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In India, infertility is frequently reduced to a biomedical failure or a social stigma, overlooking the profound psychological landscape that governs reproductive health. While the National Family Health Survey (NFHS-5) indicates a decline in India's Total Fertility Rate (TFR) to 2.0, the "fertility industry" continues to grow. However, a significant gap exists between clinical advancements and societal perceptions. The discourse is shifting toward recognizing that mental health is not a peripheral consequence of infertility, but a central determinant of reproductive outcomes.

Infertility in India: bringing mental health to the forefront of condition

Mental health is not a peripheral concern in fertility care, it is a central determinant of reproductive health; until it is treated as an integral component of care for all genders, gap between what science knows and what society believes will widen; stigma should be replaced with science, silence with dialogue, and blame with compassion

Rashikkha Ra. Iyer

Is womanhood synonymous with motherhood? This question has lingered in the Indian social imagination for generations. The country's fertility landscape remains firmly anchored in a patriarchal narrative, where a woman's worth, identity, and social legitimacy are overwhelmingly tied to her ability to bear children.

Despite the biological fact that conception requires both a man and a woman, the moral burden of infertility is placed almost exclusively on women. Women without childrenare openly discouraged from attending weddings, baby showers, or religious ceremonies. Such exclusions deepen feelings of shame, isolation, embarrassment, identity fragmentation, and perceived moral failure.

Infertility, though a medical condition like any other, is frequently subjected to moral scrutiny. Even when medical evaluations clearly identify male-factor issues — such as low sperm counts or unexplained infertility — the cultural script continues to place blame squarely on women. This persistent assumption reinforces a deeply entrenched gender bias that distorts both responsibility and compassion.

Men's mental health

What often goes unacknowledged in these conversations is that male infertility itself is deeply intertwined with mental health, and that psychological distress can directly impair sperm quality. This is well-established in contemporary reproductive science. A 2024 original research article in *Frontiers in Endocrinology* found that depression is significantly associated with decreased semen quality, including reduced sperm concentration and motility (Zhang et al., 2024). This means that the very men who are culturally insulated from blame may themselves be experiencing psychological states that biologically diminish fertility potential.

Further evidence comes from a 2025 open-access study in *Reproductive Biology and Endocrinology*, which demonstrates that depression, anxiety, and stress impair sperm quality through dysregulation of the mitochondrial PDK-PDC axis, a pathway essential for healthy sperm metabolism (Wang et al., 2025). This mechanistic insight reinforces that mental health is not merely an emotional overlay, but a physiological determinant of reproductive function.

Ironically, the very patriarchal norms that so swiftly assign fault to women also conspire to keep men silent about their own psychological distress. This enforced quietude does more than perpetuate stigma – it may be actively undermining fertility itself. Observations from clinical reviews indicate that chronic psychological stress triggers activation of the hypothalamic-pituitary-adrenal (HPA) axis, driving up cortisol levels and destabilising the hormonal milieu essential for healthy spermatogenesis.

What emerges from this body of research is a striking paradox: while women absorb the social, emotional, and reputational costs of infertility, men's unaddressed mental health burdens may be biologically fuelling the very condition for which women are castigated.

Research shows that heightened anxiety and depressive symptoms are associated with lower success rates in procedures such as IVF. The monthly cycle of hope, hyper-vigilance, and disappointment compound this stress, creating a physiological environment that is less conducive to conception. GETTY IMAGES

Infertility, though a medical condition like any other, is subjected to moral scrutiny. If the silence around men's mental health obscures its biological consequences, the landscape for women is even more fraught

Acknowledging this dual reality is not merely a matter of fairness or empathy – it is central to improving reproductive outcomes.

If the silence around men's mental health obscures its biological consequences, the emotional landscape for women is even more fraught – and the science here is equally unambiguous. Mental health challenges do not merely accompany infertility; they can actively impair reproductive function. A landmark study in *Human Reproduction* found that women experiencing high levels of psychological stress had significantly lower probabilities of conception during each menstrual cycle, with elevated salivary alpha-amylase – a biomarker of stress –correlating with reduced fecundability (Lynch et al., 2014). In other words, stress is not just a by-product of infertility; it can be a precursor.

Findings from a number of studies underscore that emotional distress is not simply "in the mind" – it is inscribed in the endocrine system.

Taken together, the evidence paints a sobering picture: women are not only socially penalised for infertility but may also be physiologically disadvantaged by the very emotional burdens that stigma imposes. It is a cruel feedback loop – one in which social pressure becomes a biological impediment, and biology becomes further ammunition for social blame. Recognising this interplay is essential. Mental health is not a peripheral concern in fertility care, it is a central determinant of reproductive health. Until emotional well-being is treated with the same seriousness as hormonal assays and ultrasound scans, the gap between what science knows and what society believes will continue to widen, to the detriment of the very people seeking to build families. The consequences of this emotional burden extend even further when couples enter the realm of infertility treatment. Assisted reproductive technologies are often portrayed as purely biomedical solutions, yet their success is intimately tied to psychological wellbeing. Chronic stress – fuelled by stigma, family pressure, financial strain, and the relentless expectation to conceive – can disrupt hormonal regulation, impair ovulation, and interfere with the body's responsiveness to treatment protocols.

Pressures of treatment

Research consistently shows that heightened anxiety and depressive symptoms are associated with lower success rates in procedures such as IVF. The monthly cycle of hope, hyper-vigilance, and disappointment compound this stress, creating a physiological environment that is less conducive to conception.

The pressures of infertility treatment also reshape the most intimate dimensions of a couple's relationship. What is ordinarily an expression of desire, connection, or spontaneity can become tightly choreographed around ovulation windows, clinic schedules, and medical directives. Many couples describe sex during treatment as increasingly mechanical – an obligation rather than an act of intimacy.

This can erode relational closeness. Over time, the emotional strain can dampen libido, heighten anxiety, and create a sense of detachment between partners. Ironically, the very effort to conceive can undermine the relational and psychological conditions that support healthy sexual functioning.

Recognising this dynamic is crucial. Fertility treatment is not only a medical journey but a relational one. Without compassionate support that acknowledges the toll on intimacy, couples may find themselves navigating not only the challenges of infertility but also the quiet erosion of the connection that once anchored their partnership.

The path forward

India stands at a crossroads. The science is clear, the human cost undeniable, and yet our cultural narratives remain stubbornly unchanged.

The first step forward is cultural honesty. We must finally sever the idea that womanhood is validated through motherhood. As long as society treats fertility as a measure of virtue, women will continue to pay with their dignity, their mental health, and in many cases, their biological chances of conceiving. Equally urgent is the need to bring men into the centre of the conversation. The data shows that male mental health directly affects fertility, yet patriarchal norms keep men silent, unexamined, and emotionally unsupported.

Clinics, too, must evolve. Mental health support cannot remain a decorative add-on to reproductive care. It must be embedded into every stage of assessment and treatment. Screening for anxiety, depression, and relational strain should be as routine as semen analysis or hormone testing. When emotional wellbeing is treated as essential, outcomes improve – not just medically, but humanely. Finally, couples need support that protects their relationships from the corrosive pressures of treatment. Infertility should not be allowed to hollow out intimacy or turn partnership into performance.

The way forward is not complicated – it is simply long overdue. We must replace stigma with science, silence with dialogue, and blame with compassion. Only then can fertility care in India move from being a site of quiet suffering to one of dignity, equity, and genuine healing.

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THE GIST

- Despite the biological fact that conception requires both a man and a woman, the moral burden of infertility is placed almost exclusively on women. Even when medical evaluations clearly identify male-factor issues — such as low sperm counts or unexplained infertility — the cultural script continues to place blame squarely on women
- Mental health challenges do not merely accompany infertility; they can actively impair reproductive function. Findings from a number of studies underscore that emotional distress is not simply "in the mind" — it is inscribed in the endocrine system
- Mental health support cannot remain a decorative add-on to reproductive care. It must be embedded into every stage of assessment and treatment. Screening for anxiety, depression, and relational strain should be as routine as semen analysis or hormone testing

News Analysis: The Infertility-Mental Health Nexus

1. The Gendered Burden of Infertility

In the Indian social imagination, womanhood is often viewed as synonymous with motherhood. This patriarchal narrative places the "moral burden" of childlessness almost exclusively on women.

