and Kashmir lead in this.

In December 2025, Madhya Pradesh's School Education Department found that 7.37 lakh children in the state have no school records. They are not enrolled in any school – private or government.

In Jharkhand and Shivpuri, for instance, 29,000 children fall into the "Drop Box" category – the department's term for those at imminent risk of dropping out. Across the State's 55 districts, more than 3,500 government schools recorded zero new admissions this academic session. Another 6,500 schools saw fewer than 10 admissions.

The department's response was to



School closures are happening across States on the grounds of rationalisation. HANU/ANAND

instruct every district education officer to paste lists of unmapped children on school noticeboards, contact them directly, and upload their details to the State portal.

Statewide, 8.38 lakh children fall under the "Drop Box" category. Another 1.23 lakhs are already recorded as dropouts. A further 1.55 lakh have left school because their families were displaced or migrated for work.

The department's flagship outreach programmes, School Chalein Hum and the Home Contact Campaign, were built to prevent exactly this. The State's own audit of its own scheme found three-quarters of a million children whose neither programme had reached.

Government data tabled in the Lok Sabha in February confirms the scale. UDSE figures show the national count of government schools falling from 11.07 lakh in 2014-15 to 10.17 lakh in 2023-24, a decline of roughly 80,000 that lines up almost exactly with NITI Aayog's own count. Private schools nationally grew from 2.88 lakh to 3.31 lakh over the same decade.

Madhya Pradesh's government schools fell from 1.22 lakh in 2018-19 to 99,411 the very next year – a drop of roughly 22,600

in twelve months. Uttar Pradesh's government schools fell from 1.63 lakh to 1.38 lakh in that identical year, a drop of over 25,000.

Reports on JMC's rationalisation programme documented children now travelling 4 to 6 km daily to reach a functioning school, violating neighbourhood school mandates of Right to Education Act (RTE).

More than 4,300 schools were closed or merged under a rationalisation scheme, with the Lok Sabha's own UDSE figures showing the state's school count falling from 23,367 in 2020-21 to 18,705 by 2022-23, alongside nearly 13,000 vacant teaching posts reported separately in the state assembly.

What is the impact of the shutdown of government schools?

Government schools in India are not a neutral public utility used evenly across classes. They are, disproportionately, the schools of the poor – of Scheduled Castes, Scheduled Tribes, and the poorer strata of backward-class communities. India is home to roughly 60% of the world's below-poverty-line population, and it is their children who fill government classrooms.

A 2019 National Sample Survey analysis found access to free education declining unevenly, with Muslim and Scheduled Caste and Scheduled Tribe households disproportionately marginalised from the schools nearest to them.

The burden falls disproportionately on girls who are the first to be withdrawn when the nearest school stops being nearby. What consolidation looks like on the ground is often a single teacher covering five classes at once – unable to know an individual child's background or tailor instruction, technically in breach of the Right to Education Act's staffing and quality norms.

Who is responsible for this trend?

In Lok Sabha, the concerned minister said education is on the concurrent list, and the responsibility for this trend lies entirely with States. But the RTE is a Central Act and the mandates on neighbourhood schools are the Centre's responsibility.

Further, the Centre seeks to intervene in State school education by making Central fund allocation for schools conditional on NEP implementation and also imposes a language policy. There are avenues for the Centre to step in against this trend.

The RTE Act, in force since 2009, guarantees free and compulsory education from age six to 14. RTE says nothing binding about the quality of what is delivered once a child is inside the classroom. It creates entitlements that children, by definition, cannot assert on their own – and parents, particularly poor and rural parents, often lack the legal and institutional capacity to enforce either. RTE assumes a symmetry of power between the state, the school, and the family that does not exist on the ground. RTE is not justiciable, in practice. School Management Committees, the one mechanism written into the RTE to give parents and communities a formal voice, largely go unconsulted.

(The author is Chairman, Central Control Commission, CPJMS)

THE GIST

▼ Nearly 94,000 government schools have closed over the past decade under State-led rationalisation drives, with Uttar Pradesh, Madhya Pradesh and Jammu and Kashmir among the worst affected, leading to falling enrolment and rising dropout risks.

▼ The closures have disproportionately affected poor, rural, Scheduled Caste, Scheduled Tribe and girl students, while questions remain over the Centre's role in enforcing neighbourhood school norms under the Right to Education Act.

- **Key Terms and Explanations**
- **School Rationalization and Consolidation**
 - School rationalization refers to the administrative policy of merging low-enrolment government schools with nearby, larger, or better-resourced institutions. The stated objective is to optimize resources, reduce the prevalence of single-teacher schools, and improve infrastructure efficiency.
 - **Example:** If three primary schools within a 3-kilometer radius each have fewer than 10 students and one teacher, the state administration merges them into a single centralized "hub" school, reallocating staff and physical infrastructure.
- **Neighborhood School Norms**
 - Under Section 6 of the Right of Children to Free and Compulsory Education (RTE) Act, 2009, state governments are legally obligated to establish a primary school within a walking distance of 1 kilometer and an upper primary school within 3 kilometers of every habitation.
 - **Example:** A small tribal hamlet situated 2.5 kilometers away from the nearest primary school violates the statutory neighborhood norm unless free, safe, and reliable transport infrastructure is provided by the state.
- **UDISE+ (Unified District Information System for Education Plus)**
 - UDISE+ is an online, real-time national data management platform managed by the Ministry of Education. It tracks school-level indicators across India, including enrolment figures, dropout trends, teacher-student ratios, and infrastructure availability.
 - **Example:** District Education Officers input annual school admissions into UDISE+ to identify schools with zero admissions or severe enrolment declines across academic sessions.
- **Unmapped Children and the "Drop Box" Category**
 - "Unmapped children" refers to school-age children who are absent from official school registries, making them invisible to state educational tracking systems. The "Drop Box" is a digital repository in state tracking portals where students who leave a school without taking a transfer certificate—or who migrate—are tagged to monitor potential dropouts.
 - **Example:** When a seasonal migrant family moves from a rural district to an urban center, their child is placed in the digital "Drop Box" until a new school in the host state officially re-enrols them.
- **Asymmetry of Power in Educational Governance**
 - This structural socio-political imbalance occurs when socially and economically disadvantaged parents lack the institutional power, legal literacy, or political leverage required to hold public school administrations accountable or challenge arbitrary closures.
 - **Example:** A daily-wage worker whose local primary school is slated for closure cannot easily take time off work or access judicial mechanisms to enforce the child's constitutional right to a nearby school.
- **School Management Committees (SMCs)**
 - Mandated under Section 21 of the RTE Act, 2009, SMCs are decentralized governance bodies comprising local parents (at least 75%), elected local body representatives, and teachers. They are tasked with monitoring school operations, preparing School Development Plans, and managing untied grants.
 - **Example:** An SMC in a village gram panchayat meets monthly to review teacher attendance, inspect mid-day meal quality, and petition the district administration against proposed school mergers.

- **Main Arguments and Substantive Parts**

- **The Shift from Expansion to Retrenchment**

Public primary education in India has entered a phase of physical retrenchment. Over the past decade, approximately 94,000 state-run schools have been closed down or merged—translating to an average closure rate of nearly 25 government schools every day. Consequently, the government school system's share of total national enrolment has dropped precipitously from 71% in 2005 to under 50% in recent academic sessions.

- **Administrative Rationalization versus Physical Accessibility**

State administrations defend these closures on grounds of administrative efficiency, arguing that maintaining under-enrolled, single-teacher primary schools is fiscally inefficient and pedagogically counterproductive. However, this logic ignores geographical realities. While the National Education Policy (NEP) 2020 endorses the creation of "School Complexes" and resource consolidation, it explicitly cautions against compromising the basic concept of neighborhood accessibility. In practice, local implementation has routinely prioritized administrative convenience over local access.

- **Geographical Disparities and State-Level Case Studies**

- The impact of school consolidation varies significantly across states:

- **Large Demographic States:** In states like Uttar Pradesh and Madhya Pradesh, hundreds of thousands of children fall into official "Drop Box" registers due to tracking failures during administrative mergers. In several districts, thousands of primary schools report fewer than ten active admissions, prompting blanket closures rather than localized interventions to understand *why* enrolment dropped in the first place.
- **Hilly and Conflict-Prone Regions:** In regions like Jammu and Kashmir, rationalization drives have forced primary school students to trek 4 to 6 kilometers across difficult terrain to reach functioning central schools, directly violating statutory RTE distance mandates.

- **Disproportionate Impact on Marginalized Communities**

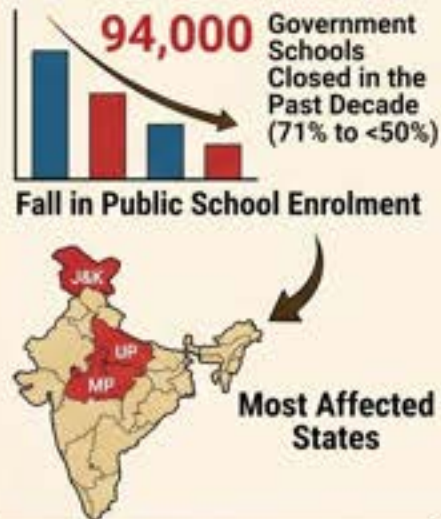
- School closures do not affect all socio-economic strata equally. Over 60% of India's population below the poverty line relies entirely on state-funded public education. National sample surveys show that Scheduled Caste (SC), Scheduled Tribe (ST), and rural Muslim households bear the heaviest burden of primary school closures.
- Furthermore, school distance acts as a major structural barrier for female literacy; when local neighborhood primary schools shut down, safety concerns and social norms lead parents to withdraw young girls from formal education altogether.

- **Weaknesses in the Right to Education Framework**

- The RTE Act, 2009 guarantees free and compulsory education for children aged 6 to 14, but its structural design assumes a power balance between the state apparatus and vulnerable parents. In practice:
 - The law focuses primarily on physical inputs rather than enforcing instructional quality or administrative accountability once a child is inside the classroom.
 - Key statutory accountability mechanisms—most notably School Management Committees (SMCs)—often exist only on paper and rarely convene to contest administrative decision-making.
 - The legal entitlements guaranteed under the RTE Act remain largely non-justiciable for marginalized families who lack the capital to pursue legal remedies.
-

DECONSTRUCTING THE CRISIS: GOVERNMENT SCHOOL CLOSURES IN INDIA | AXIA IAS ACADEMY

The Current Reality (Statistics & Affected States)



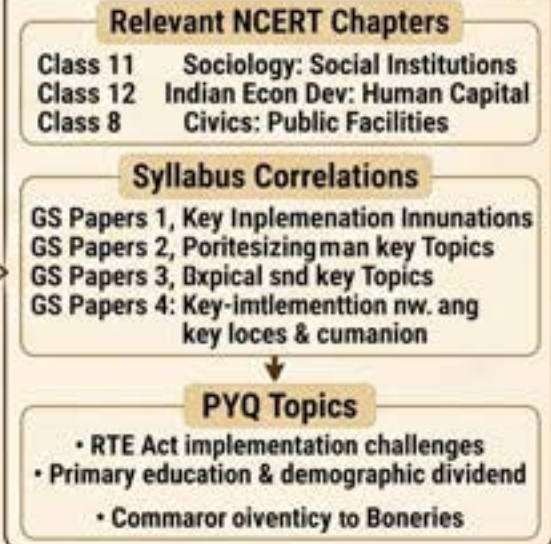
Key Terms & Explanations



Multidimensional Analysis

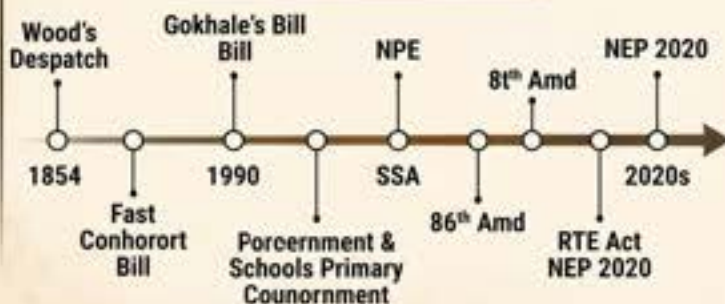


UPSC Relevance & PYQ Summary



Context & Foundation

Historical Evolution Timeline



Logical & Philosophical Base



Way Forward



Why does Kerala report a high leptospirosis burden?

Which groups are most vulnerable to contracting leptospirosis in the State?

C. Maza

The story so far:

Leptospirosis is a tropical zoonotic disease – a bacterial systemic infection caused by pathogenic *Leptospira* – highly integrated with an environment in which both humans and animals thrive. The disease, which began to be reported in Kerala since 1989, has been endemic in the State for the past three decades or more and has now become the communicable disease with the highest mortality profile. Leptospirosis is yet again in focus now, as the disease has claimed 50 lives just in the month of July this year.

What makes Kerala a hotspot for the disease?

Kerala's unique environment, with heavy monsoons, frequent floods and year-round moisture and humidity, creates ideal survival conditions for *Leptospira* bacteria in soil and water bodies such as lakes and canals. An

abundance of rodent and animal reservoir hosts live in proximity to human residential areas and farms. Paddy cultivation, pineapple plantations and canal cleaning activities expose large numbers of agricultural and manual labourers in productive ages to contaminated water, leading *Leptospira* to enter the body through mucosal surfaces, abrasions or broken skin.

The Health Department maintains that according to the data of the National Centre for Disease Control, leptospirosis is endemic in at least 12 other States, with a high burden of disease. It is better disease surveillance, extensive diagnostic facilities and aggressive logging of both confirmed and probable cases that make Kerala seem like the State with the highest leptospirosis burden, it is claimed.

Which is the population most affected by leptospirosis?

Traditionally, leptospirosis has remained an occupational hazard, with people engaged in farming, dairy farming, and cleaning work – essentially, people are at

high risk of coming into contact with soil and contaminated water – contracting the disease. The disease typically affects those in the low socio-economic strata, but there have also been cases in urban areas, where women have contracted the disease following gardening (possibly bare-handed). Health Department has also identified that construction workers – especially the migrant workers who are employed in the road works on the State's Highways – are at heightened risk of contracting leptospirosis. The proliferation of wayside eateries has increased the chances of soil contamination by rodents.

What is making the case fatality rate go up?

