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Page 07 : GS 2 : Governance / Prelims

India's aviation sector recently witnessed large-scale disruptions, especially IndiGo's wave of cancellations. This brought the spotlight on the new fatigue-management regulations introduced by the Directorate General of Civil Aviation (DGCA). While operational lapses by airlines triggered the cancellations, the debate has deepened around the centrality of human physiology in aviation safety. The new DGCA norms, aligned with global best practices, place pilot fatigue at the heart of regulatory design — a shift crucial for a rapidly expanding aviation ecosystem.

Key Analysis

1. What Has the DGCA Changed? — Human-Centric Fatigue Rules

The updated framework introduces several measures aimed at reducing fatigue risk:

- Weekly rest increased from 36 to 48 hours
- Night landings capped at two, down from six
- Broader definition of 'night duty' to restrict flying during biologically low-alertness hours
- Limits on consecutive night duties
- Mandatory fatigue reporting and enhanced roster oversight

These changes reflect the scientific understanding that pilot alertness follows circadian rhythms and cannot be endlessly stretched to meet commercial demands.

2. Scientific Basis — Why Fatigue Cannot Be Compromised

Aviation engineering is highly advanced, but humans have physiological limits:

Circadian Disruption

Long and irregular hours, time-zone changes, and overnight duties disturb sleep cycles, affecting:

- Melatonin secretion
- Sleep onset
- Cognitive recovery

Consequences for Flight Safety

Fatigue leads to:

- Slower reaction time
- Reduced vigilance

An IndiGo aircraft comes in to land in Patna. PTI

How new DGCA rules put human limits at centre of air safety

C. Aravinda

The recent disruptions in India's aviation sector, in particular IndiGo's wave of flight cancellations, have placed the spotlight on the new fatigue and rest norms developed by the Directorate General of Civil Aviation (DGCA). The cancellations appear to have stemmed from IndiGo's scheduling gaps and inadequate crew planning rather than any flaw in the regulations. In this context, any temptation to dilute the new rules must be resisted.

Aviation safety is grounded in the inviolable principles of human physiology. The DGCA's new framework is aimed at minimising fatigue. It has increased the weekly rest period from 36 to 48 hours, reduced the number of permitted night landings from six to two, and expanded the definition of night duty to restrict flying during biologically unsuitable hours. Limits on consecutive night duties, mandatory fatigue risk reporting and greater roster oversight are also part of the updated structure.

These modifications mirror practices adoptedin the U.S. and Europe after evidence mounted that fatigued pilots were often implicated in near-miss events and errors. In Europe and North America, rules limiting hours and mandatory rest have reduced fatigue-related incidents.

Advances in engineering have allowed aircraft to operate in a wide range of demanding environments. But as humans evolved to function on the ground, the regulations need to help people adapt to the stresses imposed during flight, such as lower atmospheric pressure, lower temperatures, and the physiological effects of acceleration on the body.

Pilots regularly work across time zones, often intensely so in the day's twilight hours, and often have overnight schedules as well. All these destabilise the body's circadian rhythm. Disrupting this alters melatonin secretion, delays onset of sleep, and leads to sleep debt.

The immediate physiological effects of these changes include slower reaction time, lower vigilance, impaired judgment, intermittent microsleeping, emotional irritability, and difficulty in sustaining attention. Visual strain, dry cabin air,

The new framework increases the rest period and reduces the number of night landings

dehydration, vibration, and noise can further intensify cognitive fatigue.

Research has also associated chronic circadian misalignment with higher blood pressure, metabolic disturbances, lower immunity, risk of mood disorders, gastrointestinal dysfunction, and higher cardiovascular risk. Long-haul operations create persistent jet lag and irregular meals disrupt metabolic regulation. More hours in confined postures can also feed musculoskeletal strain. Taken together, these stresses should only be expected to cause more errors during flight. Indeed, fatigue has been a recurring factor in global air safety investigations.

Although pilots are the most visible group affected by the fatigue rules, the risk goes far beyond aviation. People who work in hospitals, railway operations, and trucking, police personnel, BPO operators, and journalists all work during those hours when human alertness naturally drops. Physical labour in these hours has been associated with metabolic syndrome, higher risk of depression, cardiovascular disease, menstrual irregularities, and immune suppression. Yet managing operational risks due to fatigue in these sectors remains uneven and under-regulated. Thus the DGCA's rules are laudable for situating human physiology at the centre of aviation policy.