Social Exclusion: Women facing infertility are often excluded from auspicious ceremonies (weddings, baby showers), leading to "identity fragmentation" and deep-seated shame.

Misplaced Blame: Even when medical reports indicate male-factor infertility, the cultural script continues to castigate the woman, reinforcing a systemic gender bias in Indian society.

2. The Science of Silence: Male Infertility

The silence surrounding male mental health is not just a social issue but a biological one. Emerging research (notably studies in Frontiers in Endocrinology and Reproductive Biology and Endocrinology) reveals:

Biological Impairment: Depression and anxiety in men are linked to reduced sperm concentration, motility, and dysregulation of the **mitochondrial PDK–PDC axis**, essential for sperm metabolism.

HPA Axis Activation: Chronic stress triggers the Hypothalamic–Pituitary–Adrenal (HPA) axis, increasing cortisol levels that destabilize the hormonal environment required for healthy sperm production.

Paradox of Patriarchy: The very norms that "insulate" men from blame also discourage them from seeking psychological help, inadvertently worsening the biological conditions of infertility.

3. The "Cruel Feedback Loop" for Women

For women, the interplay between social pressure and biology creates a self-reinforcing cycle.

Stress as a Precursor: High levels of salivary alpha-amylase (a stress biomarker) correlate with reduced fecundability.

Physiological Barrier: The emotional distress caused by social stigma is "inscribed in the endocrine system," making the body less conducive to conception.

Treatment Paradox: The rigors of IVF—characterized by hope, hyper-vigilance, and disappointment—often create a "mechanical" intimacy, eroding the relational bond that supports reproductive health.

4. Structural Challenges in Fertility Care

Despite the clear links, the Indian medical ecosystem often treats mental health as a "decorative add-on."

Lack of Integration: Clinical assessments prioritize hormonal assays and ultrasounds over psychological screenings.

Relational Erosion: The intense focus on clinical "success" can hollow out the partnership, turning connection into a performance.

Conclusion

Infertility in India is a multifaceted challenge that requires moving beyond a purely biomedical approach. Addressing it effectively necessitates **severing the cultural link between womanhood and motherhood** and bringing men into the center of the reproductive health conversation. For India to modernize its fertility landscape, it must replace **stigma with science and**

silence with dialogue. Only by integrating mental health support as a core component of clinical care—on par with medical interventions—can we hope to bridge the gap between biological potential and social reality.

UPSC Mains Exam Practice Question

Ques: Infertility in India is not merely a biomedical condition but a significant psychosocial challenge. Discuss the mental health dimensions of infertility in India and suggest measures to integrate mental health support into infertility care. **(150 Words)**

Page 10 : GS III : Indian Economy

For decades, India's power distribution companies (DISCOMs) have been the "Achilles' heel" of the energy value chain, plagued by chronic financial losses and operational inefficiencies. However, as of 2026, the sector is witnessing a historic shift. For the first time, DISCOMs have collectively recorded a positive Profit After Tax (PAT) of ₹2,701 crore in FY 2024-25, signaling a "decisive turnaround" from the massive losses of the previous decade. While this progress is commendable, the sustainability of this recovery remains under scrutiny as it is heavily buoyed by state government interventions and subsidies.

DISCOMs and the road ahead

DISCOMs show improvement in performance, recording a positive turnaround marked by reduced AT&C losses, a narrowed ACS-ARR gap and improved financial discipline; however, many utilities continue to rely on tariff subsidies and loss takeovers by State governments, underscoring the scope for further improvement

EXPLAINER

T. Ramakrishnan

Better days seem to be ahead for the country's electricity sector, especially power distribution utilities, including power departments, commonly known as DISCOMs.

For long, DISCOMs, now numbering 72 across the country (44 State-owned, 16 private-sector entities, and 12 power departments), had presented a grim picture with never-declining line losses, also called Aggregate Technical and Commercial (AT&C) losses, and the consequent widening gap between the Average Cost of Supply (ACS) and the Average Revenue Realised (ARR). Between 2020-21 and 2024-25, accumulated losses rose from ₹5.5 lakh crore to ₹6.47 lakh crore, with outstanding debt increasing to ₹7.26 lakh crore. Non-cost-reflective tariffs and delayed payment of State subsidies were among the factors that contributed to this state of affairs.

A legacy of losses

As far as India is concerned, DISCOMs and losses have become synonymous, forcing specialists to use the prefix "minus" whenever a power utility's ARR exceeds its ACS. One may argue that loss-making is a legacy matter, as these power utilities – in their previous 'avatar', State Electricity Boards (SEBs), formed under the Electricity (Supply) Act, 1948 – were mostly in the red. But what was overlooked, even then and now, was that Section 59 of the law had originally required SEBs to make a profit of three or more per cent, as specified by State governments.

Signs of a turnaround

Even though many DISCOMs are struggling to cope with chronic issues, several others have begun improving their performance perceptibly in the wake of steps taken by various stakeholders, including those of the Union government. A Survey revealed that DISCOMs recorded a positive Profit After Tax (PAT) of ₹ 2,701 crore in the financial year 2024-25, marking "a decisive turnaround" from a loss of ₹67,962 crore in 2013-14. This improvement was accompanied by a reduction in AT&C losses from 22.62% to 15.04 % during the years in question. Further, the ACS-ARR gap (on an accrual basis) came down from 78 paise per unit (kilowatt-hour) to 0.06 paise per unit, signalling much improved cost recovery.

In mid-January, the Union government also made public the performance details of DISCOMs for the financial year that ended March 31, 2025. Claiming credit for the financial turnaround, the government attributed it to several measures, including the implementation of the Revamped Distribution Sector Scheme (RDSS), amendments to the Electricity Rules, and the introduction of the Late Payment Surcharge Rules.

The RDSS's objective is to improve the quality and reliability of power through a financially sustainable and operationally efficient distribution sector, with the release of funds linked to the execution of necessary measures. The effective implementation of the Rules has helped utilities arrest the mounting surcharges on legacy dues, as it allows DISCOMs to clear their dues through a maximum of 48 equated monthly instalments (EMIs).

Discipline and debt reduction

Prior to the Rules coming into force, delays and non-payments by DISCOMs had made it difficult for generators to pay for the fuel, which had to be prepaid, to continue generation, apart from having to pay the Railways in advance for the rakes.

When the Rules came into force on June 3, 2022, outstanding legacy dues totalled ₹1,39,947 crore. Since then, utilities in 13 States and Union Territories paid ₹ 1,31,942 crore till December 2025 through 39 EMIs, prepayments, and reconciliations. In January 2026, the dues went down further to ₹ 4,927 crore, with DISCOMs largely paying their current dues on time, reflecting a marked improvement in sectoral financial discipline.

Yet, not everything is rosy. Many DISCOMs, if not most, have been able to achieve the turnaround, essentially due to tariff subsidies received from and the takeover of losses by their respective governments. For instance, in the case of Tamil Nadu, during 2024-25, the Tamil Nadu Power Distribution Corporation Limited (TNPDCL), the successor to the Tamil Nadu Generation and Distribution Corporation (TANGEDCO), received ₹15,772 crore as tariff subsidy and ₹16,107 crore towards the takeover of losses. In fact, the utility recorded a profit (after tax) of ₹2,073 crore only after receiving the State government's largesse. But for the takeover of losses, TNPDCL had registered a loss of ₹14,034 crore, according to the findings of the 14th Integrated Rating Exercise conducted by the Power Finance Corporation Limited (PFC) under a framework approved by the Union Ministry of Power. The findings were released in late January 2026.