Late diagnosis and rapid progression of the disease, leading to a cascade of lethal complications such as pulmonary haemorrhage and multi-organ failure between 4.5 and 5 days, leaving a narrow therapeutic window for clinicians to intervene, has been making leptospirosis a very unpredictable disease with a

difficult prognosis in recent times. Previously, patients showed signs of complications only by the second week of the illness. Clinicians note that in the post-COVID era, dysregulatory immune response triggering a rapid cytokine storm, with patients requiring mechanical ventilation, has been a feature of most infectious diseases.

Leptospirosis is associated with a broad spectrum of severity, ranging from subclinical or mild illness to severe disease, manifesting as fever, myalgia, conjunctival suffusion and gastrointestinal issues. It is only in 5-80% that the disease worsens and the prognosis becomes unpredictable.

In the initial days, the symptoms overlap with those of any tropical fever and hence people self-treat with analgesics and remain at home, till the symptoms suddenly worsen.

The laboratory diagnosis of leptospirosis also continues to be a challenge, because current serological tests for antibodies, such as ELISA, do not give confirmatory results in the acute phase of the disease.

Molecular diagnosis (PCR) has been introduced by the State for the early detection of leptospirosis; however, these tests are not widely available across districts. Intensive management and multidisciplinary support are crucial for a patient developing complications, but secondary care hospitals often lack round-the-clock emergency management facilities and human resources, all of which add to the mortality.

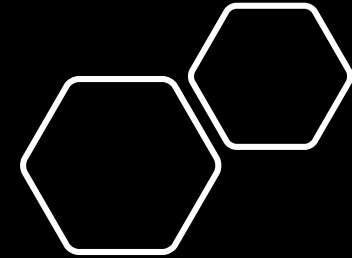
What has been Kerala's strategy?

Chemo prophylaxis with Doxycycline – 200 mg twice a week – targeting the high-risk groups has been a strategy the State has always relied on to prevent leptospirosis. Clinicians point out that one cannot go wrong in starting doxycycline early on, even when the patients' symptoms might be hard to distinguish. The strategy is very effective even after one has contracted the infectious organism because, when taken as per the protocol, doxycycline prevents the replication of *Leptospira* in the body. However, compliance has been poor and people seldom listen to the advisories issued by the Health Department.

The State's treatment protocol advised primary care physicians to maintain a high index of suspicion if a patient presents with fever and myalgia and without any respiratory symptoms and to start antibiotics as early as possible if the patient belongs to a high-risk category.

What are the modifications suggested in the strategy?

An experts' group has suggested that disease prevention strategies focusing on the vulnerable categories at high risk of occupational exposure to leptospirosis be devised and that risk communication be taken up as a campaign amongst these groups. Preventive gear, such as gum boots and heavy-duty gloves are to be provided to manual labourers and farm workers so that the risk of bare skin contact with contaminated soil and water is minimised.



- **Key Terms and Explanations**
- **Leptospirosis & Zoonotic Pathogen**
 - Leptospirosis is a tropical communicable disease caused by pathogenic, spiral-shaped bacteria belonging to the genus *Leptospira*. It is classified as a classic **zoonotic infection**—a disease transmitted naturally between vertebrate animals and humans.
 - **Transmission Mechanism:** The primary animal reservoirs are rodents (especially rats), farm livestock, and domestic pets. The bacteria are excreted in animal urine, colonizing soil, puddles, and water bodies. Humans contract the disease when skin abrasions, cuts, or mucosal surfaces (eyes, nose, mouth) come into direct contact with contaminated soil or water.
 - **Simple Example:** A paddy farmer walking barefoot through a flooded field with a minor scratch on their ankle allows the bacteria to breach the dermal barrier and enter the bloodstream.
- **Chemoprophylaxis**
 - Chemoprophylaxis refers to the administration of a pharmaceutical medication for the express purpose of **preventing** the initiation or development of an infection in high-risk individuals prior to or immediately following exposure.
 - **Operational Context:** In endemic zoonotic zones, targeted administration of antibiotics like **Doxycycline** (e.g., 200 mg once weekly) serves as a biochemical shield, inhibiting bacterial replication within human tissue even if micro-exposure has taken place.
- **Cytokine Storm & Dysregulated Immune Response**
 - A biological phenomenon where the immune system undergoes an exaggerated, uncontrolled inflammatory reaction. Instead of targeting only the pathogen, the hyper-activated immune cells flood the circulatory system with inflammatory signals (cytokines), causing widespread tissue damage.
 - **Clinical Impact:** In infectious diseases, a severe dysregulated immune response can trigger rapid fluid leaks in lungs (**pulmonary hemorrhage**) and multi-organ breakdown within a narrow window of 4 to 5 days, requiring advanced mechanical ventilation and intensive care.
- **Serological vs. Molecular Diagnostics**
 - **Serological Diagnostics (e.g., ELISA):** Tests that detect antibodies produced by the human body in response to an infection. Because immune systems take time to produce measurable antibody titers, serological tests often return false negatives during the acute (early) phase of a bacterial infection.
 - **Molecular Diagnostics (e.g., Polymerase Chain Reaction - PCR):** Advanced techniques that detect the actual genetic material (DNA) of the pathogen. PCR can confirm the presence of *Leptospira* in blood or urine within the first few days of fever, long before antibodies become detectable.
- **Disease Surveillance Paradox**
 - A situation where an administrative region reports disproportionately high disease cases not necessarily because it has the worst health environment, but because it possesses **superior diagnostic networks, aggressive contact-tracing, and robust health reporting protocols**.
 - **Analytical Insight:** Extensive logging of both confirmed and probable cases transforms hidden epidemiological burdens into visible administrative statistics, giving the impression of a higher disease burden relative to regions with poor disease tracking.

- **Main Arguments and Substantive Parts**
- **Core Thesis**
 - Tropical hydro-climatic dynamics combined with intensive human-environment interactions create an ideal eco-epidemiological habitat for *Leptospira* bacteria. Controlling this endemic burden requires shifting public health management from reactive, tertiary-hospital clinical care toward proactive, occupational risk-mitigation and early empirical prophylaxis.
- **Key Substantive Points**
- **Hydro-Climatic Hotspots and Environmental Dynamics**
 - Regions characterized by heavy monsoons, high humidity, frequent flooding, and extensive canal networks sustain ideal soil-water conditions for *Leptospira* survival. The proximity of rodent populations to residential and agricultural spaces creates continuous pathways for environmental contamination.
- **The Socio-Occupational Vulnerability Matrix**
 - The risk of infection falls disproportionately on specific labor segments:
 - **Traditional Agriculture:** Paddy cultivators, dairy farmers, and canal-maintenance crews facing constant contact with saturated soil.
 - **Urban & Infrastructure Labor:** Construction workers, road contractors, and inter-state migrant labor operating without protective gear.
 - **Informal Services:** Workers in roadside eateries and sanitation units exposed to rodent-infested urban micro-environments.
- **Clinical Bottlenecks and Rapid Progression**
 - A key driver of high mortality is the narrow therapeutic window available to medical professionals:
 - **Rapid Clinical Cascade:** Severe cases can deteriorate into multi-organ failure and pulmonary hemorrhage within **4.5 to 5 days** of symptom onset.
 - **Post-Pandemic Dysregulation:** Heightened rates of post-viral immune dysregulation can trigger aggressive cytokine storms, accelerating the need for mechanical ventilation.
 - **Early Diagnostic Gap:** Standard serological tests (ELISA) fail to detect acute infections during the initial days. While PCR tests provide definitive early detection, their availability remains largely restricted to tertiary care hubs rather than decentralized rural health centers.
- **Prophylactic Gaps and Treatment Protocols**
 - **Efficacy vs. Compliance:** Oral chemoprophylaxis using Doxycycline is highly effective at preventing bacterial replication. However, public adherence to weekly preventive regimens remains low due to poor risk perception and advisory fatigue.
 - **High Index of Suspicion Strategy:** Medical protocols encourage primary care clinicians to start empirical antibiotic treatment immediately upon presentation of undifferentiated tropical fever in high-risk patients, without waiting for laboratory confirmation.
- **The Surveillance and Reporting Reality**
 - A significant portion of the recorded disease burden stems from advanced health infrastructure. Extensive diagnostic tracking and systematic logging bring to light cases that often go uncounted in regions with weaker public health networks.

- **Historical Evolution of the Issue**
- **Pre-1980s: The Era of Undifferentiated Tropical Fevers**
- During the early post-independence decades, leptospirosis was rarely diagnosed as a distinct clinical entity in India.
- **Clinical Status:** Most acute presentations were grouped under broad categorizations like "pyrexia of unknown origin" (PUO), atypical malaria, or infectious jaundice.
- **Public Health Focus:** National health priorities focused almost entirely on vertical eradication programs for vector-borne diseases like malaria and smallpox, leaving zoonotic bacterial strains largely unmapped in public health frameworks.
- **1980s–1990s: Formal Recognition of Endemic Foci**
- Systematic clinical documentation of leptospirosis began emerging in coastal, high-rainfall regions (including Kerala, Tamil Nadu, Gujarat, and the Andaman & Nicobar Islands) during the late 1980s.
- **Epidemiological Shift:** Agricultural expansion, irrigation expansion, and canal development increased human exposure to rodent reservoirs.
- **First Health Protocols:** Outbreaks following monsoon floods led state authorities to recognize the pathogen as an endemic public health concern requiring specific clinical attention.
- **2000s–2010s: Institutionalized Surveillance and Disaster Response**
- The creation of the **Integrated Disease Surveillance Programme (IDSP)** in 2004 marked a major shift in tracking waterborne and zoonotic diseases.
- **Post-Disaster Surge Pattern:** Recurring flood events highlighted leptospirosis as a major secondary epidemic threat post-natural disasters.
- **Prophylactic Interventions:** Health departments established targeted chemoprophylaxis guidelines (Doxycycline distribution) during post-flood relief operations, attempting to institutionalize preventive measures for manual laborers and rescue workers.
- **Post-2020: The Post-Pandemic Landscape and Evolving Dynamics**
- The post-COVID-19 environment introduced new variables to the epidemiology of tropical zoonoses:
- **Altered Host Immune Responses:** Clinicians identified rapid systemic inflammatory responses in infected individuals, leading to shorter windows between initial symptom onset and severe complications.
- **Changing Demographic Vulnerabilities:** Rapid urbanization and infrastructural expansions shifted exposure risks toward inter-state migrant construction workers, manual labor forces, and informal urban vendors, requiring broader intervention strategies beyond traditional agrarian communities.



MASTERING U.P.S.C. C.S.E. TOPICS WITH AXIA IAS ACADEMY: LEPTOSPIROSIS COMPREHENSIVE ANALYSIS

1. KEY TERMS & TRANSMISSION PATHWAY

ZOONOTIC TRANSMISSION FLOW



2. MAIN ARGUMENTS & SUBSTANTIVE PARTS

PROBLEM FLOW



KEY SUBSTANTIVE POINTS

- Hydro-Climatic Hotspots**: Hydro-Climatic Ironcestanrs Hotspots
- Socio-Occupational Vulnerability Matrix**: Monitococonfined Matrix, Contaminates5-dmulnerability tronples
- Clinical Bottlenecks**: Delayed PCR, Rapid romed Progressions
- Prophylactic Gaps**: Prophylactic Caps and monlate Gaps

3. HISTORICAL EVOLUTION & PHILOSOPHICAL BASE



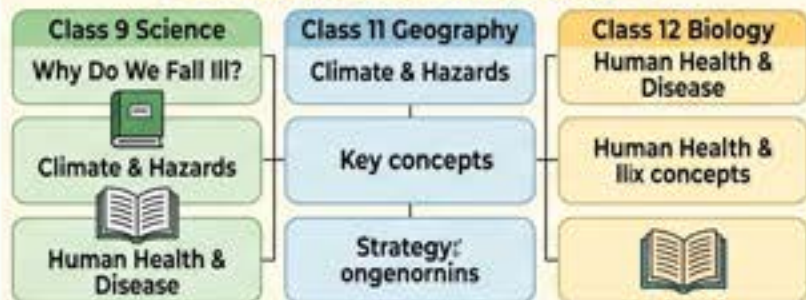
PHILOSOPHICAL BASES



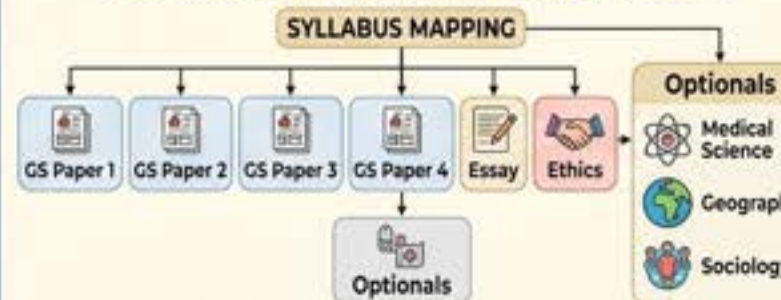
4. MULTIDIMENSIONAL ANALYSIS



5. LINKAGES WITH NCERTs



6. LINKAGES WITH UPSC SYLLABUS



7. WAY FORWARD: STRATEGIC SOLUTIONS



8. PREVIOUS YEARS' QUESTIONS (PRACTICE)



UPSC SUCCESS INSIGHTS: EDUCATOR DEVELOPED ANALYSIS

When machines do math: The promise & limits of AI

AI will likely transform how research in the field is conducted. But it would be premature to conclude that it can solve every mathematical problem



EXPERT EXPLAINS

RAJEEVA LAXMAN KARANDIKAR

PROFESSOR EMERITUS, CHENNAI MATHEMATICAL INSTITUTE

RECENTLY, MATHEMATICIAN Levant Alpge announced on X that he had found a counterexample to the Jacobian conjecture — a problem posed by Ott-Heinrich Keller in 1939. He credited his collaborator on the discovery: Claude Fable 5, Anthropic's latest AI model.

The Jacobian conjecture is probably too technical to explain in a newspaper column (an interested reader can readily find a precise statement on the internet). For Indians, it is worth knowing that Prof Shreeram Abhyankar, founder of the Bhaskaracharya Prasthithana in Pune, was interested in this question and popularised it in his lectures.