(Dr. C. Aravinda is an academic and public health physician. The views expressed here are personal. aravindaaiimsjr10@hotmail.com)

- Impaired decision-making
- Microsleeps
- Irritability
- Difficulty sustaining attention

Cabin conditions — dry air, vibration, noise — worsen fatigue further.

Chronic Health Impacts

Research links prolonged circadian misalignment to:

- Hypertension
- Metabolic disorders
- Mood disturbances
- Low immunity
- Gastrointestinal issues
- Cardiovascular risks

Such stresses directly increase the likelihood of operational errors, making strict rules indispensable.

3. International Experience — Lessons Integrated

The DGCA rules mirror fatigue-risk regulations adopted in:

- United States (FAA)
- European Union Aviation Safety Agency (EASA)

These regions tightened duty-time limits after studying multiple near-miss events involving fatigued pilots. Evidence shows a reduction in fatigue-related incidents after implementation.

Thus, India is not an outlier — rather, it is aligning with global safety benchmarks as its aviation market grows.

4. Beyond Aviation — Broader Policy Relevance

The article rightly notes that fatigue is a cross-sectoral risk, not limited to pilots.

Sectors facing similar circadian-stress challenges include:

- Healthcare workers
- Railway and trucking staff
- Police personnel
- BPO workforce
- Journalism and shift-based media

Fatigue in these sectors is associated with metabolic syndrome, depression, menstrual irregularities, immune suppression, and higher accident risk. However, regulations remain uneven and inadequate.

The DGCA's approach can act as a template for fatigue-risk management frameworks across essential services.

5. Policy Significance

- Places human physiology at the centre of safety regulation
- Highlights the need for scientific evidence-based policymaking
- Strengthens India's aviation safety architecture
- Reinforces that operational convenience cannot override human limitations
- Sets the stage for cross-sector reforms in occupational health

Conclusion

The DGCA's revised fatigue-management rules represent a progressive, science-driven shift in India's aviation policy. They acknowledge an essential truth: despite technological sophistication, the safety of modern aviation ultimately rests on human alertness and well-being. The recent disruptions should therefore not tempt dilution but serve as a reminder that robust crew planning and compliance must accompany regulatory tightening. The framework not only enhances aviation safety but also offers a model for improving occupational health across several high-risk sectors.

UPSC Prelims Practice Question

Ques: **Circadian rhythm, often mentioned in aviation safety discussions, is primarily associated with which of the following?**

(a) Regulation of blood glucose levels

(b) Body's internal clock controlling sleep–wake cycle

(c) Spatial orientation in high-altitude environments

(d) Regulation of blood pressure during stress

Ans: d)

UPSC Mains - Essay Practice Question

Ques: Technology can advance, but human limits remain constant. In the context of aviation safety, discuss this statement with suitable examples. **(150 Words)**

Page 08 : GS 3 : Indian Economy / Prelims

The Reserve Bank of India's Monetary Policy Committee (MPC) has cut the repo rate by 25 basis points to 5.25%, taking the cumulative easing in 2025 to 125 basis points. This scale of monetary easing was last seen in 2019, a period characterised by slowing growth. However, today's context is very different: India's GDP growth has accelerated from 5.6% in Q2 last year to 8.2% in Q2 this year.

Prudent action

The RBI needs to be ready for a quick policy pivot as it cuts rates

The decision made by the Reserve Bank of India's Monetary Policy Committee (MPC) to cut interest rates once again, by 25 basis points to 5.25%, is both an assessment of India's current economy and also of what to expect over the next few months. Cumulatively, interest rates have been cut by 125 basis points in calendar year 2025. The last time such large cuts had been implemented was in 2019 when rates had been cut by 135 basis points, in reaction to a plummeting growth rate. India's quarterly GDP growth rate had fallen from 8.9% in the March 2018 quarter to 3.3% by the quarter-ended December 2019. Growth is currently seeing the opposite trajectory. It has steadily been accelerating from 5.6% in Q2 of last year to the recently released 8.2% in Q2 of this year. From a growth perspective, there are at least two ways to look at the MPC's interest rate moves. The first is that the central bank is not convinced that growth is currently as robust as the numbers suggest, and so feels monetary policy needs to be as supportive as possible. After all, it could have left rates unchanged at 5.5%. The second is that the MPC feels that Indian companies are still sitting on excess capacity, and so the risks of overheating the economy are slim. So, it might as well push for more growth. The reality is probably a combination of the two: real growth looks higher due to an unusually low deflator, and companies can certainly afford to invest more, even if this is fuelled by debt. A rate cut addresses both issues.