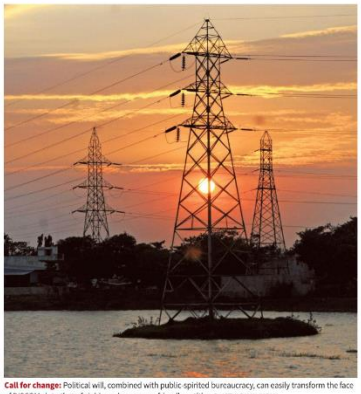
Take the case of Rajasthan: Jodhpur Vidyut Vitran Nigam Limited (JDVVNL), which, according to PFC's assessment, improved its showing during 2024-25 compared to the past. This utility recorded a profit of ₹92 crore, but this was after the receipt of ₹ 11,625 crore towards tariff subsidy and ₹ 2,540 crore towards loss takeover.

Besides, even the present position of DISCOMs enjoying revenue surplus appears to be transient, because when the utilities may have to effect pay revision for employees in a few years, the probability of them slipping back to square one – revenue deficit – is quite high.

The way forward

Still, the emphasis on government support, which is nothing new, is not to be viewed as taking away the credit for DISCOMs for enhanced performance. However, there is still scope for further improvement. At present, feeder segregation works, taken up in States such as Rajasthan, Andhra Pradesh, Gujarat, Karnataka, and Maharashtra with large rural or agricultural consumer bases separating feeders for agricultural use from non-agricultural use, should be extended to other States such as Tamil Nadu, where an unmetered power supply to the farm sector has been the norm. Only then will there be data, closer to the real picture, regarding the quantum of power supplied to agriculturists.

As Niti Aayog noted in its August 2021 study on the distribution sector, DISCOMs should be proactive in promoting the use of solar pumps in agriculture, a move that would lead to a significant decrease in power procurement costs. The political executive must resist the temptation to offer free electricity universally to domestic consumers or any other category, as economically stronger sections of society invariably benefit disproportionately by any such measure. Political will, combined with public-spirited bureaucracy, can easily transform the face of DISCOMs into that of viable and consumer-friendly entities.



Call for change: Political will, combined with public-spirited bureaucracy, can easily transform the face of DISCOMs into that of viable and consumer-friendly entities. R. JOTHI RAMALINGAM

Even though many DISCOMs are struggling to cope with chronic issues, several others have begun improving their performance

THE GIST

- DISCOMs record a decisive turnaround, with reduced AT&C losses, a sharply narrowed ACS-ARR gap and improved cost recovery following reforms and rule changes.
- Financial discipline improves, as legacy dues decline, current payments are largely made on time and mounting surcharges are arrested through structured instalments.
- Government support remains central, with tariff subsidies and loss takeovers underpinning profits, even as scope for further improvement persists through feeder segregation and efficiency measures.

On the grid

The table presents an assessment of select States based on key operational and financial parameters, including AT&C losses, accumulated surplus or deficit, and the ACS-ARR gap for 2023-24 and 2024-25

State	AT&C loss (in %)		Accumulated Surplus / -Deficit (₹ in crore)		ACS-ARR gap* (₹ per kilo watt per hour or unit) (-:deficit)	
	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
Assam	14.03	15.44	-1,324	-1,025	0.22	0.26
Manipur	13.41	12.90	-295	-290	0.45	0.20
Bihar	20.32	15.51	-18,529	-16,526	0.18	0.41
Uttar Pradesh						
State sector	16.39	19.54	-90,039	-1,00,858	-0.55	-0.73
Private sector	7.75	8.48	1,426	1,561	0.57	0.15
Punjab	10.96	19.21	-9,620	-3,404	0.20	0.30
Rajasthan	22.13	15.18	-91,565	-90,303	0.31	0.04
Gujarat						
State sector	8.97	8.25	5,165	7,355	0.58	0.40
Private sector	3.92	3.63	2,823	3,892	-0.14	0.42
Maharashtra						
State sector	23.86	17.69	-36,226	-35,671	-0.28	-0.56
Private sector	5.39	4.99	474	1,245	0.99	2.04
Madhya Pradesh	22.89	22.76	-69,506	-71,394	-0.18	0.04
Chhattisgarh	15.88	14.25	-10,016	-10,423	0.20	0.19
Jharkhand	30.51	28.19	-18,512	-20,512	-1.66	-0.95
West Bengal						
State sector	17.13	17.17	158	174	-0.17	-0.03
Private sector	4.64	4.77	197	205	-0.13	0.30
Odisha**	19.59	17.81	824	1,263	-0.10	-0.18
Telangana	19.01	19.84	-67,276	-69,741	-0.75	-0.27
Karnataka	11.89	11.92	-26,109	-34,980	-1.08	-0.69
Kerala	7.44	6.61	-37,543	-38,648	-0.42	-0.17
Andhra Pradesh	12.05	7.87	-29,210	-29,420	-0.34	0.15
Tamil Nadu	11.39	10.96	-1,66,944	-1,19,153	-0.11	0.18
ALL INDIA	15.97	15.04	6,91,416	6,47,210	0.20	0.06

AT&C - Aggregate Technical and Commercial *ACS - Average Cost of Supply | ARR - Average Revenue Realised, which covers tariff subsidy received basis but without regulatory income and UDAY grant | **where all the discoms belong to the private sector

Source: 14th Annual Integrated Rating & Ranking of Power Distribution Utilities, Power Finance Corporation

Key Drivers of the Turnaround

The recent improvement in DISCOM performance is attributed to a combination of infrastructure modernization and strict financial discipline enforced by the Union government.

1. Revamped Distribution Sector Scheme (RDSS)

Infrastructure & Metering: The RDSS has been a game-changer by linking financial assistance to performance benchmarks. The rollout of **prepaid smart meters** (reaching over 5.28 crore installations by end-2025) has improved billing and collection efficiency.

Loss Reduction: Aggregate Technical and Commercial (AT&C) losses have plummeted from **22.6% in 2014 to 15.04% in 2025**, nearing the ideal global standard.

2. Enhanced Financial Discipline

Late Payment Surcharge (LPS) Rules: The introduction of the 2022 LPS rules forced DISCOMs to clear legacy dues to power generators. Total outstanding dues dropped from **₹1.4 lakh crore** in 2022 to just **₹4,927 crore** by January 2026.

ACS-ARR Gap: The gap between the **Average Cost of Supply (ACS)** and **Average Revenue Realised (ARR)** has narrowed significantly to **0.06 paise per unit**, reflecting much-improved cost recovery.

Persistent Challenges: The "Glass Half Full" Scenario

Despite the positive PAT, structural vulnerabilities suggest that the recovery may be fragile.

Reliance on State Largesse: Many DISCOMs, such as those in Tamil Nadu and Rajasthan, achieved profitability only through massive **state government subsidies** and the **takeover of losses**. Without this support, several utilities would still be deep in the red.

The "Pay Revision" Risk: Analysts warn that the current revenue surplus might be transient. Upcoming employee pay revisions and rising operational costs could easily push DISCOMs back into a revenue deficit.

Unmetered Supply: In states like Tamil Nadu, unmetered agricultural supply remains a major blind spot, leading to data inaccuracies regarding actual power consumption and theft.

The Road Ahead: Future Reforms

To transform DISCOMs from "loss-making legacies" into "viable entities," the next phase of reforms must focus on technology and political courage.

Feeder Segregation: Extending the separation of agricultural and non-agricultural feeders nationwide is essential to accurately measure and manage rural power demand.

Solarisation of Agriculture: Proactively promoting **solar pumps** (under the PM-KUSUM scheme) can drastically reduce the power procurement costs for DISCOMs by shifting the farm load to off-grid or decentralized solar power.

Draft National Electricity Policy (NEP) 2026: The new policy proposes **Resource Adequacy (RA)** planning at the utility level and emphasizes **market-based power purchase** to ensure DISCOMs are not locked into expensive, long-term contracts.

Digital Public Infrastructure: The proposed **India Energy Stack (IES)** aims to create a digital foundation for peer-to-peer energy trading and EV integration, turning consumers into active participants in the grid.