Mathematics has a long history of such bold claims eventually being overturned. There are a great many examples of very hard problems, some centuries old, giving in to human tenacity.

A conjecture made in 1782 by Leonhard Euler, one of the all-time great mathematicians, stood unchallenged for nearly 180 years until R. C. Bose, S. S. Shrikhande and E. T. Parker disproved it, earning themselves the nickname "Euler's Spoilers" in a prominent New York Times article. Fermat's Last Theorem, proposed without proof in 1637, took 350 years to prove, finally falling in 1994-95. The Riemann Hypothesis, on the other hand, has resisted resolution for over 160 years and remains one of the seven Millennium Prize Problems — solve it and the Clay Institute owes you a million dollars.

Why do mathematicians keep making these bets? Because the search itself tends to pay off even when the original question doesn't get solved. George Boole's 19th-century proposal for a symbolic calculus — now called Boolean Algebra — went on to become the backbone of computer science. Making bold assertions and waiting decades, or centuries, to see themselves vindicated or de-

• THE CENTURY-OLD IDEA UNDERPINNING LARGE LANGUAGE MODELS

• A large language model (LLM), like ChatGPT or Claude, doesn't 'memorise' the vast amounts of content it is trained on. Rather, it builds an intricate statistical map of language by observing how words and ideas co-occur across countless contexts.

• But the idea of treating language statistically goes back at least to 1953, when the mathematician Andrey Markov analysed the sequence of vowels and consonants in Alexander Pushkin's novel-in-verse 'Eugene Onegin', effectively

inventing what is now called the Markov chain.

• That thread — modelling

language as a chain of probabilities — ran through a century of research until 2017, when eight researchers at Google Brain published a paper with the deceptively modest title 'Attention is All You Need'. It introduced the Transformer, the architecture underlying essentially every major LLM since, including ChatGPT.

• A century of statistical groundwork, years of relentless engineering and one architectural breakthrough brought language modelling to a place none of us, staring at early search engines, would have believed possible.



molished is simply how the field works.

AI enters the arena

So, the Jacobian conjecture's fate is interesting on its own terms. But the more striking story may be the growing role AI models — particularly Large Language Models (LLMs) — are playing in advanced mathematics.

The Jacobian result wasn't a one-off. In May 2026, OpenAI announced that one of its internal reasoning models had produced a counterexample to a 1946 conjecture by Paul Erdős concerning unit distances between points in the plane — a problem that had resisted specialists for 80 years. The construction put forward by AI was subsequently verified and written up by nine outside mathematicians, including Fields medalist Tim Gowers. Will Sawin of Princeton went on to sharpen the result further.

Three years ago, when ChatGPT was new, I suspected many mathematicians — myself included — assumed LLMs were good for retrieving information already sitting in documents, but incapable of original mathematical thinking. That assumption has not aged well. At the 2024 International Mathematical Olympiad (IMO), Google DeepMind's AlphaProof and AlphaGeometry 2 — specialised theorem proving systems, not general LLMs — solved four of six problems

for a silver-medal score of 28/42. By IMO 2025, Google's Gemini Deep Think worked entirely in natural language, was officially graded by IMO coordinators under contest conditions and solved five of six problems (35/42) — a gold-medal score. OpenAI's own model reached an identical 35/42 the same year, graded independently by three former IMO medalists.

At IMO 2026 in Shanghai, OpenAI's GPT-5.6 reportedly solved all six problems on a single unsteered attempt. Independent testing by researchers including SigurdPlot Labs suggests several frontier models — GPT-5.6 Std, Anthropic's Claude Fable 5, and others — reached a perfect 42/42 score, with Fable reportedly the fastest to finish. These results are self-reported or independently reproduced rather than certified by IMO coordinators. Even with that caveat, the trajectory from silver to gold to a plausible perfect score in three years is a genuine step change from what reasoning models could do at the start of this decade.

Solving critical problems

Much of mathematical research begins with a question — either posed by another mathematician or arising from a real-world application. Often the real challenge is figuring out under what assumptions the question has an answer. If a theorem is already known under stronger assumptions, a great deal of research consists of finding which of those assumptions are truly essen-

tial and which can be weakened or dropped.

This typically means exploring many possibilities, testing examples, and hunting for patterns. This is exactly the kind of work AI excels at. It can rapidly sift through a vast space of possibilities, surface promising directions, and — when guided by well-formulated prompts and given the relevant mathematical context — even generate proofs. For problems of this type, AI can dramatically accelerate research.

But not every mathematical breakthrough follows this pattern. Some of the deepest advances come from entirely new concepts, unexpected insights or radically different ways of framing a problem — not from searching more efficiently within an existing framework.

Whether AI can reliably produce that kind of conceptual leap is still an open question. So the honest answer is yes, AI can already help solve many important problems in mathematics, and it will likely transform how mathematical research is done. But it would be premature to conclude that AI can solve every mathematical problem.

The catch

Here is the crucial limitation: an LLM has no built-in guarantee that what it says is true. It generates text that is statistically plausible, not necessarily correct — it is built to produce the most probable answer to your prompt, not a certified one.

There's a pleasing echo of this, two centuries early, in Boole himself. Soon after proposing his symbolic calculus, he wrote a book with the sprawling title *An Investigation of the Laws of Thought, on Which Are Founded the Mathematical Theories of Logic and Probability* (1854). Boole was already trying to formalise reasoning as something you could compute — logic on one hand, probability on the other. Today's LLMs are, in a sense, living proof of the second half of that title: engines of probability rather than certainty.

But users must remember that LLMs have no innate fact-checker and no direct access to the world beyond its training. It can occasionally produce convincing but entirely wrong statements — the phenomenon now widely called hallucination. It is built to generate the most probable continuation of a conversation, not to certify the truth of every sentence. That combination — extraordinary linguistic and mathematical fluency alongside occasional factual unreliability — defines both the power and the limits of today's LLMs.



A weekly column decoding AI's new frontiers, how they shape the world and our place in it

Leveraging LLMs

LLMs are exceptional partners for brainstorming, drafting and accelerating research.

But like any knowledgeable collaborator, they work best when their most important claims are checked against reliable, independent sources.

- **Key Terms and Explanations**
- **Large Language Models (LLMs) & Transformer Architecture**
 - **Concept:** Advanced artificial intelligence systems trained on massive text corpora to predict sequence continuations. Rather than memorizing statements, they build high-dimensional statistical maps of language structure.
 - **Mechanism:** Built upon the Transformer architecture (utilizing self-attention mechanisms), these models assign probabilities to token sequences based on context.
 - **Example:** When given the prompt "The sum of the angles in a triangle is...", an LLM calculates the statistical likelihood of subsequent words to generate "180 degrees" based on patterns learned during training.
- **Markov Chains & Probabilistic Text Modeling**
 - **Concept:** A stochastic model describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event.
 - **Historical Context:** Originated in 1913 when mathematician Andrey Markov analyzed vowel-consonant letter transitions in literature, establishing the mathematical foundation for modern natural language processing.
 - **Example:** Predicting whether the next letter in a sentence will be a vowel based solely on whether the current letter is a consonant.
- **Symbolic Calculus & Boolean Algebra**
 - **Concept:** A system of mathematical logic developed by George Boole in 1854 that reduces logical propositions to binary variables (1 for True, 0 for False) and fundamental logical operations (AND, OR, NOT).
 - **Relevance:** Forms the theoretical backbone of modern digital computing and formal logic circuits, attempting to unify the laws of thought with algebraic manipulation.
 - **Example:** Representing the conditional rule "If it rains AND I do not have an umbrella, THEN I get wet" as a deterministic algebraic equation.
- **Mathematical Conjectures & Counterexamples**
 - **Concept:** A conjecture is a proposed mathematical statement that appears true based on preliminary evidence but lacks a rigorous formal proof. A counterexample is a single valid case that refutes the conjecture entirely.
 - **Historical Context:** Euler's Sum of Powers Conjecture stood for nearly 180 years until mathematicians found a counterexample in 1966.
 - **Example:** Refuting the conjecture "All odd numbers are prime" by producing the single counterexample of the number 9.
- **Heuristic Search vs. Conceptual Leaps**
 - **Concept:** *Heuristic Search* refers to algorithmic exploration through vast, pre-existing combinatorial decision trees to locate solutions. *Conceptual Leaps* represent the human capacity to invent entirely new theoretical frameworks, definitions, or abstractions.
 - **Analogy:** A heuristic search is like systematically searching every room in a labyrinth for an exit, whereas a conceptual leap is like designing a flying apparatus to bypass the labyrinth altogether.
- **AI Hallucination & Epistemic Gap**
 - **Concept:** The phenomenon where a generative model outputs assertions that are syntactically coherent and plausible-sounding, but semantically false or logically invalid.
 - **Epistemic Gap:** The structural divide between generating syntactically probable text and guaranteeing mathematical certainty.
 - **Example:** An AI model generating a five-page mathematical proof that looks flawless to a non-expert, yet contains a subtle logical fallacy on step three that invalidates the conclusion.

- **Main Arguments and Substantive Parts**
- **Core Thesis**
 - Artificial Intelligence and Large Language Models are profoundly shifting the methodology of mathematical research by accelerating hypothesis generation, pattern search, and counterexample discovery. However, because these systems function as statistical probability engines rather than deterministic verifiers, they cannot replace the human necessity for conceptual innovation and formal proof certification.
- **Substantive Arguments and Evidence**
 - **The Transition from Search Engines to Reasoning Partners:**
 - Historically, computational tools served merely as calculation engines or static lookup tables.
 - Modern LLMs demonstrate an emergent capacity to assist in active problem-solving, such as proposing counterexamples to long-standing conjectures (e.g., progress on Erdős distance problems and complex geometric conjectures).
 - Competitive benchmarks showcase this evolution: AI systems have progressed from basic computational assistance to achieving near-perfect gold-medal performances on International Mathematical Olympiad (IMO) benchmarks.
 - **The Century-Old Lineage of Probabilistic Language:**
 - The modern capability of LLMs is not a sudden magic trick, but the culmination of a century of mathematical development.
 - Lineage traces from Andrey Markov's 1913 stochastic chains, through George Boole's dual investigation into probability and formal logic, to the 2017 Transformer architecture ("Attention Is All You Need").
 - This historical thread proves that LLMs remain fundamentally probabilistic at their core, generating the most statistically likely output rather than executing formal mathematical logic.
 - **The Limitation of Plausibility vs. Certainty:**
 - Mathematical rigor demands zero margin for error; a proof that is 99% correct is mathematically unproven.
 - LLMs optimize for maximum statistical likelihood based on training data distribution. They lack an internal truth-checker or direct access to real-world semantics.
 - Consequently, AI-generated reasoning must undergo rigorous independent human verification or formal proof-checking software before being accepted into scientific literature.
 - **The Dual Nature of Mathematical Breakthroughs:**
 - *Type A Breakthroughs:* Involve searching vast combinatorial spaces within an established theoretical framework. AI excels here by rapidly surfacing promising directions and testing edge cases.
 - *Type B Breakthroughs:* Require creating radical new concepts, reformulating paradigms, or questioning underlying assumptions (e.g., non-Euclidean geometry). AI currently shows little capacity for these transformative leaps.

- **Historical Evolution of the Issue**
- **Pre-Independence & Theoretical Foundations (19th Century – Early 20th Century)**
 - **1854:** George Boole publishes *The Laws of Thought*, attempting to formalize human reasoning into mathematical equations, laying the groundwork for both formal logic and probability theory.
 - **1913:** Andrey Markov introduces Markov Chains by analyzing letter sequences in literature, establishing the statistical framework for modern language modeling.
 - **1936:** Alan Turing conceptualizes the universal Turing machine, establishing the theoretical boundaries of what can be computed deterministically versus what remains undecidable.
- **Early Computational Integration (Mid-20th Century – Late 20th Century)**
 - **1950s–1960s:** Early artificial intelligence research splits into two paradigms: Symbolic AI (rule-based formal logic) and Connectionist AI (neural networks). Symbolic logic dominates early mathematical computing.
 - **1976:** The Four Color Theorem becomes the first major mathematical theorem to be proved using computer code. This sparks deep philosophical debates regarding whether a proof that cannot be fully verified by hand constitutes genuine human knowledge.
 - **1994–1995:** Andrew Wiles proves Fermat's Last Theorem—a problem that stood unsolved for 350 years—demonstrating the supreme power of deep, human-driven conceptual unification across disparate mathematical fields.
- **The Deep Learning Revolution & Transformer Era (2000s – 2017)**
 - **2000s:** Statistical machine learning begins displacing rule-based systems across industrial and scientific applications due to vast increases in digital data and compute power.
 - **2017:** Researchers publish the seminal paper "*Attention Is All You Need*", introducing the Transformer architecture. This breakthrough enables scalable parallel training on massive text datasets, setting the stage for modern LLMs.
- **Deep Reasoning Models & Scientific Integration (2020s – Present)**
 - **2020–2023:** General-purpose LLMs demonstrate impressive linguistic fluency but struggle with multi-step logical consistency, frequently suffering from mathematical hallucinations.
 - **2024–Present:** Specialization shifts toward hybrid models combining neural networks with formal logic systems (e.g., AlphaProof, Deep Think systems). These models achieve benchmark success on advanced mathematics competitions (IMO) and assist professional mathematicians in isolating candidate counterexamples for complex open problems.



AXIA
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PREVIOUS YEAR INSIGHT

- 2018 (GS II): Analyse strategic importance of chokepoints to the Indian ocean its strategists, and major inonihier strategies
- 2020 (GS III): Discuss Blue Economy in IOR to analyse sin lstrategic convonctions
- 2022 (GS II): Implications of AUKUS on stability.