The MPC also possibly feels that the economic impact of the U.S.'s 50% tariffs have not yet fully played out. Supply chains take some time to realign, and so there might still be a further shift away from Indian exporters. Cheaper credit going ahead is something Indian MSMEs, especially exporters, will welcome. On the inflation front, the MPC has lowered its outlook for the year to a benign 2%. However, a jump in food prices or oil prices, for whatever reason, will undo all its calculations. The MPC must be ready to raise rates at the first sign of inflation rising faster than expected. The 2019 rate cut episode saw inflation jumping from 2% in January 2019 to 7.6% in about a year. Taken together, the rate cut suggests that the MPC feels that India's seemingly robust growth could do with further help, while inflationary worries are a thing of the past. Its decision to retain its neutral stance is a prudent one. Global uncertainty is such that growth and inflation trajectories could reverse direction suddenly, which would need a quick policy pivot.

Key Analysis

1. Why Cut Rates During High Growth? — Interpreting the MPC's Intent

There are two main interpretations of the rate cut:

(a) Concern that growth is overstated or fragile

- The MPC may believe that headline growth is inflated by a low GDP deflator, not by broad-based real economic strength.
- This makes monetary support desirable, especially when private investment remains uneven.

(b) Belief that the economy still has slack

- Indian corporates appear to be running with excess capacity, which lowers the risk of overheating.
- In such conditions, lower interest rates can help trigger fresh investment — even if debt-financed.

Reality likely lies between both

The MPC seems to be using monetary easing as a tool to reinforce growth momentum, bridge capacity gaps, and support credit-driven investment cycles.

2. External Pressures: U.S. Tariffs and Export Headwinds

The MPC is also likely responding to global trade risks, particularly the U.S.'s 50% tariff on select imports, which affects Indian exporters.

- Supply chains take months to realign.
- Export-oriented MSMEs may face reduced demand.
- Cheaper domestic credit through rate cuts gives these firms a buffer to manage price competitiveness and working-capital cycles.

Thus, the rate cut has a strong external sector rationale, not just a domestic one.

3. Inflation: The Calm Before a Possible Storm

The MPC has revised inflation estimates downward to a very benign 2%. This provides the policy space for rate cuts.
However, this situation is highly fragile:

Upside risks to inflation

- Food inflation shocks
- Geopolitical disruptions driving up crude oil
- Weather-related supply issues
- Imported inflation due to currency movements

The article rightly reminds that in 2019, after similar rate cuts, inflation jumped from 2% to 7.6% in one year — demonstrating how quickly macroeconomic conditions can reverse.

Policy implication

The MPC must be ready to pivot immediately and raise rates if inflation shows signs of overshooting.

4. A Neutral Stance: Why It Matters

Despite the rate cut, the MPC has held onto its neutral stance, signalling:

- No commitment to a prolonged easing cycle
- Readiness to respond in either direction — tightening or easing
- Recognition of global uncertainty and volatile commodity prices

This is a credibility-enhancing move, especially when global monetary policy cycles are divergent.

5. Broader Economic Significance

- Supports credit-sensitive sectors (MSMEs, housing, manufacturing).
- Encourages investment cycles amid high-capacity slack.
- Helps exporters facing tariff and demand shocks.
- Maintains inflation vigilance to avoid repeating the 2019 episode.

The decision showcases data-driven flexibility, a hallmark of modern central banking.

Conclusion

The RBI's latest rate cut reflects a nuanced view of India's economic landscape: strong headline growth, weak private investment, global trade pressures, and subdued inflation. The MPC has chosen to support growth while signalling caution through a neutral stance. Given the volatility of global markets and the unpredictable nature of inflation, the real test lies in the RBI's ability to pivot quickly if growth slows or inflation rises. In this sense, the decision is both prudent and pragmatic, balancing India's aspirations for higher growth with the timeless central bank responsibility of preserving macroeconomic stability.

UPSC Prelims Practice Question

Ques : Which of the following best describes the term "neutral stance" in monetary policy?