Conclusion

The 2025-26 turnaround of DISCOMs marks a significant milestone, proving that with the right combination of infrastructure investment (RDSS) and legal enforcement (LPS Rules), the "synonymy" between DISCOMs and losses can be broken. However, true financial independence will only be achieved when utilities move away from state-funded bailouts toward **cost-reflective tariffs** and **operational autonomy**. The road ahead requires the political will to end universal free electricity and a bureaucratic commitment to technological modernization, ensuring that DISCOMs become the resilient engine of India's energy transition.

UPSC Prelims Exam Practice Question

Ques: With reference to the recent turnaround of Power Distribution Companies (DISCOMs) in India, consider the following statements:

1. The Revamped Distribution Sector Scheme (RDSS) links financial assistance to performance-based outcomes such as reduction in AT&C losses.

2. The introduction of Late Payment Surcharge (LPS) Rules has increased the outstanding dues of DISCOMs to power generators.

3. Smart prepaid metering has contributed to improvement in billing and collection efficiency.

Which of the statements given above are correct?

a) 1 and 3 only

b) 1 and 2 only

c) 2 and 3 only

d) 1, 2 and 3

Ans : a)

UPSC Mains Exam Practice Question

Ques: Discuss how schemes such as Revamped Distribution Sector Scheme and the enforcement of Late Payment Surcharge (LPS) Rules have altered the financial behaviour of DISCOMs. What limitations still persist? **(250 words)**

Page 11 : GS III : Science and Tech / Prelims exam

As India accelerates its transition toward green energy and electric mobility, the demand for Advanced Chemistry Cells (ACC) is projected to reach nearly 256 GWh by 2032. While Lithium-ion batteries (Li-ion) currently dominate this space, India's lack of domestic lithium reserves and heavy reliance on a concentrated global supply chain—primarily China—pose a significant threat to its energy sovereignty. In this context, Sodium-ion battery (SIB) technology is emerging as a strategic imperative. By leveraging abundant local resources and existing manufacturing workflows, sodium-ion offers a pathway to a more resilient, cost-effective, and safe energy ecosystem.

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Rethinking battery strategy in India: the case for sodium-ion technology

India's dependence on lithium-ion batteries exposes structural constraints linked to critical minerals, import dependence, and supply security; sodium-ion batteries emerge as a safer alternative with lower material risk, compatible with existing infrastructure, and the potential to strengthen energy security

Jaideep Saraswat
Nikhil Mall

Batteries have become deeply embedded in modern life. From laptops, mobile phones, wearable devices such as smartwatches and wireless earphones, to power tools, electric vehicles (EVs), and large-scale battery energy storage systems, batteries now underpin both personal convenience and critical infrastructure. A newer trend is also emerging, with batteries being integrated directly into household appliances. These developments collectively point to a future saturated with batteries, making energy storage a foundational pillar of economic growth, energy security, and the clean energy transition.

Dominant, not a perfect solution

Among the various battery chemistries that have existed or are still in use, lithium-ion batteries have emerged as the dominant global technology. This dominance is largely driven by their high energy density, low self-discharge rates, and long cycle life. Sustained global focus on lithium-ion technology over the past two decades has resulted in steady improvements in performance, manufacturing efficiency, and large-scale capacity build-out. By 2024, global lithium-ion manufacturing capacity had reached nearly 2.5 times annual demand, further accelerating cost reductions through economies of scale. As a result, costs have fallen dramatically, from nearly $1,100 per kWh in the early 2010s to about $108 per kWh in 2025.

However, the success of lithium-ion batteries masks several structural challenges. These batteries are highly resource-intensive and depend on critical minerals such as lithium, cobalt, nickel, and graphite. The availability of these materials is unevenly distributed across a handful of countries, while refining and processing capacities are even more geographically concentrated. This creates vulnerabilities related to supply security, price volatility, and geopolitical risk. As global demand for batteries accelerates, these constraints are likely to intensify, reinforcing the need for alternative technologies that can support a more resilient and equitable energy transition.

Ambitions and structural constraints

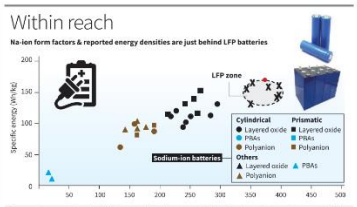
The Government of India has made sustained efforts to build domestic battery manufacturing capacity, most notably through the Production Linked Incentive (PLI) scheme for Advanced Chemistry Cells launched in 2021. Under this scheme, around 40 GWh of manufacturing capacity has been allocated so far. While this represents meaningful progress, deployment remains at an early stage, with just over 1 GWh commissioned to date and additional capacities expected to come online gradually.

More critically, India's upstream ecosystem, from raw material availability and mineral processing to cathode and anode active material production and separator manufacturing, remains underdeveloped. Domestic reserves of lithium are limited and yet to be proven commercially viable, while processing infrastructure is still nascent. Consequently, import dependence for lithium-ion batteries is likely to persist for a considerable period. This reality underscores the importance of parallel investments in alternative battery technologies that can reduce material risk and strengthen long term energy security. Sodium-ion batteries (SIBs) represent one such technology, offering significant promise for India in the medium to long term.

Energy density: sodium vs lithium

From a fundamental perspective, sodium-ion batteries exhibit lower specific energy (Wh/kg) than lithium-ion batteries, largely because sodium has a higher atomic mass than lithium, which intuitively leads to more mass per unit of stored energy. However, this performance gap is often overstated. In practice, it can be significantly narrowed if the mass of other cell components in sodium-ion batteries is reduced, thereby compensating for the higher mass of sodium itself. Moreover, among commercially available sodium-ion chemistries, layered transition-metal oxide cathodes already deliver higher specific energy than polyanionic compounds and Prussian blue analogues, underscoring the growing competitiveness of sodium-ion technology.

Importantly, layered oxide sodium-ion batteries are now approaching the specific energy of lithium iron phosphate (LFP) batteries, as illustrated in **Figure 1**. Although their volumetric energy density (Wh/L) still trails that of LFP, ongoing materials and cell-level optimisations are expected to substantially narrow this gap and potentially lead to meaningful overlap. It is also important to emphasise that this comparison is based on commercially available products, whereas laboratory-scale and pilot-level research results suggest even greater performance potential. By contrast, comparisons with high-energy lithium nickel manganese cobalt (NMC) chemistries are less instructive, as NMC batteries occupy a distinct performance space and entail separate trade-offs related to safety and reliance on critical minerals.



The specific energy density of a battery indicates the amount of electrical energy it can store per unit of its own mass, measured in Watt-hours per kilogram (Wh/kg), determining how light a battery can be for a given potential. The volumetric energy density of a battery refers to the amount of energy it can store per unit volume, measured in Watt-hours per litre (Wh/L), defining how compact a battery is. Ideally, both should be high. We notice that commercially available layered oxide sodium-ion batteries of different shapes have better specific energy density and volumetric energy density than their sodium-ion counterparts built of polyanionic compounds and Prussian blue analogues (PBAs). However, they have lower specific energy density and volumetric energy density than lithium iron phosphate (LFP) batteries, indicated as (x). Data from the Volta Foundation's Annual Battery Report 2024

EV manufacturers should be encouraged through procurement policies, pilot programmes, and regulatory nudges to type-test and approve vehicle platforms using sodium-ion batteries alongside lithium-ion options. This approval strategy would allow rapid substitution in response to supply disruptions or cost fluctuations

Safety first

Safety is one of the most compelling advantages of sodium-ion batteries. Studies, including those conducted by the U.S. Naval Research Laboratory, have shown that sodium-ion cells exhibit significantly lower peak temperature rise during thermal runaway events compared to lithium-ion cells. This intrinsic safety advantage extends well beyond cell performance into storage, handling, and transportation.

Lithium-ion batteries are classified as "Dangerous Goods" by national and international transport authorities, necessitating strict packaging, handling, and transportation requirements. They are typically shipped at a state of charge not exceeding 30%, which increases logistical complexity and cost. These restrictions stem from the use of copper current collectors on the anode side, which can dissolve at low voltages and redeposit on the cathode, increasing the risk of internal short circuits.