SYLLABUS CORRELATION

BLUE ECONOMY POTENTIAL



RESOURCE POTENTIAL & SUSTAINABLE DEVELOPMENT

COMPREHENSIVE ANALYSIS: GEOPOLITICAL DYNAMICS OF THE INDIAN OCEAN REGION (IOR) & INDIA'S STRATEGIC INTERESTS

UPSC CSE MAINS & PRELIMS PREPARATION BOARD



NON-TRADITIONAL SECURITY THREATS



GLOBAL PARTNERSHIPS & MULTILATERAL COOPERATION

UPSC CSE LINKAGES

- GS II: International Relations
- GS III: Internal Security (Maritime), Economic Geography

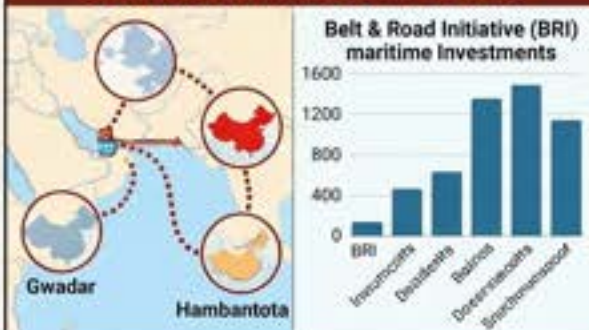
SYLLABUS CORRELATION

STRATEGIC CHOKE POINTS



CRITICAL MARITIME GATEWAYS

CHINA'S STRING OF PEARLS



ENERGY SECURITY & REGIONAL INFLUENCE

INDIA'S COUNTER-STRATEGY



NET SECURITY PROVIDER & SAGAR VISION

• CLIMATE

What makes Kerala particularly vulnerable to landslides

Anagha Jayakumar
New Delhi, August 2

TWO YEARS after the devastating Wayanad landslides, exceptionally heavy rain triggered fresh landslides, mudslides and flooding across parts of Kerala on Saturday, killing at least six people and leaving several others feared missing.

The India Meteorological Department (IMD) said that widespread rainfall was likely over Kerala on Sunday and Monday, with heavy rainfall in isolated places and strong winds with 40 to 50 kmph speeds.

Neetha K Gopal, head of the IMD's Meteorological Centre in Thiruvananthapuram, told *The Indian Express* that the intense spell was being driven by an offshore trough extending from the south Gujarat coast to Kerala, strong southwesterly winds across the Arabian Sea, and a strong north-south pressure gradient along the west coast. Together, these conditions had strengthened the monsoon flow and produced widespread rainfall across Kerala.

"This was not rainfall confined to one or two places. It was a widespread heavy rainfall event," Gopal said. She added that

a large quantity of rain had fallen within a short period, leaving little time for the water to drain away.

"It was the cumulative effect of the preceding rainfall, combined with today's intense and widespread rainfall activity," Gopal said, underscoring that the landslides were not triggered by a single burst of rain alone.

Why landslides occur

Landslides are natural disasters that occur mainly in mountainous terrains with conducive soil, rock, geology and slope conditions. A sudden movement of rock, boulders, earth or debris down a slope is called a landslide.

While they are fairly common, landslides are extremely hazardous and pose a threat to human and animal lives, damaging property, roads and bridges, disrupting communication lines and snapping power lines.

Landslides generally result from a combination of two sets of factors:

- Conditioning factors, such as soil topography, rocks, geomorphology, and slope angles, among others, make some parts of

Landslide atlas

- In 2023, ISRO's National Remote Sensing Centre, Hyderabad, released a 'landslide atlas' based on landslide events recorded from 1998 to 2022.

- The database showed that while the Western Ghats recorded fewer landslide events than the Himalayan region, Kerala accounted for a disproportionately high share of landslide fatalities.



Rescue operations in Kottayam after a landslide on Saturday. PTI

the country more vulnerable to landslides.

- Triggering factors, which include intense rainfall and anthropogenic activities such as haphazard land use, unscientific construction, and large-scale destruction of forests.

Most landslides in India are rain-induced events. Other natural causes include earthquakes, snow-melting and undercutting of slopes due to flooding. They may also be caused by anthropogenic activities such as excavation, cutting of hills and

trees, excessive infrastructure development, and overgrazing by cattle.

How human intervention increases risk

Kerala's landslide risk is largely concentrated along the Western Ghats, especially in central and northern districts such as Idukki, Pathanamthitta, Kottayam, Wayanad, Kozhikode and Malappuram. The region's steep slopes, geology and changing land use make it inherently susceptible to landslides.

During spells of intense or prolonged rainfall, water infiltrates the loose soil and reaches the interface between the soil and the underlying rock, weakening the bond between the two. This is significant because preceding rainfall can progressively saturate slopes, while a subsequent burst of heavy rain can add large quantities of water over a short period, increasing runoff and the likelihood of slope failure.

Land-use changes and human interventions have also contributed to the region's fragility, with quarrying, road laying, and the expansion of plantations altering the stability of slopes and natural drainage.

- **Key Terms and Explanations**

- **Landslide Dynamics and Mass Wasting:** A landslide refers to the downslope movement of soil, rock, or organic debris under the direct force of gravity. This occurs when the shear stress acting on a slope exceeds the shear strength of the slope material.
- **Conditioning vs. Triggering Factors:** Conditioning factors represent the inherent, static susceptibility of a terrain, such as steep slope gradients, weak underlying geology, and loose soil structure. Triggering factors are dynamic events that immediately set the landslide in motion, such as short-duration intense rainfall, prolonged monsoonal spells, or seismic tremors.
- **Offshore Trough and Pressure Gradient:** An offshore trough is an elongated area of low atmospheric pressure parallel to the coastline. When paired with a steep pressure gradient across the Arabian Sea, it accelerates strong, moisture-laden southwesterly monsoonal winds directly toward the coastal landmass, resulting in concentrated, high-volume rainfall over short windows.
- **Antecedent Rainfall and Pore-Water Pressure:** Antecedent rainfall is the cumulative volume of rain that falls over several days or weeks prior to a slope failure event. As rainwater infiltrates soil, it fills pore spaces between soil particles, generating pore-water pressure that pushes soil grains apart and eliminates friction at the soil-bedrock interface.
- **Geospatial Landslide Hazard Atlas:** A data-driven mapping system created using satellite remote sensing, Geographic Information System (GIS) mapping, and historical disaster records. It classifies regions into differential hazard zones (e.g., low, moderate, high, or severe risk) based on terrain slope, lithology, land-use patterns, and historical event density.

- **Main Arguments and Substantive Parts**

- The vulnerability of ecological hotspots like the Western Ghats—and states like Kerala in particular—is defined by a complex interplay between physical geography, climate variability, and human intervention.
 - **The Dual Mechanism of Physical Susceptibility:** Slope instability in the Western Ghats is driven by both inherent terrain vulnerability and dynamic climate triggers. Steep escarpments, highly weathered tropical soil layers, and fractured bedrock form a structurally vulnerable foundation. When exposed to monsoonal windward effects, offshore troughs, and strong pressure gradients, these slopes absorb extraordinary volumes of moisture over short temporal windows, accelerating mechanical failure.
 - **Cumulative Rainfall as the Primary Tipping Point:** Sudden cloudbursts are not the sole drivers of slope failure. Prolonged, multi-day antecedent rainfall acts as a primary catalyst by gradually saturating the subsoil. Once the water table rises within the slope matrix, pore-water pressure increases exponentially, destabilizing the interface between the topsoil and the underlying impermeable bedrock. A final, sharp burst of rainfall then easily triggers catastrophic mass movement.
 - **Disproportionate Human Fatalities Relative to Event Frequency:** A crucial paradox exists in India's landslide hazard landscape: while the Himalayan mountain system records a far higher total frequency of landslide events, the Western Ghats—particularly regions like central and northern Kerala—experience a disproportionately higher human fatality rate. This discrepancy stems directly from intense population density along high-gradient slopes, linear infrastructure built across natural drainage lines, and settlement expansion into ecological buffer zones.
 - **Anthropogenic Amplification of Slope Instability:** Natural geological hazards become full-scale human disasters due to unscientific land-use changes. Unregulated hill-cutting for road construction, extensive rock quarrying, alterations to natural stream networks, overgrazing, and replacing native multi-tiered rainforests with shallow-rooted monoculture plantations (such as rubber or tea) severely undermine the structural integrity of slope ecosystems.

- **Historical Evolution of the Issue**

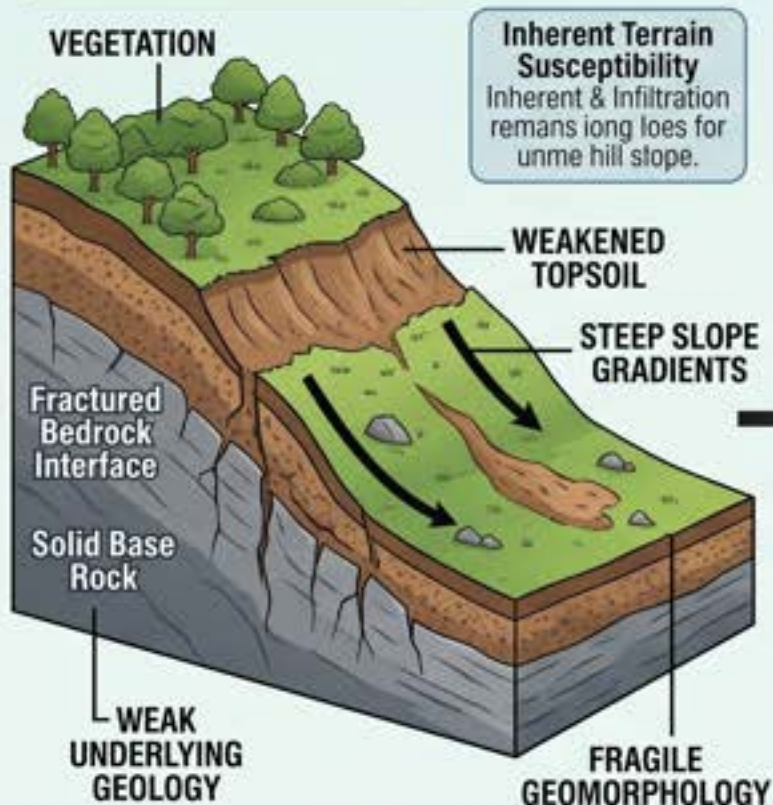
- **Colonial Exploitation and Plantation Economy (Late 19th to Early 20th Century):** The initial ecological transformation of the Western Ghats began under British administration. Vast tracts of continuous, dense tropical rainforests were cleared to establish commercial cash-crop plantations, primarily tea, coffee, and rubber. This transition removed deep-rooted tree species whose root networks held fragile topsoil to the bedrock, replacing them with shallow-rooted crop varieties.
- **Post-Independence High-Range Migration and Mega-Projects (1950s–1980s):** Following independence, state-sponsored agricultural migration policies (such as the "Grow More Food" campaign) encouraged thousands of peasant families to move into the High Ranges of the Western Ghats (e.g., Idukki, Wayanad, Pathanamthitta). Concurrently, major civil engineering projects—including large hydroelectric dams, quarrying operations, and extensive mountain road networks—were built without geotechnical slope evaluations, severely disrupting micro-level hydrology.
- **The Ecological Regulatory Standoff (2010–2013):** In response to deteriorating ecological health, the Ministry of Environment, Forest and Climate Change constituted the Western Ghats Ecology Expert Panel (WGEEP), chaired by Madhav Gadgil in 2011. The Gadgil Report recommended designating the entire Western Ghats as an Ecologically Sensitive Area (ESA) divided into three levels of protection (ESZ-1, ESZ-2, ESZ-3), proposing strict bans on quarrying, mining, and new townships in fragile zones. Following strong public pushback and political resistance, the Kasturirangan Working Group (2013) reduced the proposed ESA footprint to just 37% of the region. Policy implementation stagnated due to competing economic interests.
- **Modern Era of Compound Climate Disasters (2018–Present):** Rapid sea surface warming in the Arabian Sea has altered traditional monsoon dynamics, creating frequent high-intensity mini-cloudbursts and localized torrential rainfall events. Coupled with legacy environmental degradation, the region entered a new era of severe disasters, marked by devastating landslides in Wayanad, Idukki (Pettimudi), Kozhikode (Kavalappara), and Kottayam, shifting the policy focus from basic conservation to urgent disaster risk reduction (DRR).

- **Way Forward**

- **Granular High-Resolution Hazard Zonation:** Move from macro-level risk mapping to micro-level hazard zonation (1:5,000 scale mapping) using satellite data and AI-based terrain modeling. This enables local planning authorities to identify high-risk individual hillslopes, stream channels, and settlements.
- **Integrated Early Warning Systems (EWS):** Install automated weather stations, soil moisture sensors, and dynamic pore-water pressure indicators across high-risk mountain zones. Setting real-time rainfall threshold alerts allows local district administrations to initiate preventative evacuations hours before a failure occurs.

WHY KERALA IS PARTICULARLY VULNERABLE TO LANDSLIDES

NATURAL CONDITIONING FACTORS



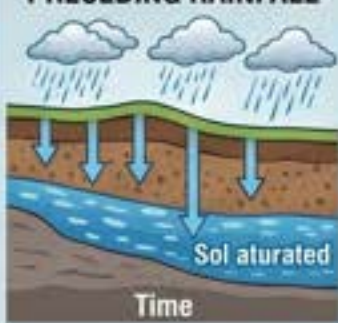
Inherent Terrain Susceptibility
A natural confluence affects the infiltration of weakened fractured bedrock interface, inherent inherent terrain susceptibility.

Inherent Terrain Susceptibility to be inherent terrain autographed to fatal cumulative effect if affords the radn saturation effect and imreases of a precdion saturation.

THE RAINFALL TRIGGERING MECHANISM



CUMULATIVE EFFECT OF PRECEDING RAINFALL



Weakens the Bond

Time

Water Saturation

Increased Runoff

Slope Failure

HUMAN INTERVENTION AMPLIFICATION

HUMAN SLOPEAUVITY



HAPHAZARD LAND USE



UNSCIENTIFIC CONSTRUCTION



DEFORESTATION



QUARRYING



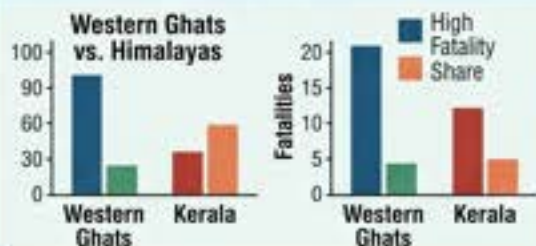
ROAD-LAYING



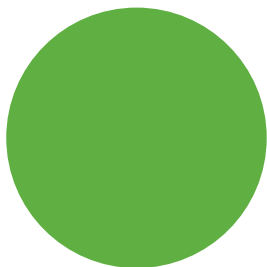
PLANTATION EXPANSION

SLOPE FAILURE & LANDSLIDE
Hazardous to Life, Property, Infrastructure

LANDSLIDE HAZARD IN INDIA & KERALA (ISRO-NRSC DATA)



KERALA HAS DISPROPORTIONATELY HIGH LANDSLIDE FATALITIES



• LEGAL

For doxxing victims in India, a patchwork of laws to navigate

Vineet Bhatta

New Delhi, August 2

WOMEN WHO participated in the protests at Delhi's Jantar Mantar are finding themselves at the centre of an online backlash.