A. RBI will continue cutting rates for the next few quarters

B. RBI will keep rates unchanged for at least one year

C. RBI may either increase or decrease rates depending on future data

D. RBI will not focus on inflation while deciding rates

Ans : c)

UPSC Mains Practice Question

Ques : Modern central banking is not about predicting the future but about remaining flexible to change course swiftly. Elaborate with reference to the RBI's recent monetary policy actions.

Page 09 : GS 2 : International Relations / Prelims

As China finalises its 15th Five-Year Plan and projects ambitious global developmental outreach, the article argues that India and China — two ancient civilisations and rising powers — share vast opportunities for cooperation, despite their complex geopolitical relationship. At a time when Asia's political dynamics are shifting, the piece suggests that economic complementarity, people-to-people ties, and multilateral engagement can shape a more stable regional order.

A new step in the dragon-elephant tango

Xu Wei

Chinese Consul General in Kolkata

Recently, at the Fourth Plenary Session of the 20th Central Committee of the Communist Party of China (CPC) in Beijing, the proposal for the 15th Five-Year Plan was approved. It not only charts China's course for the next five years but also unlocks broad development opportunities for the world.

As two ancient civilisations awakening to new horizons, China and India are not just neighbours, but partners in shaping the future. They are now at a critical stage of national development. China is advancing the great rejuvenation of the nation on all fronts through Chinese modernisation, while India is striving towards its 'Viksit Bharat 2047' vision. Development is the most significant common ground and a shared priority for both countries.

China's growth

During the 14th Five-Year Plan period (2021-2025), China has achieved historic milestones. Its economy grew at an average annual rate of 5.5% and is projected to reach RMB 140 trillion (about $20 trillion) this year. Per capita GDP has remained above $13,000 for two consecutive years, placing China among the leading upper-middle-income countries. China now ranks among the top 10 in the Global Innovation Index. Renewable energy now accounts for about 60% of the total installed power generation capacity, and air, water, and soil quality continue to improve. China is one of the top three trading partners for 157 countries and regions, including India. Contributing approximately 30% to global economic growth, China remains an anchor and engine for the world economy.

The fundamental reason for China's success lies in the centralised and unified leadership of the CPC, and in its adherence to "drawing a blueprint until it becomes a reality"– scientifically formulating and successively implementing five-year plans. As President Xi Jinping noted, "From the 1st Five-Year Plan to the 14th Five-Year Plan, the consistent theme has been to build China into a modern socialist country." Throughout this process, China has combined an effective market with a well-functioning government, integrated top-level design with public consultation, maintained policy stability and continuity, and kept pace with the people's growing aspirations.

The proposal for the 15th Five-Year Plan sends a strong signal that China will continue to promote high-quality development and high-level opening up, offering stable cooperation opportunities for countries worldwide. As fellow emerging economies and major developing nations, China and India have broad prospects and great potential for cooperation across various fields.

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Potential for cooperation

First, economic and trade cooperation is built on a solid foundation. China is one of India's most important trading partners. In 2024, bilateral trade reached $138.46 billion. From January to October this year, trade volume hit $127.63 billion, an 11% year-on-year increase. India's exports to China have grown significantly. We welcome friends from the Indian business community to make full use of platforms such as the Canton Fair, the China International Import Expo, the China International Fair for Trade in Services, and the China International Consumer Products Fair to introduce more high-quality products and services to consumers in both countries.

Second, industrial collaboration is defined by complementary strengths. China, the world's largest manufacturing economy, boasts the most complete industrial system and strong capabilities in electronics, infrastructure, new energy, and AI. India excels in IT, software development, and biopharma. Against the backdrop of the new round of technological revolution and industrial transformation, synergy between China and India will yield mutual benefits and enhance their positions in the global industrial and value chains.

Third, friendship, rooted in close contact between the people, is key to sound bilateral relations. China and India share a history of friendly exchanges spanning thousands of years. India's diverse culture deeply appeals to the Chinese people, with yoga, Bollywood movies, and Darjeeling tea enjoying great popularity. This year, China resumed Indian pilgrimages to the sacred mountain and holy lake in the Xizang Autonomous Region, and India reinstated tourist visas for Chinese citizens. Several direct flights between the two countries were restored. We look forward to more two-way visits by tourists, artists, scholars, and the youth.

Fourth, multilateral cooperation serves our broad common interests. In today's world, economic globalisation is facing headwinds. As important members of multilateral mechanisms such as BRICS, the SCO, and the G20, China and India should enhance communication and coordination on major international and regional issues, jointly address challenges such as climate change, food security, and public health, and work together towards an equal and orderly multipolar world, as well as a universally beneficial and inclusive economic globalisation.