Sodium-ion batteries do not suffer from these limitations. They use aluminium current collectors on both the anode and cathode sides, as sodium does not form unstable alloys with aluminium. As a result, sodium-ion cells can be safely stored and transported at zero volts without degradation or safety risks. Prolonged storage at zero volts has been shown not to compromise cycling stability. This feature offers significant benefits across the value chain, including safer handling, lower transportation costs, and greater flexibility in manufacturing and installation.

Manufacturing ready

Another critical advantage of sodium-ion batteries is their compatibility with existing lithium-ion manufacturing infrastructure. With relatively minor modifications, lithium-ion production lines can be adapted to manufacture sodium-ion cells. This dramatically lowers the capital barrier to adoption and allows manufacturers to hedge against raw material supply risks.

The primary process difference lies in moisture sensitivity during cell stack preparation. Sodium-ion batteries require more stringent vacuum drying conditions, as residual moisture can have a greater negative impact on performance. While lithium-ion cells can tolerate drying at relatively mild vacuum levels, sodium-ion cells require deeper vacuum conditions, which may marginally increase energy consumption and manufacturing costs. However, as the industry progresses toward dry electrode coating and advanced manufacturing techniques, these challenges are expected to diminish.

Sodium-ion batteries offer a structurally different material pathway compared to lithium-ion systems. Sodium is derived from abundantly available resources such as soda ash, which are far more plentiful and geographically diversified than lithium. Several sodium-ion chemistries eliminate the need for critical minerals.

In addition, sodium-ion batteries use aluminium as the current collector for both electrodes. Aluminium is cheaper, lighter, and more widely available than copper, resulting in cost savings and weight advantages. These material choices significantly reduce exposure to global commodity price volatility and enhance supply chain resilience, a critical consideration for a country like India.

Why sodium-ion matters

Taken together, these attributes suggest that sodium-ion batteries are not merely an experimental technology but a commercially viable and strategically important solution. Cost projections indicate that sodium-ion batteries could undercut lithium-ion batteries by 2035. As of 2025, around 70 GWh of sodium-ion manufacturing capacity is already operational globally, with expectations of scaling to nearly 400 GWh by 2030. This rapid expansion highlights the urgency for India to engage early and decisively with this technology.

Policy, regulatory, and ecosystem recommendations for India

To ensure sodium-ion batteries become a meaningful part of India's energy storage landscape, a coordinated policy and regulatory approach is essential. Public support for upstream battery infrastructure, such as cathode, anode, electrolyte, and separator manufacturing, should explicitly include sodium-ion chemistries rather than remaining narrowly focused on lithium-ion systems. Future incentive programs, including revisions to the PLI framework, should encourage flexibility, ensuring that new battery plants are designed to accommodate both lithium-ion and sodium-ion production with minimal retrofitting from the very beginning. From a regulatory standpoint, standards, safety codes, and certification pathways must be updated to explicitly include sodium-ion batteries, enabling faster commercialisation and deployment.

EV manufacturers should be encouraged through procurement policies, pilot programmes, and regulatory nudges to type-test and approve vehicle platforms using sodium-ion batteries alongside lithium-ion options. This dual approval strategy would allow rapid substitution in response to supply disruptions or cost fluctuations.

Finally, targeted public funding for R&D, demonstration projects, and early deployments, particularly in grid storage, two- and three-wheeler EVs, and stationary applications, can help build market confidence.

By aligning industrial policy, regulation, and market incentives, India can foster a fair, resilient, and future-ready battery ecosystem in which sodium-ion batteries play a central role.

Jaideep Saraswat leads the Electric Mobility vertical at Vasudha Foundation where he focuses on addressing key barriers to EV adoption and advancing sustainable mobility solutions; Nikhil Mall is also part of the Electric Mobility vertical contributing to research, stakeholder engagement, and initiatives that promote the transition to clean transportation

Why Sodium-Ion? The Strategic Case for India

1. Mineral Security and Resource Abundance

Unlike lithium, which is scarce and geographically concentrated, sodium is the **sixth most abundant element** on Earth. India is the world's third-largest producer of sodium chloride (salt), providing a stable, domestic source of raw materials.

Cathode & Anode: SIBs can use iron, manganese, and hard carbon (derived from biomass), reducing the need for critical minerals like Cobalt and Nickel.

Current Collectors: SIBs use **Aluminum** for both the anode and cathode, whereas Li-ion requires expensive Copper for the anode. This switch significantly reduces material costs and supply chain vulnerability.

2. Enhanced Safety and Logistics

Thermal Stability: Sodium-ion chemistries are inherently more stable. They exhibit a lower risk of thermal runaway (fire) and perform better in extreme temperatures (retaining ~90% capacity at -20°C), making them ideal for India's diverse climatic conditions—from the Himalayas to the Thar Desert.

Zero-Volt Storage: Lithium batteries are "Dangerous Goods" that must be shipped at partial charge to prevent damage. SIBs can be discharged to **0 Volts** for transport without degradation, making them safer and cheaper to ship and store.

3. Manufacturing Synergy

Sodium-ion technology is "drop-in" compatible with current Li-ion production lines. Indian manufacturers can pivot to SIB production with minimal modifications to existing equipment, lowering the capital expenditure (CapEx) barrier for new Gigafactories.

Comparative Performance: SIB vs. LIB (LFP)

Feature	Lithium-Ion (LFP)	Sodium-Ion (SIB)
Energy Density	High (~170–200 Wh/kg)	Moderate (~140–160 Wh/kg)
Cost (Projected)	Baseline	**20–30% lower** at scale
Charging Speed	Standard	**Superior** (can reach 80% in <15 mins)
Cycle Life	3,000–6,000 cycles	2,000–4,000 cycles (improving)
Ideal Use Case	Long-range EVs, high-end electronics	**2-wheelers, 3-wheelers, Grid Storage**

Key Challenges

Despite the potential, two major hurdles remain:

Energy Density Gap: SIBs are currently heavier and bulkier than Li-ion, making them less suitable for long-range passenger cars.

Nascent Ecosystem: While the technology is maturing, India lacks the large-scale "upstream" facilities for specialized components like **hard carbon anodes** and **layered oxide cathodes**.

Policy Recommendations for India

To capitalize on this technology, a multi-pronged approach is required:

Inclusive PLI Schemes: The Production Linked Incentive (PLI) for Advanced Chemistry Cells should be expanded to explicitly reward sodium-ion manufacturing and its upstream components.

Standardization: The Bureau of Indian Standards (BIS) must fast-track safety and performance protocols specific to sodium-ion to facilitate market entry.

Targeted Deployment: Government procurement for public transport (e-buses), rural micro-grids, and stationary energy storage should prioritize SIBs to create early market volume.

R&D Support: Funding for academic and private research into **Prussian Blue analogues** and **Hard Carbon** will ensure India owns the intellectual property of the next energy wave.

Conclusion

Sodium-ion technology is not a "Lithium-killer" but a vital partner in India's energy portfolio. For a price-sensitive market like India, the ability to produce cheaper, safer, and locally sourced batteries for two-wheelers and the power grid is the key to achieving Atmanirbhar Bharat in the energy sector. By adopting a dual-track strategy—utilizing lithium for high-performance needs while scaling sodium for mass-market applications—India can insulate its economy from global commodity shocks and lead the global South in the clean energy transition.

UPSC Prelims Exam Practice Question

Ques: Consider the following statements regarding lithium-ion batteries in the Indian context:

1. India possesses commercially viable lithium reserves sufficient to meet domestic battery demand.

2. Lithium-ion batteries depend on critical minerals with geographically concentrated supply chains.

3. Lithium-ion batteries are classified as dangerous goods for transportation purposes.

Which of the statements given above are correct?

a) 1 and 3 only

b) 1 and 2 only

c) 2 and 3 only

d) 1, 2 and 3

Ans: a)

UPSC Mains Exam Practice Question

Ques: Examine the role of the Production Linked Incentive Scheme for Advanced Chemistry Cells in strengthening India's battery ecosystem. Why is technology neutrality important for the long-term success of such schemes? **(250 words)**

Page 12 : GS II : International Relations and Indian Economy

On **February 5, 2026**, India and the six-nation **Gulf Cooperation Council (GCC)**—comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE—formally signed the Terms of Reference (ToR) for a Free Trade Agreement (FTA). This landmark event in New Delhi marks the official resumption of negotiations that had remained stalled since 2008. Given that the GCC is collectively India's largest merchandise trading partner, this pact is a cornerstone of India's "Extended Neighborhood" policy, aimed at securing energy supplies, protecting the vast Indian diaspora, and attracting massive sovereign wealth investments.