Social media accounts have shared videos and photographs of a number of such women at the protests, and made public their personal details such as phone numbers and home addresses. This has resulted in instances of harassment, including rape and death threats.

The act of publicly revealing private personal information to intimidate or shame someone is known as doxxing. Despite its severe real-world consequences, doxxing is not explicitly defined or penalised as a criminal offence under Indian law. Legal experts say that victims have to navigate a patchwork of existing statutes under the Bharatiya Nyaya Sanhita (BNS) and the Information Technology (IT) Act to find recourse.

Laws in India

The issue must be viewed in two parts, Supreme Court lawyer Shruti Narayan told *The Indian Express*: dissemination of personal information, and subsequent threats or harassment based on that information. The latter is easier to prosecute under criminal law.

If doxxing leads to someone monitoring a woman's internet use or trying to contact her repeatedly, it attracts Section 78 of the BNS, which deals with stalking. Rape and death threats fall under Section 351 of the BNS, which deals with criminal intimidation. If the victim is a minor, Section 32 of the Protection of Children from Sexual Offences Act is invoked.

Supreme Court lawyer Prasanna S said that if the

• WHAT IS DOXXING?

- The act of publicly revealing private personal information to intimidate or shame someone is known as doxxing.
- Despite its severe real-world consequences, doxxing is not explicitly defined or penalised as a criminal offence under Indian law.

doxxing involves the publication of pictures that humiliate a woman, it can trigger Section 79 of the BNS — which punishes acts "intended to insult the modesty of a woman" and those that "intrude upon the privacy of... a woman". If the published content relates to the violation of one's reputation, provisions for criminal defamation can be invoked, he added.

However, when it comes to the mere publication of personal data, the law is uncertain. Prasanna explained that the act of doxxing itself is largely treated as a civil offence under the IT Act, rather than a criminal one, "unless intimate images are shared".

Section 66E of the IT Act criminalises the capturing or publishing of images of private body parts without consent. For general personal data, victims have to rely on Section 72A of the IT Act, which penalises the unauthorised disclosure of information. But this section primarily provides for a financial penalty of up to Rs 5 lakh, making it a civil wrong rather than a criminal offence.

Platform accountability

Victims can also hold social media platforms accountable. Under the IT (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021, platforms are legally obligated to make reasonable efforts to prevent users from hosting information "invasive of another's privacy including bodily privacy, insulting or harassing on the basis of gender".

The Rules mandate strict timelines for platforms to act. Intermediaries are required to acknowledge complaints within 24 hours and resolve them within seven days. For complaints regarding content that falls under specific severe categories — such as privacy invasions or harassment — platforms must resolve the issue within 36 hours.

If a platform fails to comply with these rules or ignores court orders, it risks losing its "safe harbour" protection — a legal immunity that shields tech companies from being prosecuted for what users post on their sites. In practice, however, "different platforms of course have varying levels of responsiveness and safety tools," Namrata Maheshwari, Asia Pacific Policy Manager and Global Encryption Policy Lead at Access Now, an international digital rights organisation, told *The Indian Express*.

For immediate relief, lawyers advise victims to preserve all evidence, including screenshots and URLs of the abusive posts.

- **Key Terms and Explanations**
- **Doxxing**
 - **Definition:** Doxxing (short for "dropping dox" or documents) refers to the malicious act of gathering and publicly releasing an individual's private, sensitive, or personally identifiable information (PII)—such as home addresses, personal phone numbers, real names, workplace details, or financial records—without their explicit consent.
 - **Core Objective:** The intent is almost always punitive or coercive, aimed at intimidating, shaming, harassing, or inciting real-world threats against the victim.
- **Safe Harbour Protection**
 - **Definition:** A legal doctrine, codified under **Section 79 of the Information Technology (IT) Act, 2000**, that shields digital intermediaries (such as social media platforms, internet service providers, and web hosts) from criminal or civil liability for third-party content uploaded by users on their platforms.
 - **Operational Condition:** This immunity is conditional, not absolute. To retain safe harbour protection, platforms must exercise "due diligence" and strictly adhere to government guidelines, including the rapid removal of unlawful or policy-violating content upon receiving official notice or user grievances within prescribed timeframes.
- **Informational Privacy vs. Bodily Privacy**
 - **Informational Privacy:** The right of an individual to control the collection, dissemination, and usage of their personal data (e.g., phone numbers, location history, private correspondence).
 - **Bodily Privacy:** Protection against the unauthorized capture, exposure, or violation of an individual's physical body or intimate images (e.g., non-consensual sharing of intimate images or invasive photography).
 - **Key Difference in Indian Law:** While violations of bodily privacy trigger stringent criminal penalties (e.g., Section 66E of the IT Act or voyeurism under criminal codes), violations of informational privacy (like publishing phone numbers) are predominantly treated as civil wrongs carrying financial penalties rather than immediate criminal detention.
- **Intermediary Guidelines and Digital Media Ethics Code Rules, 2021**
 - **Definition:** A set of subordinate rules framed under the IT Act that mandate strict compliance frameworks for tech platforms operating in India.
 - **Key Provisions for Digital Harassment:**
 - **Acknowledgement Window:** Intermediaries must acknowledge complaints regarding content violations within **24 hours**.
 - **Standard Redressal Window:** Complaints must be resolved within **7 days** (previously 15 days).
 - **Emergency/Severe Categories Takedown:** Content involving non-consensual intimacy, severe privacy breaches, or gender-based harassment must be removed or access disabled within **36 hours** of receiving a valid complaint.

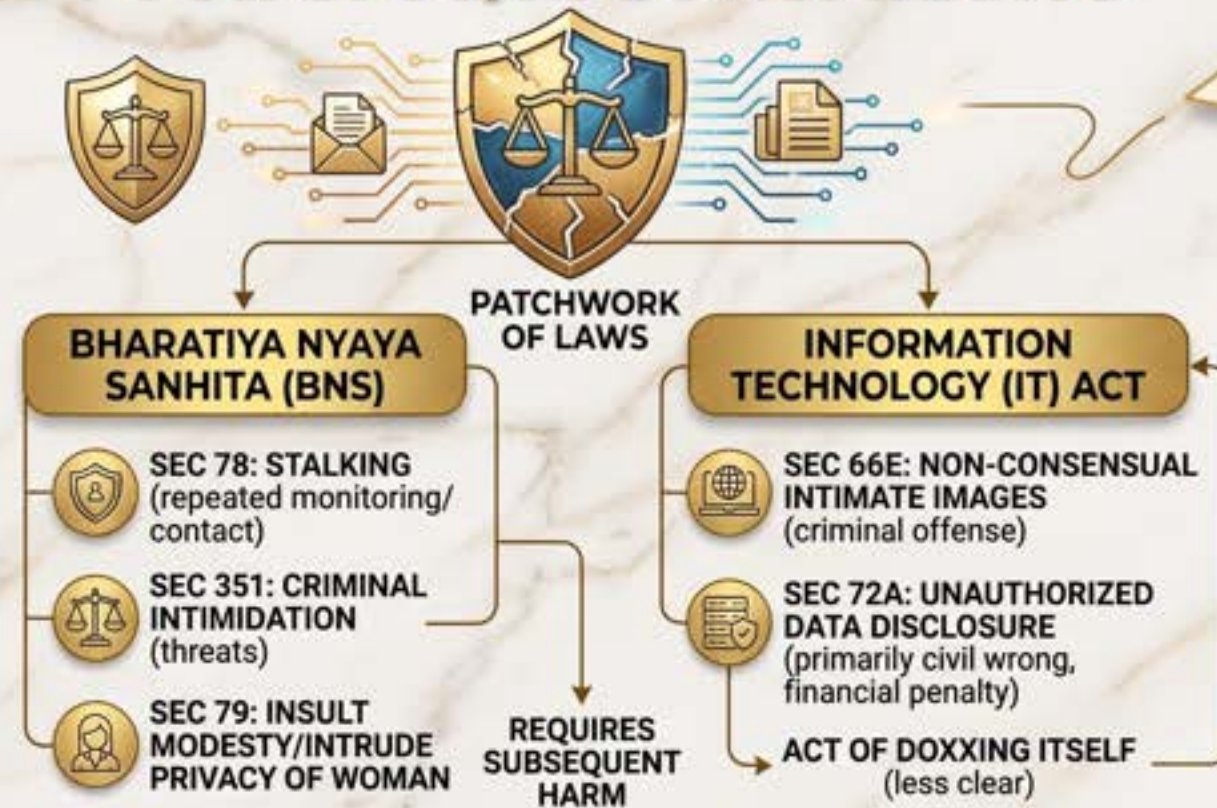
- **Main Arguments and Substantive Parts**
- **Core Thesis**
 - India's existing legal mechanism against digital targeted exposure operates through a fragmented, reactive, and patchwork legal framework. While criminal law effectively addresses *consequential* actions—such as direct stalking, threats, or harassment—the foundational act of weaponizing personal data (doxxing itself) remains under-regulated, falling into a grey zone between civil data protection claims and high-threshold criminal offenses.
- **Key Substantive Points**
- **The Structural Gap Between Exposure and Consequence**
 - Criminal law mechanisms under the Bharatiya Nyaya Sanhita (BNS)—such as Section 78 (stalking) or Section 351 (criminal intimidation)—require proof of overt, subsequent acts like persistent tracking or explicit threats of violence.
 - The preliminary act of publishing an individual's private phone number or address on a public forum does not, by itself, automatically trigger these criminal provisions unless direct malicious intent or resultant harassment can be definitively established in court.
- **Civil Remedies vs. Criminal Realities**
 - Section 72A of the IT Act penalizes the unauthorized disclosure of information, but it is primarily structured as a civil wrong leading to monetary compensation (up to ₹5 lakh) rather than criminal prosecution.
 - For victims facing rapid, mob-driven harassment, a civil remedy offers little immediate deterrence against anonymous or pseudonymous digital mobs.
- **Asymmetry of Harm and Platform Enforcement**
 - The real-world consequences of doxxing are immediate, asymmetric, and long-lasting, disproportionately impacting women, civil society activists, and minority voices.
 - While the Intermediary Rules of 2021 impose statutory timelines (24-hour acknowledgement and 36-hour/7-day redressal) under threat of losing safe harbour immunity, enforcement in practice varies widely across platforms due to algorithmic content moderation limitations and jurisdiction challenges.
- **Counterarguments and Nuanced Perspectives**
- **The Risk of Over-Criminalization and Free Speech Chilling**
 - **Perspective:** Legal scholars caution against creating overly broad, draconian anti-doxxing laws that could be weaponized by powerful state or non-state actors to suppress investigative journalism, civic activism, or public whistleblowing.
 - **Nuance:** Exposing public records of a corrupt official or identifying a violent offender via public footage serves a clear public interest. Any legislative definition of doxxing must strictly differentiate between public interest transparency and targeted private harassment.
- **Statutory Burden on Digital Intermediaries**
 - Tech platforms argue that imposing strict criminal liability for failing to proactively intercept user-generated text containing personal information (like phone numbers) could lead to automated, over-broad censorship and violate user privacy through invasive content monitoring.

- **Historical Evolution of the Issue**
- **Pre-Digital to Early Internet Era (Pre-2000s)**
 - Privacy violations were predominantly physical or paper-based, governed under traditional tort law, Indian Penal Code (IPC) provisions regarding trespass, defamation, and criminal intimidation.
 - The enactment of the **Information Technology Act, 2000** focused primarily on facilitating e-commerce, digital signatures, and basic network integrity, paying limited attention to social media harassment or data privacy.
- **The Expansion Phase and Section 66A Era (2008–2015)**
 - **2008 IT Act Amendments:** Introduced provisions addressing cyber-harassment, unauthorized disclosure (Section 72A), and voyeurism/bodily privacy (Section 66E). It also introduced Section 66A, which broadly criminalized sending "offensive" online messages.
 - **Shreya Singhal v. Union of India (2015):** The Supreme Court struck down Section 66A due to its vague, overbroad, and chilling impact on free speech (Article 19(1)(a)). While crucial for speech freedom, this created an enforcement vacuum regarding online targeted abuse, forcing law enforcement to rely on traditional, physical-world criminal laws.
- **The Constitutional Privacy Landmark (2017)**
 - **Justice K.S. Puttaswamy v. Union of India (2017):** A unanimous 9-judge bench declared the Right to Privacy as a fundamental right intrinsic to life and personal liberty under Article 21 of the Indian Constitution.
 - The court explicitly recognized **informational privacy** as a core component of human dignity, laying the normative groundwork for regulating unauthorized personal data dissemination.
- **Modern Intermediary Framework and Criminal Recodification (2021–Present)**
 - **IT Rules, 2021:** Shifted focus to platform accountability, introducing statutory redressal timelines and linking safe harbour (Section 79) protection to compliance with content-removal mandates.
 - **Bharatiya Nyaya Sanhita (BNS) Transition:** Replaced the IPC, re-codifying stalking (Section 78), criminal intimidation (Section 351), and acts insulting the modesty of a woman (Section 79), yet maintaining the legacy approach of addressing harassment only *after* harmful secondary actions manifest.