One hundred years ago, when Tagore first set foot in China, he said, "I always feel that India has been one of China's extremely close relatives, and China and India have been enjoying time-honoured and affectionate brotherhood." This year marks the 75th anniversary of the establishment of our diplomatic relations. Under the strategic guidance of our leaders, China-India relations have continued to improve and develop. When the dragon and the elephant move in step, the dance not only brings stability and progress to Asia, but also adds a pivotal anchor for the world.

Key Analysis

1. China's Development Trajectory and Global Significance

China highlights achievements under the 14th Five-Year Plan (2021–2025):

- Average annual growth of 5.5%

- GDP touching RMB 140 trillion (~$20 trillion)
- Per capita income above $13,000
- High ranking in the Global Innovation Index
- Renewable energy comprising 60% of installed capacity
- Contribution of ~30% to global economic growth

China's narrative attributes this success to:

- Five-year planning continuity
- Centralised CPC leadership
- Blend of state capacity + market economy
- Top-level design + public participation

China positions the 15th Five-Year Plan as a blueprint for continued "high-quality development" and "high-level opening-up," signalling openness to global economic partnerships — including with India.

2. India–China Economic and Trade Potential

Despite geopolitical strains, trade remains robust:

- Bilateral trade in 2024: $138.46 billion
- Jan–Oct 2025: $127.63 billion, up 11% YoY
- Indian exports to China have grown

China encourages greater Indian participation in fairs like the Canton Fair, CIIE, and consumer product expos, signalling interest in deepening commercial links.

3. Industrial Complementarity: A Win–Win Possibility

The article stresses mutual complementarities:

China's strengths

- Mass manufacturing
- Electronics, infrastructure, renewable energy
- Artificial intelligence, machinery, EVs

India's strengths

- IT and software services

- Biopharma and pharmaceuticals
- Talent pool in digital innovation

Both countries, facing a global technological shift, can benefit from synergistic industrial integration, enhancing their positions in global value chains.

4. People-to-People Exchanges: Soft Power as a Stabiliser

The article highlights strong cultural connections:

- Indian yoga, films, and tea popular in China
- Resumption of Indian pilgrimages to Kailash–Mansarovar
- Restoration of visas and direct flights
- Encouragement of tourism, academic exchanges, and youth interactions

Significance

Such exchanges help reduce trust deficits and promote stability in bilateral relations strained due to border tensions, geopolitical competition, and media narratives.

5. Multilateral Cooperation: Converging Interests

China and India are key members of:

- BRICS
- Shanghai Cooperation Organisation (SCO)
- G20

Shared focus areas include:

- Climate change
- Food and energy security
- Global health
- Reforming global governance
- Multipolarity and fairer globalisation

6. The Diplomatic Message in the Article

Subtly, the article communicates:

- China's willingness to stabilise ties amid border issues

- A focus on development-first diplomacy
- China's interest in portraying India as a partner, not a competitor
- A narrative-driven effort to rebuild trust as both nations enter crucial developmental phases

This aligns with China's broader strategy of strengthening regional partnerships while countering Western-led economic realignment.

Conclusion

The article frames India–China relations as a dance between two civilisational giants — the dragon and the elephant. While geopolitical tensions, especially along the border, cannot be overlooked, China signals that its new Five-Year Plan opens possibilities for renewed cooperation in trade, technology, climate action, and multilateral platforms. For India, strategically engaging China while safeguarding national interests is essential for regional stability and global influence.

UPSC Prelims Practice Question

Ques: Which of the following multilateral groupings include both India and China?

1. SCO
2. BRICS
3. G20
4. QUAD

Select the correct answer:

A. 1, 2 and 3 only

B. 1 and 2 only

C. 2 and 4 only

D. 1, 2, 3 and 4

Ans: a)

UPSC Mains Practice Question

Ques : The industrial complementarities between India and China present significant opportunities for value chain integration. Examine the potential and constraints of such cooperation. **(250 words)**

Page 10 : GS 3 : Science & Tech

Neurotechnology—devices that can directly record, decode, or stimulate brain activity—is emerging as one of the most transformative scientific frontiers of the 21st century. The article highlights how Brain-Computer Interfaces (BCIs) and related technologies are rapidly advancing globally and why India, with its rising neurological disease burden and expanding tech ecosystem, must strategically invest in this domain.