India, GCC nations sign terms of reference for FTA

Appropriate that we enter a robust trading arrangement for greater free flow of goods and services, and predictability, stability to policy: Goyal

T.C.A. Sharad Raghavan
NEW DELHI

Representatives of India and the six-nation Gulf Cooperation Council (GCC) on Thursday signed the Terms of Reference for negotiations on a free trade agreement (FTA). The GCC countries are together India's largest merchandise trade partners, with total merchandise trade exceeding that done with even the EU and the U.S.

The Terms of Reference (ToR) were signed by India's chief negotiator for the FTA, Additional Secretary Ajay Bhadoo, and his counterpart representing the Secretariat General of the Gulf Cooperation Council, Raja Al Marzouki. The signing of the ToR is a necessary precursor for the start of formal negotiations. The GCC countries are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE.

The GCC countries are together India's largest merchandise trade partners.

"It is most appropriate that we now enter into a much stronger and robust trading arrangement, which will enable a greater free flow of goods and services, bring predictability and stability to policy, help encourage greater degree of investments and take our bilateral relations between the six nation GCC group and India to greater heights," Commerce and Industry Minister Piyush Goyal, who presided over the signing, said in his speech.

Bilateral benefit

Mr. Goyal pointed out that the two sides could significantly benefit from each other, with India's workforce both within the GCC countries as well as in India standing to gain from the eventual agreement.

"The GCC countries can help us with further diversification and growth of our energy sources, opportunities for our youth, and massive amounts of investments that different countries have already committed at different points of time, which will further get an impetus with a free trade agreement between India and the GCC nations," he added.

Key Highlights of the India-GCC Economic Ties (FY 2024-25)

The GCC holds unparalleled importance in India's global trade profile, often exceeding the trade volumes India shares with the US or the EU.

Metric	Details
Total Bilateral Trade	**$178.56 Billion** (15.42% of India's global trade)
India's Exports	$56.87 Billion (Engineering goods, rice, textiles, gems & jewelry)
India's Imports	$121.68 Billion (Crude oil, LNG, petrochemicals, gold)
Cumulative FDI	Over **$31.14 Billion** (as of September 2025)
Indian Diaspora	Nearly **10 Million** (Source of ~30-50% of India's remittances)

Strategic Significance for India

1. Energy Security and Diversification

The GCC provides over **60% of India's crude oil** and **70% of its natural gas** requirements. The FTA aims to move beyond a simple buyer-seller relationship toward **strategic energy partnerships**, including joint investments in India's Strategic Petroleum Reserves (SPR) and collaboration in Green Hydrogen and renewables.

2. Market Access for Goods and Services

Goods: India seeks the elimination of high import duties on labor-intensive sectors like textiles, leather, and agricultural products.

Services: As a global leader in IT and healthcare, India is pushing for easier mobility for its professionals (Mode 4 of GATS) and better market access for its fintech and digital education firms.

3. Investment Impetus

The Gulf nations house some of the world's largest **Sovereign Wealth Funds** (e.g., PIF of Saudi Arabia, ADIA of UAE). An FTA provides the "predictability and stability" mentioned by Minister Piyush Goyal, encouraging these funds to invest in India's National Infrastructure Pipeline (NIP) and the **India-Middle East-Europe Economic Corridor (IMEC)**.

4. Food Security for the Gulf

While the Gulf secures India's energy, India secures the Gulf's food. The FTA will likely include specialized "green lanes" for Indian agricultural exports (wheat, rice, organic produce), positioning India as a reliable food hub for the desert-climate region.

Challenges in Negotiations

Trade Deficit: India runs a significant trade deficit with the GCC ($64.8 Billion in FY25) due to oil imports. The challenge lies in boosting non-oil exports to bridge this gap.

Rules of Origin (RoO): Preventing the re-routing of Chinese goods through Gulf ports into India remains a primary concern for Indian negotiators.

Internal GCC Dynamics: Negotiating with a bloc of six nations, each with differing economic priorities (e.g., Saudi Arabia's Vision 2030 vs. UAE's diversification), is more complex than bilateral deals like the existing India-UAE CEPA.

Conclusion

The signing of the ToR is a "signal to the globe" that India and the Gulf are moving toward a comprehensive strategic integration. For India, the GCC FTA is not just a trade deal; it is a mechanism to institutionalize its presence in West Asia, secure its energy future, and safeguard the welfare of its 10 million-strong workforce. Success in these negotiations will be a "force multiplier," cementing India's role as a dominant economic player in the Indo-Pacific and beyond.

UPSC Prelims Exam Practice Question

Ques: With reference to the India–GCC Free Trade Agreement negotiations, consider the following statements:

1. The signing of the Terms of Reference (ToR) in 2026 marked the formal resumption of India–GCC FTA talks after a long pause.

2. The GCC is India's largest merchandise trading partner in terms of total bilateral trade.

3. India currently runs a trade surplus with the GCC due to strong service exports.

Which of the statements given above are correct?

a) 1 and 2 only

b) 1 and 3 only

c) 2 and 3 only

d) 1, 2 and 3

Ans: a)

UPSC Prelims Exam Practice Question

Ques: Discuss the strategic significance of the proposed India–GCC Free Trade Agreement for India's energy security, investment inflows, and diaspora welfare. **(250 words)**

Page 14 : GS II : International Relations

On **February 5, 2026**, the **New Strategic Arms Reduction Treaty (New START)** officially expired, marking a historic and perilous transition in global security. For the first time since **1972**, the world's two largest nuclear powers—the United States and Russia—are no longer bound by any legally enforceable limits on their strategic nuclear arsenals. This lapse dissolves the last remaining pillar of the bilateral arms control framework that helped manage the Cold War and its aftermath. With the "guardrails" gone, the international community now faces a three-way nuclear competition involving a rapidly modernizing China, alongside the rise of destabilizing technologies like hypersonics and AI-driven command systems.

New START's expiry risks pushing the world to unchecked nuclear rivalry

NEWS ANALYSIS

Vasudevan Mukunth

The New Strategic Arms Reduction Treaty (New START) officially expired on February 5, marking the end of the last remaining bilateral agreement constraining the nuclear arsenals of the U.S. and Russia. The New START treaty emerged from a period of diplomatic reset between Washington and Moscow in the late 2000s.

After entering into force on February 5, 2011, New START set up verifiable limits on the strategic offensive arms of both nations, including capping the number of deployed warheads to 1,550, and required both parties to reach these limits within seven years and maintain them thereafter. It also allowed 18 on-site inspections a year, mandated data exchange, and set up a bilateral commission to resolve issues.

New START was constantly beleaguered. Russia often argued that U.S. missile defense systems undermined the strategic balance, suggesting that if one side could neutralise the other's retaliatory strike, the 'mutually assured destruction' dynamic would be broken. The U.S. expressed concerns over conventional prompt global strike capabilities, where precise conventional warheads are placed on ballistic missiles, systems that New START counted under its nuclear limits.

Later Russia also unveiled several novel strategic systems, including the Sarmat heavy ICBM and the Avangard hypersonic glide vehicle. While the U.S. successfully argued that these should be counted under New START, other systems like the nuclear-powered underwater drone Poseidon and nuclear-powered cruise missile Burevestnik remained outside the treaty's technical definitions.