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UNDERSTANDING DOXXING IN INDIA: A COMPREHENSIVE LEGAL ANALYSIS FOR UPSC/APSC ASPIRANTS

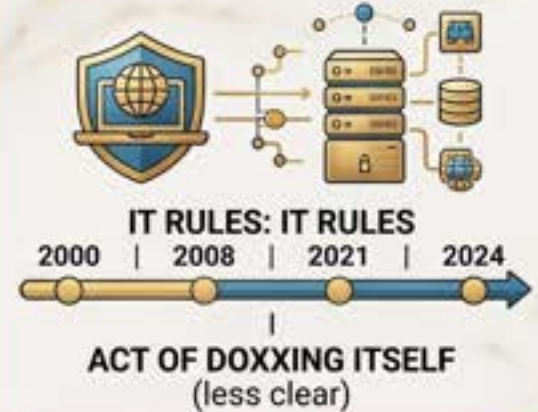


SEC 66E: NON-CONSENSUAL INTIMATE IMAGES
(criminal offense)

SEC 66E: NON-CONSENSUAL INTIMATE IMAGES (criminal offss)

SEC 351: CRIMINAL INTIMIDATION (threats)

SEC 79: MODESTY/INTRUDE PRIVACY OF WOMAN



WHAT IS DOXXING?

The malicious act of publicly revealing private personal info (PII) like phone numbers, addresses, to intimidate or shame. NOT explicitly defined as a standalone criminal offense.



1 INFORMATIONAL VS. BODILY PRIVACY 2

INFORMATIONAL (e.g., publishing address)	BODILY (e.g., non-consensual images)
→ CONFLICTED REMEDY: Civil Wrong/Penalty	→ CLEARER OFFENSE: Criminal Penalty

UPSC RELEVANCE (GS PAPERS)

GS 1	GS 2	GS 3	GS 4
- Society - Gender Violence	- Polity - Fundamental Rights - Patchwork Laws	- Cyber Security - Social Media Misuse	- Ethics - Cyber Ethics

• ECONOMICS

Tamil Nadu's economy is growing rapidly; why are its revenues not keeping pace

Arun Janardhanan
Chennai, August 2

FOR DECADES, Tamil Nadu has been among India's most diversified and industrialised economies. It manufactures automobiles and electronics, exports textiles, attracts investment, builds highways and industrial parks, and has steadily expanded its services sector.

Yet, the government's latest White Paper on the state's finances shows that even as the economy expanded in the post-pandemic years, the government's own finances weakened. Revenue has failed to keep pace with economic growth and debt has continued to rise.

It is against this backdrop that the Tamil Nadu government has now constituted the Revenue Augmentation Committee under former Planning Commission deputy chairman Montek Singh Ahluwalia.

On paper, the committee's mandate is straightforward: improve tax administration, plug leakages, identify new tax and

non-tax revenues, recommend reforms, and suggest ways to increase revenue from liquor and public assets.

But viewed through the White Paper, the committee is really being asked to answer a much larger question. Why has the state's revenue stopped reflecting the growth of its economy?

Growth, revenue: Out of step

The White Paper shows that Tamil Nadu's own-tax effort (revenue from taxes the state levied) weakened even during the post-Covid economic recovery. The White Paper characterises this deterioration as structural rather than cyclical. It points to administrative shortcomings, leakages and corruption as major reasons for declining revenue effort. But identifying leakages is only one part of the exercise.

"Fast-growing sectors may not be adequately captured. Some activities may be lightly taxed relative to their economic value. In other areas, taxes may exist but enforcement may remain weak. Adminis-

Tamil Nadu's revenues

YEAR	OWN TAX REVENUE AS % OF GSDP
2021-22	5.93%
2022-23	6.63%
2023-24	6.22%
2024-25	5.78%
2025-26 (RE)	5.45%

SOURCE: STATE BUDGETS, RBI, WHITE PAPER ON THE FISCAL MANAGEMENT OF TAMIL NADU

trative inefficiency, evasion and exemptions together may prevent the state from collecting what the economy is already generating," a senior official with the state finance department told *The Indian Express*.

Revenue not only factor

The committee's title focuses on rev-

enue augmentation, but there is another equally important question: how efficiently is public money being spent?

"Public finance does not improve only by collecting more. It also improves when leakages on the expenditure side are reduced," said a senior consultant attached to the state finance and expenditure domains. "Procurement systems, project implementation, subsidies, contracting and delivery mechanisms all become part of the conversation about fiscal sustainability. The White Paper itself notes that committed expenditure — including salaries, pensions and interest — has steadily consumed a larger share of revenue receipts, leaving progressively less fiscal space for development expenditure and capital investment," he said.

Rebuilding non-tax revenues

The committee has also been asked to examine non-tax revenues — from dividends of public sector undertakings and land monetisation to user charges and public utilities.

Experts point out that the quality of public services influences the willingness of citizens to pay fees, charges and tariffs. Fiscal reform, therefore, is inseparable from administrative reform. Technology occupies a central place in the committee's terms of reference. Digital systems can simplify compliance, reduce discretion and improve monitoring. Yet experience across departments suggests that technology alone rarely eliminates corruption.

"Many departments including the Road Transport department have already undergone substantial digitisation. Yet corruption and commission practices often survive because institutions gradually adapt around technological safeguards. The challenge therefore lies not merely in introducing digital systems but in strengthening governance itself — aligning incentives, increasing accountability, improving supervision and ensuring that institutions cannot simply discover new ways to bypass technological controls," said the expert advising several government plans in association

with the state finance department.

Difficult choices

If improving compliance appears politically straightforward, other recommendations may prove considerably more contentious. The committee has been asked to examine user charges, liquor policy, asset monetisation and other non-tax revenues.

Each involves trade-offs. Higher registration fees may affect property markets. Changes in utility charges may influence affordability. Altering liquor policy raises questions extending well beyond revenue alone.

Also, multiple experts known to the new committee formation and its purpose said the expenditure reforms may require uncomfortable assessments of whether every programme is delivering outcomes proportionate to its fiscal cost.

The committee's challenge is therefore also political.

FULL REPORT ON
[INDIANEXPRESS.COM/EXPLAINED](https://indianexpress.com/explained)

- **Key Terms and Explanations**
 - **Own Tax Revenue (OTR) to GSDP Ratio:**
 - **Explanation:** This metric measures the proportion of a state's total economic output (Gross State Domestic Product) collected through its own direct and indirect taxes, excluding central transfers and grants.
 - **Example:** If a state produces goods and services worth ₹100 crore in a year and collects ₹6 crore through its own taxes (like state GST, stamp duty, and motor vehicle tax), its OTR-to-GSDP ratio is **6%**. A declining ratio indicates that revenue generation is failing to keep pace with economic expansion.
 - **Tax Buoyancy:**
 - **Explanation:** Tax buoyancy measures the responsiveness of tax revenue growth to changes in Gross Domestic Product (GDP) or Gross State Domestic Product (GSDP).
 - **Example:** A tax buoyancy greater than **1** means tax collections grow at a faster rate than the economy. If the economy grows by **8%** and tax collection increases by **10%**, the tax system is buoyant. A ratio below **1** signals structural inefficiencies or widespread tax leakage.
 - **Structural vs. Cyclical Fiscal Deterioration:**
 - **Explanation:** Structural deterioration refers to permanent, systemic flaws in the tax architecture or expenditure profile (such as narrow tax bases or administrative corruption). Cyclical deterioration is temporary and caused by short-term macroeconomic downturns like recessions or global crises.
 - **Example:** A drop in fuel tax revenue during a temporary pandemic lockdown is *cyclical*. A steady decline in property tax collection over a decade due to outdated land valuation methods is *structural*.
 - **Committed Expenditure:**
 - **Explanation:** These are obligatory, non-negotiable government expenditures that cannot be easily cut in the short term, primarily comprising salaries, pensions, and interest payments on past borrowing.
 - **Example:** When a state spends over **60%** of its revenue receipts solely on paying existing civil servants, retired employees, and servicing accumulated debt, it leaves minimal fiscal space for building new roads, hospitals, or schools.
 - **Asset Monetization and Non-Tax Revenue:**
 - **Explanation:** Non-tax revenue refers to income generated by the government through sources other than taxation, such as user charges, public utility tariffs, state enterprise dividends, and leasing public assets.
 - **Example:** Collecting fees for highway usage (toll charges) or leasing unutilized government-owned land to private solar developers generates non-tax revenue without imposing new taxes.

- **Main Arguments and Substantive Parts**

- **The Sub-National Growth-Revenue Paradox**

- High-performing industrial states often witness a stark contradiction: rapid expansion in economic output driven by manufacturing, tech, and services alongside a stagnant or declining tax-to-GSDP ratio. While the state's total economic pie expands, state tax revenue as a percentage of GSDP declines steadily. This demonstrates that economic growth does not automatically translate into public revenue unless the tax administration evolves in tandem with structural economic shifts.

- **Administrative Inefficiencies and Tax Leakages**

- The core cause of revenue stagnation is structural rather than cyclical. Rapidly growing sectors—particularly modern service industries, digital commerce, and complex real estate markets—often remain under-taxed relative to their true economic value. Furthermore, administrative bottlenecks, tax evasion, enforcement gaps, and widespread exemptions prevent sub-national governments from capturing the full fiscal potential of their expanding economies.

- **Squeeze on Developmental Fiscal Space**

- On the expenditure side, sub-national budgets face growing pressure from committed liabilities, including salaries, pensions, and interest payments. When committed expenditure swallows a disproportionate share of revenue receipts, states face a shrinkage in developmental fiscal space. Consequently, critical capital investments in public infrastructure, health, and education are sidelined, forcing governments to rely on borrowing and creating a persistent cycle of debt accumulation.

- **Limits of Purely Technological Solutions**

- While digitizing public administration (such as online vehicle registration or electronic land records) streamlines processes, it does not automatically eliminate corruption or tax leakages. Institutions and corrupt practices often adapt around digital safeguards. Technology acts merely as a tool; without institutional restructuring, administrative accountability, and aligned personnel incentives, technological intervention yields diminishing returns in revenue collection.

- **Political Economy of Fiscal Rationalization**

- Augmenting non-tax revenues—through revised user charges, updated property registration fees, utility tariff hikes, and public asset monetization—faces severe political and social friction. Raising charges on essential public services risks public pushback and raises equity concerns regarding affordability for marginalized groups. Sub-national governments must navigate the trade-off between fiscal sustainability and political feasibility.

- **Historical Evolution of the Issue**

- **Pre-1991: Controlled Economy and Sub-National Dependence**

- During the planned economy era, states had limited tax autonomy. State revenues were primarily anchored in traditional sales taxes, state excise on alcohol, and stamp duties. Major economic decisions were driven by central allocation, and states relied heavily on central tax transfers and grants recommended by Finance Commissions. Fiscal deficits were often monetized or absorbed through indirect central assistance.

- **Post-1991 Reforms and the FRBM Framework**

- The 1991 economic reforms shifted the growth engine toward private investment, sparking inter-state competition to attract capital. As industrial states expanded rapidly, sales tax systems became fragmented, leading to tax wars between states. To enforce fiscal discipline, the central government enacted the Fiscal Responsibility and Budget Management (FRBM) Act in 2003, prompting states to enact their own Fiscal Responsibility Legislation (FRL) between 2003 and 2005. States were mandated to cap their fiscal deficit at **3%** of GSDP and eliminate revenue deficits.

- **The VAT Transition (2005)**

- In 2005, India replaced state sales taxes with the Value Added Tax (VAT). VAT harmonized tax rates, reduced the cascading effect of taxes, and improved compliance transparency. For industrial states, VAT provided a major boost to own tax revenues, aligning tax collection with rising state manufacturing output.

- **The GST Regime (2017) and Loss of Tax Autonomy**

- The implementation of the Goods and Services Tax (GST) in 2017 marked a major structural shift in Indian fiscal federalism. States pooled their sovereign power to levy indirect taxes into the GST Council, losing individual authority to alter tax rates on most goods and services (excluding alcohol for human consumption and specified petroleum products). To cushion the transition, the Centre guaranteed a **14%** annual revenue growth protection through the GST Compensation mechanism for five years.

- **Post-2022 Challenges and the Search for Fiscal Autonomy**

- The expiration of the GST Compensation regime in June 2022, combined with post-pandemic economic disruptions, exposed structural vulnerabilities in state finances. Industrial states found that while their GSDP continued to grow, their primary indirect tax tool (GST) was bound by national consensus rates, while local direct instruments (property tax, land revenue, user charges) remained politically difficult to reform. Today, states are turning to specialized fiscal committees to optimize tax administration, plug systemic leakages, and monetize non-tax assets.

RAPIDLY GROWING ECONOMY (GSDP)



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COMPREHENSIVE FISCAL ANALYSIS: TAMIL NADU'S GROWTH-REVENUE DIVERGENCE.

OWN TAX REVENUE AS % OF GSDP (TREND)



CAUSES OF FISCAL WEAKNESS

REVENUE STAGNATION & RISING DEBT

CAUSES OF FISCAL WEAKNESS

- ADMINISTRATIVE INEFFICIENCY**
Leakages & Weak Enforcement
- EVASION & UNDER-CAPTURING**
Fast-Growing Sectors not effectively taxed
- COMMITTED EXPENDITURE PRESSURE**
Salaries, Pensions, Interest eat into Revenue Receipts
- NON-TAX REVENUE POTENTIAL UNTAPPED**
Low User Charges, Monetization needs

UPSC/TNPSC RELEVANCE: KEY CONCEPTS



FISCAL FEDERALISM
(Union-State Finance relations)



PFM & TAX ADMINISTRATION



CAPITAL EXPENDITURE & GSDP MULTIPLIER



CITIZEN'S WILLINGNESS TO PAY & SERVICE QUALITY

GOVERNANCE BEYOND TECHNOLOGY:
Digital systems alone are insufficient. Institutional strengthening, aligned incentives, and accountability are key.



REVENUE AUGMENTATION COMMITTEE:

ROADMAP FOR FISCAL REFORM

(Under Montek Singh Ahluwalia, Former Planning Commission Deputy Chairman)

- 1. IMPROVE ADMIN**
Plug Leakages, Strengthen Oversight
- 2. IDENTIFY NEW REVENUE**
Capturing emerging industries
- 3. REFORM NON-TAX SOURCES**
Rationalize User Charges, Asset Monetization
- 4. EXPENDITURE REVIEWS**
Target Subsidies, Rationalize Committed Spending
- 5. GOVERNANCE STRENGTHENING**
Align Incentives, Beyond Digitization Alone



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AgniKul eyes reusable rocket mission

BIG LEAGUE. Space tech firm seeks to revolutionise launch economics; aims for early 2027 timeline for SpaceX-style cosmic venture

Sindhu Hariharan
Rohan Das
Chennai

Space tech start-up AgniKul Cosmos is aiming for an early 2027 timeline for its Mission 2, which will not only place a commercial payload in orbit but also attempt to recover the rocket's lower stage for reuse.