How can India benefit from neurotechnology?

What is a Brain-Computer Interface? Can such technologies be used for human enhancement or military advantage? How can neurotechnology help non-communicable and injury-related neurological disorders? How are other nations advancing?

EXPLAINER

Shambhavi Naik

The story so far:
The brain remains humanity's final frontier. In the decades ahead, neurotechnology will stretch the boundaries of what it means to understand, and even shape, the functioning of the human brain.

What is neurotechnology?
Neurotechnology is the use of mechanical tools to talk directly to the brain. It includes systems that can record, monitor, or even influence neural activity, opening up new ways to understand how the mind works and, consequently, how it might be repaired or enhanced. Drawing on advances in neuroscience, AI, engineering, and computing, these devices can now sense or stimulate brain signals in real time. At the heart of this revolution is the Brain-Computer Interface (BCI), a technology that blends neuroscience and computing to translate thoughts into action. BCIs can turn brain signals into digital commands that control a computer cursor, a wheelchair, or even a robotic arm. Some systems rely on non-invasive sensors, such as EEG headsets; others use implanted electrodes for more precise control.

A BCI essentially listens to the brain, decodes its signals, and can turn them into instructions for a prosthetic to follow. Some devices are purely diagnostic, helping scientists study brain disorders or cognitive function. Others go further, allowing paralysed patients to move prosthetic limbs, or stimulating certain brain regions to treat depression or Parkinson's disease.

In labs, researchers have even managed to connect the brains of two mice, transmitting simple information from one to the other. But human applications remain mostly therapeutic for now, focused on rehabilitation, neuroprosthetics, and mental health. The idea of using such interfaces for human enhancement or military advantage is technically likely but will need fierce ethical debate before its use.

Brave future: Former U.S. President Barack Obama announces the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative in Washington on April 2, 2013. REUTERS

Why does India need it?
India carries a significant neurological disease burden, from strokes and spinal cord injuries to Parkinson's disease and depression. Between 1990 and 2019, the share of non-communicable and injury-related neurological disorders in India's overall disease load rose steadily, with stroke emerging as the largest contributor. For those living with paralysis, neuroprosthetics could restore mobility and communication. For mental health patients, targeted neural stimulation offers the possibility of reducing long-term dependence on medication. But the opportunity extends far beyond healthcare. Neurotechnology sits at the intersection of biotechnology, engineering, and AI, sectors where India is rapidly developing global competence.

Where does India stand today?
India is creating academic and private sector strengths in neurotechnologies. IIT Kanpur researchers recently unveiled a BCI-based robotic hand that could be useful for stroke patients. The National Brain Research Centre in Manesar, and the Brain Research Centre at IISc, Bangalore are leading research centres for neuroscience. Dognosis, a startup, is using neurotechnology to study brain signals in dogs, aiming to detect the neural patterns that occur when they recognise the scent of cancer in human breath samples. This is an application of neurotechnology used in animals but with the potential to revolutionise cancer screening in humans.

What are other countries doing?
The U.S. is the global leader in neurotechnologies. The NIH's Brain Research Through Advancing Innovative Neurotechnologies® Initiative, or The BRAIN Initiative®, is a partnership between federal and non-federal partners to accelerate the development of innovative neurotechnologies. In May 2024, Neuralink received approval from the Food and Drug Administration for in-human trials of its BCI and has already demonstrated the ability of its BCIs to restore some prosthetic-enabled motor function in paralytic patients. The China Brain Project (2016-2030) focuses on understanding cognition, developing brain-inspired AI, and treating neurological disorders. EU and Chile are pioneering laws for BCIs and neurorights.

Neurotechnologies are a set of emerging technologies with a wide set of applications in healthcare to gaming to recreation. These are important for India not only from a mental health perspective but also as an economic opportunity. Given the nascency of the field, there is much progress to be made and India's genomic diversity, available expertise and increasing awareness about brain research positions India as a potential hub for its development.

However, if there is inadequate regulatory support, BCI development and adoption will be thwarted. A public engagement strategy to discuss the benefits and risks of BCIs would help in understanding public perception of these technologies. Instead of a singular policy for all BCIs, tailored regulatory pathways for the different types of BCIs based on their benefits and risks would help development of beneficial BCIs in the Indian context. A regulatory pathway that assesses BCI on technical and ethical aspects, including ensuring data privacy and user autonomy is of utmost need.