For the first time since 1972, there are no legally binding limits on the number of nuclear weapons the U.S. and Russia can deploy. AP

No binding limits

The treaty was originally set to expire in 2021. Just days before the deadline, the Biden administration and the Kremlin agreed to a one-time, five-year extension, moving the expiration date to February 5, 2026. But in February 2023, after the conflict in Ukraine escalated and undermined bilateral relations, President Vladimir Putin said he was suspending Russia's participation in New START because, Moscow said, the U.S. was seeking a "strategic defeat" of Russia and that western aid to Ukraine made on-site inspections in Russia impossible. The U.S. soon followed.

Today, for the first time since 1972, there are no legally binding limits on the number of strategic nuclear weapons the U.S. and Russia can deploy. The formal channels to verify the locations and status of nuclear forces have ceased to exist, forcing intelligence agencies to rely entirely on satellite imagery and other unilateral methods, which are more error-prone and easier to politicise.

Nuclear and non-nuclear strategic systems are also entangled today and that, together with the premium both sides place on non-contact options like cyberattacks, can threaten nuclear command and control without crossing a nuclear threshold. This is why analysts have stressed the loss of predictability rather than the appearance of new warheads alone.

New START's expiry also makes the prospect of including China and other nuclear states in a larger nonproliferation regime harder in practice. Washington can now argue that it shouldn't be the only state constrained while Beijing grows. Moscow can argue that it shouldn't accept constraints while NATO's aggregate capabilities shape its security environment. And Beijing has already argued that its arsenal is smaller than those of the U.S. and Russia and that therefore it's "not fair or reasonable" to demand it enter their disarmament framework now.

In 2025, Arms Control Association board chairman Thomas Countryman argued that the most realistic near-term path is a regime with three prongs: the U.S. and Russia establishing measures to restore basic level of transparency, the P5 group standardising definitions and modest transparency practices; and setting up of nonproliferation tools such as hotlines, launch notifications, incident prevention, and fissile material security, to involve more states without immediately forcing them to count each other's warheads.

The Final Days: 11th-Hour Diplomatic Impasse

Despite a 2025 proposal by President Vladimir Putin to mutually observe New START limits for one additional year, the treaty's expiration became inevitable due to deep-seated geopolitical friction:

- **The "China Precondition":** The Trump administration maintains that any "better agreement" must include China. Beijing has consistently rejected this, noting its arsenal (estimated at ~600+ warheads) is still a fraction of the U.S. and Russian stockpiles (~5,000+ each).
- **The Ukraine Factor:** Russia had already "suspended" participation in 2023, citing Western support for Ukraine as a barrier to on-site inspections.
- **Verification Collapse:** While both sides currently claim to remain within the limit of **1,550 deployed warheads**, the end of the treaty terminates the **18 annual on-site inspections** and the biannual data exchanges that provided vital predictability.

Strategic Risks: Living in a "Post-Treaty" World

1. The Threat of "Uploading"

Military analysts warn that both nations could rapidly increase their deployed forces by "uploading" stored warheads onto existing delivery systems.

U.S. Capability: Could potentially double its deployed warheads within a few years by utilizing spare capacity on Minuteman III and Trident II missiles.

Russian Advantage: Russia is assessed to have a faster "upload" potential and is already deploying "exotic" systems like the **Sarmat ICBM** and **Avangard hypersonic vehicle**, which were previously counted under treaty limits.

2. Intelligence Gaps and "Worst-Case" Planning

Without mutual inspections, the U.S. and Russia must rely solely on **National Technical Means (NTM)** like satellite imagery. This increases the likelihood of miscalculation, where one side expands its force simply because it *suspects* the other is doing so, triggering a classic **security dilemma**.

3. Proliferation and the NPT

The **Nuclear Non-Proliferation Treaty (NPT)**, set for review later this year, is under immense strain. Non-nuclear states argue that the U.S. and Russia are violating their **Article VI** obligation to pursue disarmament, potentially encouraging countries like Poland, South Korea, or Turkey to reconsider their own nuclear status.

Comparative Nuclear Landscapes (Estimated 2026)

Country	Est. Total Inventory	Strategic Limits (Pre-Feb 5)	Future Trend
Russia	~5,500	1,550 Warheads / 700 Launchers	Modernizing "Exotic" Systems
United States	~5,100	1,550 Warheads / 700 Launchers	Comprehensive Modernization
China	~650	Unconstrained	Path to 1,000+ by 2030

Conclusion

The expiry of New START is not merely the end of a document; it is the end of a **predictable nuclear order**. As we move into 2026, the absence of transparency creates a vacuum that "worst-case scenario" planners will likely fill with calls for expansion. The path forward requires moving beyond bilateral deals to a **multilateral risk-reduction framework** that includes hotlines, launch notifications, and standardizing definitions of emerging technologies. Without a new "rules-based order" for the nuclear age, the risk of use—whether by intent or accident—is at its highest level in over half a century.

UPSC Mains Exam Practice Question

Ques: The expiry of New START marks the end of a predictable nuclear order rather than merely the lapse of a treaty. Critically examine this statement in the context of verification mechanisms, strategic stability, and great power rivalry. **(150 Words)**

The fading of India's environmental jurisprudence

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From its Aravalli ranges to its mangroves, India is at the same moral crossroads that Amitav Ghosh captures in *The Hungry Tide*, where the tides remember what the law chooses to forget. If environmental justice continues to be diluted in the name of development, the Constitution of India risks becoming a silent witness to ecological loss, where the consequences, like the tide itself, will return with unforgiving force.

On December 18, 2025, for non-coal mining projects, the policy of land acquisition first and Environmental Impact Assessment (EIA) later was changed. Now, an EIA can be done without details about the location and area. The Supreme Court of India helped in the dilution of environmental justice by recalling the case, *Vanashakti vs Union Of India* (2025) that banned retrospective environmental clearances. Within five months, a Bench led by (then) Chief Justice of India (CJI) B.R. Gavai, recalled the progressive judgment.

From mountains to mangroves

Recent developments indicate a slow, but systematic, dilution of ecological protection. The CJI, Justice Surya Kant, *suo motu*, stayed the controversial order, saving the reputation of the Court. But the debate concerning the Aravallis is not just about a technical argument on definition. It marks a paradigm change in the perception of development, the role of the environment, and the constitutional obligation by the state.

Similarly, the judicial sanctions to the destruction of 158 mangroves for Adani Cementation Limited (2025) in Raigarh, Maharashtra, and the new environmentally unfriendly infrastructure schemes such as the Char Dham highway in the Himalayas, highlight a dangerous trend – that the health of the environment is further being undermined by the government whose proximity with the corporate world is an open secret though it is also true that the private sector has been severely criticised in the annual Economic Survey presented in January 2026.

The Aravallis, traditionally acknowledged as the ecological backbone of north-western India, play a vital role which includes checking desertification, enhancing the recharge of groundwater, controlling micro-climates and maintaining biodiversity. Interestingly, the Court itself has recognised this ecological role. In *M.C. Mehta vs Union of India and Ors.* (2004), a ban was imposed on mining in the Aravalli region.

Later orders that culminated in the year 2010 admitted that unregulated mining in the area had had irreparable effects on the environment. More importantly, in these proceedings, the Court quashed efforts to restrict the Aravallis to a definition based on the landform's height, especially the suggestion that only landforms over 100 metres could be a component of the Aravalli ranges.

The Court realised how such a strict interpretation would ignore huge tracts of ecologically crucial land, thus foiling the objective of environmental conservation. The 100m norm was discarded in 2010 on an ecological basis. The hills and ridges at a low altitude are of significant importance in the preservation of groundwater and soil stability in the semi-arid landscapes. The Aravallis are not just a cluster of isolated peaks but are a geomorphological system. Unfortunately, the latest height-centric definition does not pay attention to crucial factors such as hydrology, biodiversity and ecological interdependence. It was due to the need to circumvent this reductionist strategy that the Court relied on the precautionary principle, in *Vellore Citizens' Welfare Forum vs Union of India and Others* (1996), rejecting the idea of any artificial limit.