The architecture for the reusable launch vehicle is almost finalised, Srinath Ravichandran, Co-founder and CEO of AgniKul Cosmos, told *businessline*. "All the pieces of the tech needed for reusability are in place; we will now have to sequence them exactly," he said.

After lift-off, AgniKul's lower-stage rocket will function as an independent vehicle once separated from the rest of the rocket, and it will attempt a vertical landing on a barge in the Bay of Bengal after lifting off from Sriharikota. "It has come to a point where we are thinking of that [lower stage] alone as

its own separate rocket with its own brain and its own hardware to return," Ravichandran said.

The plan is to start taking the hardware to the launch location as it becomes ready, probably by this year. The launch itself will depend on the monsoon and a few pending approvals, he adds.

Success in this attempt will put the Indian start-up in the same league as SpaceX and mark a breakthrough for launch economics in the Indian space tech sector. Notably, both stages are being designed for multi-use — the upper stage is envisaged to remain in orbit as a reusable satellite bus.

ECONOMICS OF REUSE

Moin SPM, Co-founder and COO of AgniKul Cosmos, says that 3D printing enables automated, repeatable, error-free production while improving the reliability of their launch. Most importantly, recovery now decouples engine capacity from launch cadence, he notes.



SEEKING BREAKTHROUGH. Srinath Ravichandran (left), Co-founder and CEO, AgniKul Cosmos and Moin SPM, Co-founder and COO, at their office at IIT Research Park, Chennai BUJO GHOSH

"Conservatively speaking, we could make around five rockets but potentially do about 25 launches through refurbishment and reuse," he said.

The founders say customer visibility is strong, driven by growth in Indian satellite companies and global launch demand.

The company also considers Skyroot's commercial launch as a policy win for the

sector. "Every single nuance of what it means to do an orbital launch is being proven now... we have gotten so much inbound interest generally with that launch happening," Ravichandran says.

INSIDE THE FACILITIES

At the centre of these ambitions are AgniKul's two facilities in Chennai, toured recently by *businessline*.

The 'rocket factory' at the

IIT-Madras Research Park, through the company's partnership with EOS as its official 3D-printing technology partner, churns out Agnilet, the company's fully integrated, single-piece semi-cryogenic engine, made from Inconel, from scratch.

Electrical discharge machines slice the engine off its build plate once printed, and an in-house-built de-powdering machine — a point of pride for the team — completes the process. Together, these can produce one fully 3D-printed rocket engine every 72 hours.

The engine then travels 30 km to AgniKul's test facilities in Thaiyur, where test rigs put every component — engines, thermal control systems, electrical systems, liquid oxygen propellant, and more — through repeated tests before final integration.

A young team runs the operation, supported by retired ISRO engineers as advisors.

Uma Maheswari, the Project Director for Mission 1, also spearheads multiple

rounds of testing needed for Mission 2. Saraniya Periaswamy, the Launch Vehicle Director, will now have to ensure that the booster is able to land vertically after stage separation.

LOOKING AHEAD

"You'll start seeing us regularly fly the rockets that we've already flown, so that will be a big win for us," say the founders.

"Our upcoming unit near Thoothukudi should also be operational by then and help us scale production to meet demand," they add.

"There is a lot of demand; many people want to go to space, and there is a shortage of launch vehicles," says Moin.

bl.  **video**

Watch the
full interview
here



<https://tinyurl.com/AgniKulCosmosMission2>

- **Key Terms and Concepts**
 - **Reusable Launch Vehicle (RLV):** A launch system designed to return to Earth after placing a payload into orbit, allowing the core rocket components to be recovered, refurbished, and flown again.
 - **Additive Manufacturing (3D Printing in Aerospace):** A process that builds three-dimensional objects layer-by-layer directly from digital CAD models, using specialized metal alloys like Inconel.
 - **Semi-Cryogenic Propulsion:** An engine system that uses refined kerosene (or specialized liquid hydrocarbons) as fuel alongside liquid oxygen (LOX) as an oxidizer at sub-zero temperatures.
 - **Vertical Takeoff, Vertical Landing (VTVL):** A technological capability where a rocket launches vertically into space and uses precise thruster control and landing legs to land back on Earth in an upright position.
 - **Orbital Satellite Bus (Reusable Upper Stage):** An upper rocket stage designed to remain in orbit after deploying its primary payload, functioning as a sustained host platform for secondary payloads or scientific experiments rather than immediately turning into space debris.
 - **Launch Cadence:** The frequency or rate at which a launch service provider can prepare, assemble, and execute rocket launches over a given operational timeline.
- **Main Arguments and Substantive Parts**
- **Core Thesis**
 - The Indian private space sector is undergoing a structural paradigm shift, moving from component manufacturing and state-led support roles toward indigenous, high-margin commercial spaceflight. By integrating additive manufacturing with reusable rocket architectures, private entities are reshaping launch economics to meet growing global satellite demand.
- **Key Substantive Pillars**
 - **Economic Transformation via Reusability:** The primary bottleneck of space access has historically been the disposable nature of launch vehicles. Recovering lower-stage boosters decouples hardware production limits from launch frequency, drastically reducing the cost-per-kilogram of payload delivered into orbit.
 - **Disruptive Manufacturing via Additive Processes:** Traditional rocket engine production involves hundreds of precision-machined parts, complex supply chains, and extensive welding. Utilizing automated 3D printing cuts manufacturing times to hours, eliminates human assembly errors, and increases structural reliability.
 - **Addressing the Global Supply Bottleneck:** The global expansion of satellite constellations has created a severe global deficit in small and medium launch vehicles. Indigenously developed, highly scalable private launch platforms allow Indian firms to capture a significant market share in the global commercial launch sector.
 - **Dual-Use Architecture and Orbital Sustainability:** Designing upper stages to serve as long-term orbital satellite buses addresses two critical goals: maximizing economic returns per mission and mitigating the growing threat of space debris in Low Earth Orbit (LEO).
- **Structural Challenges & Counterarguments**
 - **High Initial Failure Risks:** Reusable space technology requires precise real-time guidance, navigation, and control (GNC) algorithms for atmospheric re-entry. The engineering margins for error during vertical barge landings are minimal.
 - **Capital Intensity vs. Gestation Periods:** Deep-tech hardware startups face long development cycles and substantial capital requirements before achieving consistent commercial revenue, making them vulnerable to capital market volatility.

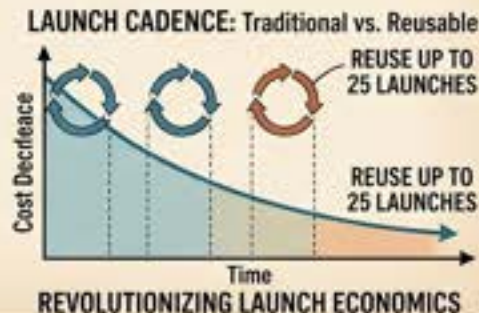
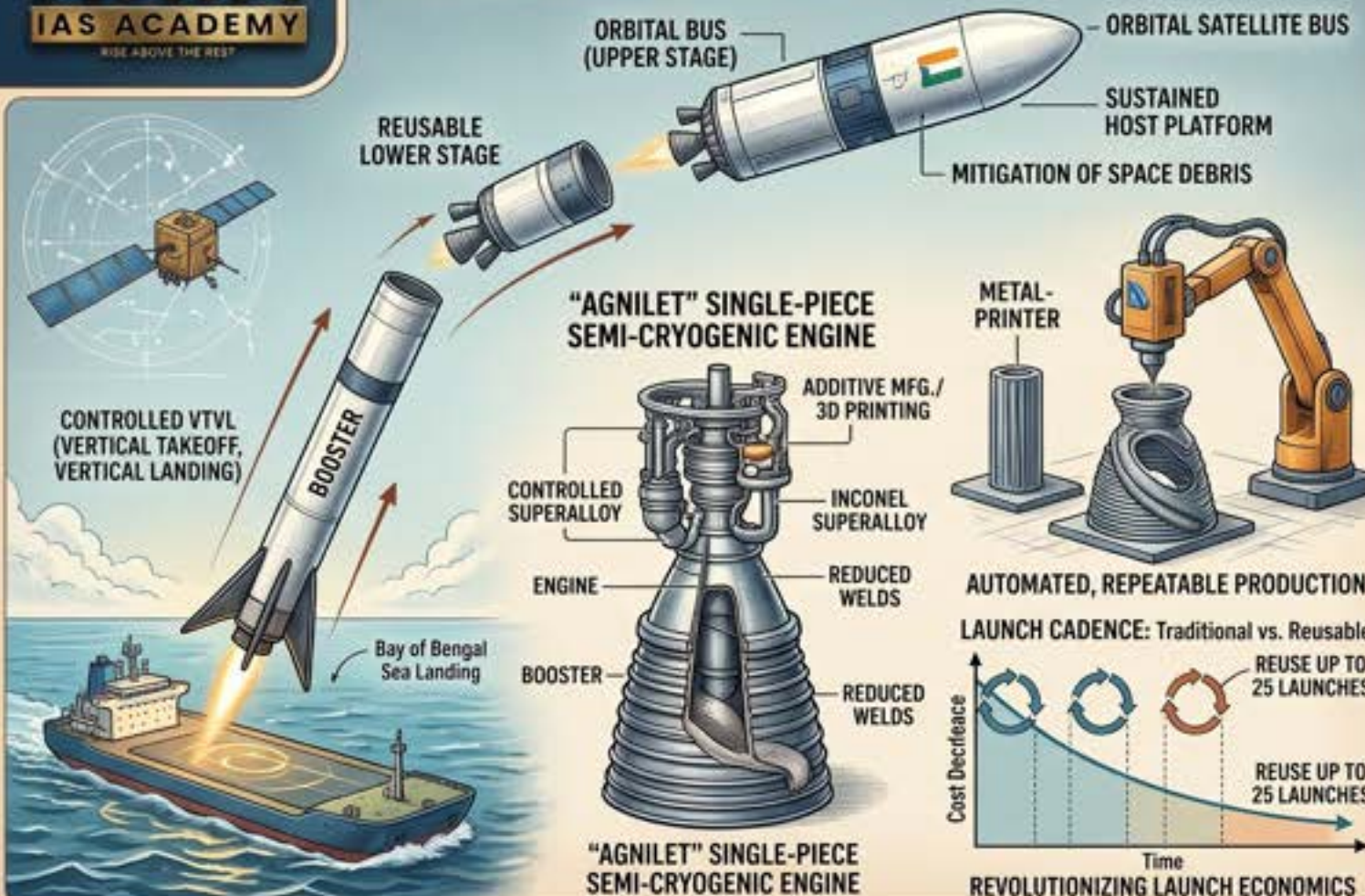
- **Historical Evolution of Space Launch Capabilities**
- **Institutional Foundations (1962–1969)**
 - **1962:** Establishing the Indian National Committee for Space Research (INCOSPAR) under Dr. Vikram Sarabhai initiates India's formal space journey, focusing on atmospheric research via sounding rockets.
 - **1969:** The formation of the Indian Space Research Organisation (ISRO) codifies a mission to leverage space technology primarily for national development, rural communication, weather forecasting, and resource mapping.
- **Era of State Monopoly & Capability Building (1970s–1990s)**
 - **1970s–1980s:** Development of the Satellite Launch Vehicle (SLV-3) and Augmented Satellite Launch Vehicle (ASLV) proves foundational principles of multi-stage solid propulsion.
 - **1990s:** The induction of the Polar Satellite Launch Vehicle (PSLV) provides India with autonomous, cost-effective access to space. During this period, the private sector operates strictly as build-to-print component suppliers for state-owned projects under the Department of Space.
- **Commercialization & Vendor Supply Phase (2000s–2019)**
 - **2000s:** ISRO establishes Antrix Corporation to commercialize satellite launches for international customers using the reliable PSLV framework.
 - **2010s:** Development of the Geosynchronous Satellite Launch Vehicle (GSLV Mark II and III) grants heavy-payload launch capabilities. Private aerospace companies evolve from sub-assembly contractors into key manufacturing partners for ISRO's hardware.
- **Deep Space Reforms & The Startup Era (2020–Present)**
 - **2020 Space Sector Reforms:** The Union Government opens the space sector to private enterprise, creating **IN-SPACe** (Indian National Space Promotion and Authorization Centre) as an independent regulatory body.
 - **2023 Indian Space Policy:** Clarifies operational roles: ISRO focuses on core R&D, deep-space exploration, and technology demonstration; NewSpace India Limited (NSIL) manages commercial assets; and private firms are empowered to build, launch, and operate end-to-end space systems.
 - **100% FDI Liberalization (2024):** Foreign Direct Investment norms are eased, permitting up to 100% FDI under automatic and approval routes across satellite manufacturing, launch vehicles, and component production, laying the groundwork for private reusable space ventures.



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COMPREHENSIVE ANALYSIS: REUSABLE SPACE TECHNOLOGY & PRIVATE SECTOR REFORMS

REUSABLE LAUNCH SEQUENCE & CORE CONCEPTS



MULTIDIMENSIONAL ANALYSIS



UPSC CSE SYLLABUS LINKAGES

GS 1	GS 2	GS 3	GS 4	Essay	Optionals
Semi Cryogenic Space Activities (Act)	GS 1	GS 2 GS 2	GS 4 GS 4	Essay	Optionals

WAY FORWARD

- Enact Space activities Act
- Risk-Share Insurance
- Dedicated Infra
- Concated Integrity
- Concated for imprints
- PPPs procetsses

KEY TERMS & EXPLANATIONS

VTVL Controlled controlled separation	Semi-Cryogenic Evonine coasable muonate
Additive Mfg. Reduced 3D printing	Additive Mfg. Send mommsc, mecal orpanes
Laurs Cadence Testical engine	Launch Cadence Communcations and space cadence

UPSC CSE SYLLABUS LINKAGES

GS 1	GS 2	GS 3	GS 4	Essay	Optionals
GS 1 GS 2	NDS	GS 2 GS 3	NDS	-	-

NCERT LINKAGES

Class 11 Physics	Class 11 Chemistry	Class 12 Economics
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PREVIOUS YEARS QUESTIONS

- 2023 GS-3 IN-SPACE, questions are iody to rervert In-SPACE
- 2017 GS-3 RLV - First Space andiest in India munition lab-miderives
- 2023 GS-3 RLV - Now strategization and space caship
- 2017 GS-3 RLV - Not sot procection in India foremendoaned

RBI funding restrictions hit derivatives trading volumes

STEEP FALL. NSE index futures and options activity slumps sharply in July

Suresh P Iyengar
Mumbai

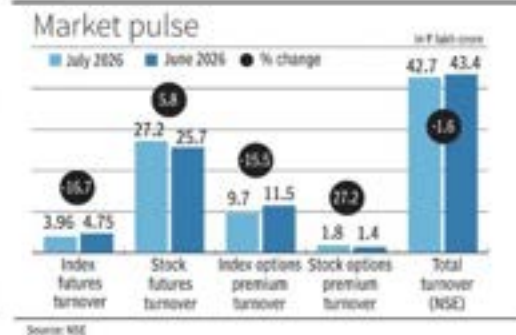
The RBI's tighter funding norms for capital market intermediaries have started reflecting in derivatives trading volumes, with turnover in NSE's index futures and options segment declining sharply in July.