The higher judiciary appears to be aiding a watering down of environmental protection

The strange acceptance by the top court of the 100-metre definition, in *In Re: Issue Relating to Definition of Aravalli Hills and Ranges* (2025), marked a clear departure from the position taken in 2010. In trying to keep landforms above a predetermined elevation as the sole subject of legal protection, the Court has efficiently deprived the Aravalli ranges of any statutory and judicial protection over large portions. Such a change has serious constitutional implications.

The right to a clean and healthy environment, which has been broadly understood in the application of Article 21, is directly involved. Article 48A, which requires the state to ensure the conservation and the enhancement of the environment, is now a hollow proclamation in instances where the interpretation of the law by the judiciary can promote rather than safeguard ecological exclusion. In fact, India's courts have been more enthusiastic about cow slaughter (Article 48) and uniform civil code (Article 44).

The discriminatory protection or preservation of some landforms in relation to their height creates an absurd classification that has no rational nexus to ecological goals. An interpretation of a law that safeguards outstanding hills and exposes the surrounding ecosystems to exploitation contravenes the principle of non-arbitrariness that forms the core of Article 14.

A leniency

This watering down of environmental protection is seen not only in the case of the Aravallis. This has been the case over years with courts and regulatory bodies supporting development projects based on the assurance of mitigation instead of their enforcing environmental norms to the letter. This is evident in the undermining of the EIA process and the legalisation of post-facto and conditional clearances, even after the judicial warnings. In *Common Cause vs Union of India* (2017), the Court had made it clear that the legalisation of illegal mining and environmental offences could not be done after the fact, and that the environmental law is to serve as a deterrent. But judicial leniency later in regard to lapses in procedure corresponds to a slow weakening of this principle.

The results of this kind of dilution are seen in cases of coastal urban ecology, especially the mangroves of Mumbai. Mangroves are multi-layered ecosystems which act as natural flood control systems, sinks of carbon and reservoirs of biodiversity. They protect against storm surges and tidal flooding. Continued judicial authorisations to fell (and transplant) about 34,000 mangrove trees to build infrastructure are a setback. Allowing mangrove destruction on a large scale on the 'promise of compensatory afforestation' marks the destruction of ecological science and constitutional responsibility. It requires decades to develop mature mangrove ecosystems, which cannot be compensated by having a plantation drive in some other place.

Another example is the Char Dham highway project in Uttarakhand. A June 2025 study identified 811 landslide zones along the Char Dham project. The Himalayan ecosystem is one of the most delicate in the world, and the road widening project on such a large scale has grave dangers – triggering landslides and disturbing rivers.

In *Citizens for Green Doon vs Union of India* (2021), the Court recognised the ecological importance of the area, but still allowed wider roads on the grounds of strategic defence needs. The flash floods and ecological disturbances that affected Uttarakhand raise questions about this 'balancing act'. The ill-effects of the current infrastructural rush affect future generations, especially when the constitutional obligations on the government and the citizen, under Article 48A and Article 51A(g), make it clear that it is the responsibility of citizens to safeguard the environment.

Strong players and the issue of fairness

Environmental clearances of corporations and large-scale infrastructure projects, especially those supported by serious capital in mining, highways or urban redevelopment, can pass through regulatory barriers rather easily. If there is a hearing, it is cut short, objections raised are considered obstructionist, and environmental compliance becomes a mere checklist. This casts grave doubts on procedural fairness and transparency which are contained in Article 14. When it disproportionately gives more privileges to economically strong players, environmental governance can destroy the trust of the populace and constitutional equality.

The changing stance of the judiciary in this dismal picture is crucial. Traditionally, courts have been the custodians of environmental rights as they have broadened the constitutional interpretation on issues of environmental damage. Judgments such as *M.C. Mehta vs Kamal Nath and Ors.* (1996) held that the public trust doctrine was deeply rooted in the belief that natural resources belonged to the state, were held in the trust of the people and could not be sold to be exploited privately. When such definitions or clearances are approved by the courts to promote the degradation of the environment, they basically go against the court's own jurisprudence. The Green Bench of the Supreme Court must sit regularly. Similar Benches must be set up in all the High Courts. Ease of business should not make destruction of the environment easy.

The views expressed are personal

GS Paper III : Environment

UPSC Mains Practice Question: India's environmental jurisprudence is witnessing a shift from the Precautionary Principle to a balancing approach favouring development. Critically examine this trend with reference to recent judicial decisions and policy changes. **(250 Words)**

Context :

India's environmental legal framework, once hailed globally as a beacon of judicial activism and the "Public Trust Doctrine," is currently facing a significant structural retreat. Recent legislative shifts and judicial recalls in late 2025 and early 2026 suggest a transition from "Precautionary Principles" to a "Balancing Act" that increasingly favors rapid industrialization. From the ancient Aravalli ridges to the sensitive mangroves of the Konkan coast, the legal safeguards intended to protect India's ecological heritage are being recalibrated under the banner of "Ease of Doing Business" and strategic development.

1. The Decimation of the Aravallis: A Definition-Led Crisis

The Aravalli Range, North India's primary shield against desertification, has been stripped of significant protection due to a technical redefinition.

- **The 100-Metre Standard:** In **December 2025**, the Supreme Court settled on a uniform geomorphological definition, classifying "Aravalli hills" only as formations rising at least 100 metres from the surrounding topography.
- **Ecological Fallout:** This ignores the "low-relief" ancient ridges that are hydrogeologically vital. By exempting hillocks under 100m, vast tracts of land are now open to mining and real estate, threatening groundwater recharge for the Delhi-NCR and Rajasthan regions.

2. The Retreat of the Supreme Court: The Vanashakti Recall

Perhaps the most jarring shift occurred with the recall of the Vanashakti vs. Union of India (2025) judgment.

- **The Initial Blow:** In May 2025, a landmark ruling struck down the 2017 and 2021 notifications that allowed **ex-post facto (retrospective)** environmental clearances. The Court had called such clearances a "gross illegality."
- **The U-Turn:** By **November 2025**, following a review petition by real estate bodies (CREDAI), the Bench recalled this judgment. This move essentially restores the mechanism for regularizing environmental violations after a project has already commenced, weakening the deterrent effect of environmental law.

3. Policy Shifts: "Acquisition First, Assessment Later"

The Ministry of Environment, Forest, and Climate Change (MoEF&CC) introduced a pivotal policy change on **December 18, 2025**, for non-coal mining and infrastructure:

- **Delinking Land and EIA:** Developers no longer need to show proof of land acquisition or owner consent before obtaining an Environmental Impact Assessment (EIA) or clearance.

The Risk: Conducting an EIA without specific details of the land area covered makes the assessment speculative. Critics argue this turns environmental clearance into a "fait accompli," making it nearly impossible to stop a project once it has been approved in principle.

4. Mangroves and the "Compensatory" Fallacy

The judicial sanction for destroying 158 mangroves for Adani Cementation's jetty in Raigad (2025) highlights a growing reliance on Compensatory Afforestation.

Ecological Science vs. Infrastructure: The courts accepted the promise of replanting mangroves at a higher ratio elsewhere. However, environmentalists argue that a "man-made plantation" cannot replicate the complex, multi-layered biodiversity and flood-protection capabilities of a mature, decades-old mangrove ecosystem.

5. Paradoxes in the Economic Survey 2026

The Economic Survey presented in January 2026 offered a rare critique of the private sector, noting a "lack of appetite" for long-term nation-building and risk absorption.

"Indian corporates have a relative lack of willingness to invest in long-term risk... regulatory arbitrage and firm-specific accommodations often dominate productivity." — Economic Survey 2025-26

This creates a paradox: while the government eases environmental norms to assist the corporate sector, its own economic reports suggest that these companies are failing to transition toward sustainable, R&D-driven competitiveness, relying instead on "discretionary" policy favors.

Conclusion

India's environmental jurisprudence is at a "moral crossroads." The shift toward height-centric definitions of mountains, the acceptance of retrospective clearances, and the delinking of land status from environmental impact signify a fading of the Green Bench's legacy. If the Constitution becomes a "silent witness" to these dilutions, the ecological consequences—manifesting as landslides in the Himalayas or flooding in Mumbai—will be felt by future generations long after the current "developmental" gains have faded.