Market participants, however, believe the full impact is yet to play out as a portion of bank funding sanctioned before the new rules kicked in on July 1 continued to support trading activity during the month.

Data from NSE showed that index futures turnover fell 17 per cent month-on-month to ₹3.96 lakh crore in July from ₹4.75 lakh crore in June, while index options premium turnover declined 16 per cent to ₹9.70 lakh crore from ₹11.5 lakh crore.

Overall NSE derivatives turnover was down 2 per cent at ₹42.7 lakh crore against ₹43.4 lakh crore in June. Stock futures and stock options premium turnover, however, rose 6 per cent and 27 per cent respectively.

Industry players said the decline in index derivatives



volumes could have been steeper had previously committed bank funding been fully exhausted. They expect the impact of reduced bank support for proprietary traders to become more evident in the coming months as existing facilities are renewed under the revised framework.

FUNDING FRAMEWORK

The RBI's revised funding framework has raised cash collateral requirements for bank guarantees and limited some intraday credit facilities, which has reduced the leverage available to proprietary traders and brokers.

Roop Bhootra, Whole-Time Director, Anand Rathi

Share and Stock Brokers, said the impact of the revised framework is expected to unfold gradually as existing facilities are replaced under the new norms.

"Derivatives turnover could witness further moderation over the coming months, especially in the options segment where proprietary traders contribute significantly to market volumes," he said. Several market participants expressed disappointment with the regulatory tightening, arguing that proprietary trading firms have historically maintained strong credit discipline and have rarely been a source of defaults for banks.

At the same time, they ac-

knowledgeed that the industry is likely to adapt given the attractive returns still available in the derivatives market. Traders are expected to explore alternative funding arrangements, although the transition could alter the competitive landscape.

Market participants believe that if domestic prop desks reduce their activity due to lower leverage, foreign portfolio investors, global trading firms, and other players with stronger funding capabilities could take advantage of the resulting opportunity. "The market never leaves a profitable opportunity vacant. If one set of participants pulls back, another typically steps in," said a senior broker.

MOST ATTRACTIVE

Amit Majumdar, Group Chief Strategy Officer, Angel One, said domestic proprietary trading desks are adjusting to the evolving regulatory environment. "Returns for prop traders in the Indian derivatives market remain among the most attractive globally, even without leverage, which keeps them incentivised to stay engaged," he said.

- **Key Terms and Explanations**

- **Financial Derivatives (Futures and Options)**

- Financial derivatives are standard financial contracts whose value is derived from an underlying asset, such as individual equities, stock market indices, commodities, or currencies.

- **Futures Contract:** A legally binding agreement to buy or sell an asset at a predetermined price on a specified future date.

- **Options Contract:** A contract that grants the buyer the right, but not the obligation, to buy (Call Option) or sell (Put Option) an underlying asset at a specified strike price within a set timeframe.

- **Capital Market Intermediaries and Proprietary Trading Desks**

- Intermediaries are institutional actors—such as stockbrokers, clearing members, and investment firms—that facilitate liquidity and settlement in financial markets.

- **Proprietary Trading (Prop Desks):** Refers to firms or specialized divisions within brokerages that trade stocks, bonds, currencies, or derivatives using the firm's own capital rather than client funds to generate direct trading profits.

- **Bank Guarantees (BGs) and Cash Collateral Requirements**

- A Bank Guarantee is a formal pledge issued by a commercial bank assuring a third party (such as a Clearing Corporation) that the bank will cover a financial liability if the intermediary defaults on its obligations.

- **Cash Collateral:** To secure a Bank Guarantee, commercial banks require stockbrokers to deposit a portion of the guarantee amount as cash or cash equivalents. Tighter central bank norms elevate this required cash ratio, directly locking up broker capital.

- **Intraday Credit Facilities and Leverage**

- **Intraday Credit:** Ultra-short-term, temporary credit lines granted by commercial banks to stockbrokers during trading hours to meet intra-day margin call spikes and settlement obligations.

- **Leverage:** The practice of using borrowed capital or financial instruments to amplify exposure beyond initial cash equity, magnifying both potential gains and losses.

- **Macroprudential Regulation**

- Regulatory policy frameworks implemented by a central bank to address systemic risks across the financial ecosystem, safeguarding financial stability rather than merely ensuring the solvency of individual institutions.

- **Main Arguments and Substantive Parts**

- **Core Thesis**

- The Reserve Bank of India's (RBI) tightened funding and collateral frameworks for capital market intermediaries are designed to de-risk the banking sector from stock market volatility. By restricting low-cost bank leverage and raising cash collateral requirements for Bank Guarantees, the central bank intentionally moderates excessive speculative activity in the financial derivatives segment, prioritizing systemic stability over high market turnover.

- **Key Points and Operational Mechanisms**

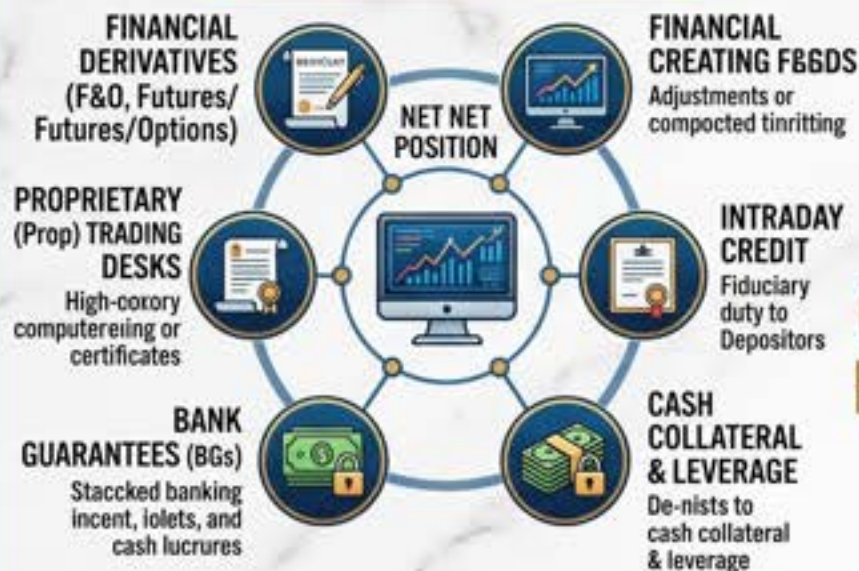
- **Moderation in High-Leverage Segments:** Restrictive credit guidelines directly depress trading activity in index-based derivatives. Index futures and index options premium turnovers experience noticeable contractions as margin funding costs rise for domestic trading desks.
- **Lagged Transmission of Policy Impact:** The full cooling effect of regulatory tightening takes time to materialize fully. Credit lines and bank guarantees sanctioned prior to new regulatory enforcement dates cushion initial market activity, with cumulative volume declines sharpening as existing facilities come up for renewal under stricter norms.
- **Asymmetric Capital Reallocation:** While broad index derivatives experience volume contractions due to tighter bank leverage, stock-specific futures and options can show resilience or short-term volume surges as market participants realign strategies toward stock-specific momentum and relative valuation plays.
- **Structural Displacement of Market Participants:** Higher funding hurdles for domestic proprietary desks create a structural shift. Well-capitalized entities—such as Foreign Portfolio Investors (FPIs), global quantitative trading firms, and entities with non-bank funding sources—step into trading voids, capturing market share from leverage-constrained domestic players.

- **Counterarguments and Industry Perspectives**

- **Low Default History vs. Regulatory Overreach:** Market intermediaries argue that proprietary trading desks maintain rigorous internal risk controls, strict stop-loss protocols, and an impeccable track record regarding bank loan repayments, meaning they pose minimal direct credit risk to commercial banks.
- **Liquidity Impairment Concerns:** Industry participants contend that curbing leverage reduces market depth, increases bid-ask spreads, and makes hedging more expensive for genuine institutional investors and corporate hedgers.
- **Regulatory Arbitrage:** Stricter domestic banking norms may inadvertently disadvantage domestic capital, favoring foreign offshore funds operating under different capital adequacy regimes.

- **Historical Evolution of the Issue**
- **Pre-Liberalisation and the Early Financial System (Pre-1991)**
 - Prior to financial sector reforms, Indian stock markets operated largely through informal credit channels and the physical *Badla* carry-forward system. Commercial banks lacked structured exposure limits to stockbrokers, leading to periodic liquidity shocks and interconnected risks between banking assets and stock exchanges.
- **Post-1992 Reforms and Institutional Formalisation**
 - The 1992 equity market crisis, driven by the misuse of Bank Receipts (BRs) to channel uncollateralized bank funds into equity trading, marked a turning point.
 - **Statutory Status to SEBI (1992):** Establishment of an independent capital markets regulator.
 - **RBI Credit Separation:** RBI instituted strict guidelines prohibiting direct, uncollateralized commercial bank funding for speculative stock market operations.
- **Introduction of Derivatives and the L.C. Gupta Committee (1998–2000)**
 - Following the recommendations of the L.C. Gupta Committee (1998), exchange-traded financial derivatives were officially launched in India in 2000. The framework mandated strong clearing house guarantees, standardized index contracts, and explicit margin requirements to prevent market manipulation.
- **Post-2008 Global Financial Crisis (GFC) and Macroprudential Shifts**
 - The 2008 financial crisis underscored how interconnected bank credit and complex OTC/exchange derivatives could spark systemic crises. Global central banks, including the RBI, adopted Basel III norms and established the Financial Stability and Development Council (FSDC) in 2010 to monitor cross-regulatory risks between banking and capital markets.
- **The Post-COVID Derivatives Boom and Modern Tightening (2020–Present)**
 - The period following 2020 witnessed an unprecedented surge in index options trading, driven by algorithmic prop desks, low-cost discount brokerages, and increased retail participation. Fearing potential financial contagion, retail wealth erosion, and indirect bank risk exposure, the RBI progressively tightened exposure rules, culminating in strict collateral frameworks for bank guarantees and credit facilities granted to capital market intermediaries.

KEY TERMS EXPLAINER



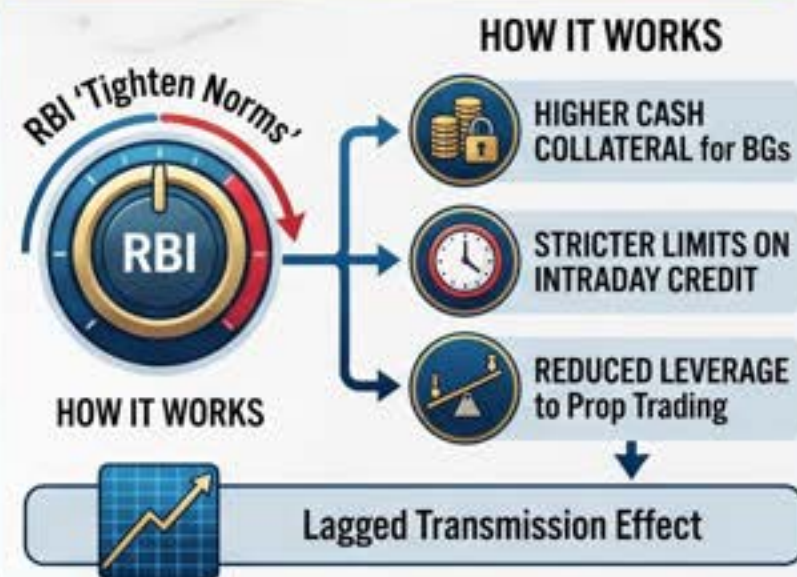
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COMPREHENSIVE ANALYSIS: RBI FUNDING RESTRICTIONS & DERIVATIVES TRADING



THE RBI POLICY & MECHANISM FLOWCHART



MARKET IMPACT DATA (NSE JULY)

1	INDEX FUTURES TURNOVER	₹3.96L Cr	▼ -17%
2	INDEX OPTIONS PREMIUM TURNOVER	₹9.70L Cr	▼ -16%
3	TOTAL NSE DERIVATIVES TURNOVER	₹42.7L Cr	↓ -2%

* Note: Prop Trading Desk adjustment to the Prop Trading Desk networkers to exchanged for action.



MULTIDIMENSIONAL HIGHLIGHTS



Social
Protects Household Savings



Political
Prevents Systemic Crashes



Ethical
Fiduciary Duty to Depositors



Legal
RBI Act & Banking Regulation Act Powers



International
Reallocation to FPIs



Economic
De-risks Banks from Markets



HISTORICAL TIMELINE & UPSC CSE LINKAGES

- Pre-1991 (Informal)
- 1992 (Harshad Mehta Scam, SEBI statutory)
- 1998-2000 (LC Gupta Cmt, F&O start)
- 2010 (Post-GFC, FSDC)
- 2020-Present (COVID boom, tightening)
- GS 3 (Economy, Banking, Risk)
- GS 2 (Statutory Bodies, Policy)
- GS 4 (Corporate Governance, Ethics)
- ESSAY (Free Markets vs State Reg)



WAY FORWARD & RECOMMENDATIONS

- 1 Tiered Framework
- 2 Diversified NBFC Funding
- 1 Joint RBI-SEBI Risk Desk
- 3 Risk Disclosure Rules



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