The author is chairperson, Takshashila Institution's Health & Life Sciences Policy.

THE GIST

- BCIs can turn brain signals into digital commands that control a computer cursor, a wheelchair, or even a robotic arm. Some systems rely on non-invasive sensors, such as EEG headsets; others use implanted electrodes for more precise control.
- India carries a significant neurological disease burden, from strokes and spinal cord injuries to Parkinson's disease and depression.
- The China Brain Project (2016-2030) focuses on understanding cognition, developing brain-inspired AI, and treating neurological disorders. EU and Chile are pioneering laws for BCIs and neurorights.

Key Analysis

1. What is Neurotechnology?

Neurotechnology refers to tools that interact directly with the nervous system to:

- Monitor brain activity
- Decode neural signals
- Stimulate the brain

- Repair or enhance neural functions

It blends neuroscience, AI, biotechnology, and engineering.

What is a Brain-Computer Interface (BCI)?

A BCI is a system that:

1. Listens to the brain (using EEG sensors or implanted electrodes)
2. Decodes neural signals
3. Translates them into digital commands
4. Controls external devices, such as:
    - Wheelchairs
    - Robotic arms
    - Computer cursors
    - Prosthetic limbs

BCIs can also stimulate brain regions to treat conditions like Parkinson's, depression, epilepsy, etc.

Human Enhancement & Military Use—Is It Possible?

Technically yes, ethically controversial.

Potential enhancive or military applications:

- Cognitive enhancement for soldiers
- Communication through thought-to-thought transmission
- Drone or weapon system control via neural signals
- Stress-resilience or fatigue-monitoring helmets

But these raise questions related to privacy, autonomy, informed consent, neuro-rights, and dual-use risks.

2. Why Does India Need Neurotechnology?

India faces a significant neurological disease burden:

- Stroke (largest contributor to neurological disability)
- Spinal cord injuries
- Parkinson's disease

- Depression and mental health disorders
- Age-linked cognitive decline

Between 1990 and 2019, non-communicable and injury-related neurological disorders increased substantially.

How Neurotechnology Can Help India

- Neuroprosthetics can restore mobility for paralysed patients.
- Targeted brain stimulation can reduce dependency on psychiatric medications.
- Brain monitoring tools can assist early diagnosis of neurological diseases.
- Low-cost Indian innovations can become globally competitive.

Economic & Strategic Opportunity

Neurotechnology aligns with India's strengths:

- AI and IT expertise
- Biotechnology workforce
- A strong engineering ecosystem
- Large and diverse population for data-driven research (with ethical safeguards)

India could become a global hub for affordable, scalable neurotech solutions.

3. Where Does India Stand Today?

India is developing capabilities across academia and private sector:

Academic Research

- IIT Kanpur: BCI-powered robotic hand for stroke rehabilitation
- National Brain Research Centre (NBRC), Manesar: Neuroscience and cognitive research
- IISc Brain Research Centre: Neural computation, disease mapping

Startups

- Dognosis:
    - Uses neurotechnology in dogs
    - Aims to detect neural signatures when dogs sense cancer in human breath
    - Potential future breakthrough for non-invasive cancer screening

These demonstrate a growing ecosystem—but still in early stages.

4. What Are Other Countries Doing?

United States

- BRAIN Initiative: Major public-private research program
- Neuralink:
  - FDA approval for human trials
  - Early success in enabling paralysed patients to control prosthetics

China

- China Brain Project (2016–2030)
  - Focus on cognition
  - Brain-inspired AI
  - Clinical neuroscience

Europe & Chile

- Pioneering neuro-rights legislation
- Emphasis on privacy, autonomy, cognitive liberty, and data protection

Global momentum shows that neurotech is becoming a key component of future health, security, and technological leadership.

5. What Should India Do? – Policy and Regulatory Needs

India risks falling behind without strong governance.

Key Requirements

a) Tailored Regulatory Pathways

Not all BCIs are the same—

- Non-invasive headsets
- Implantable electrodes
- Neurostimulation devices
- Cognitive enhancement tools

Each needs a separate risk–benefit assessment.

b) Ensure Ethical Oversight

- Brain data privacy
- User autonomy
- Preventing coercive uses
- Transparency in algorithmic interpretation of neural data

c) Public Engagement

Citizens must understand:

- Risks
- Benefits
- Future implications

d) National Mission for Neurotechnology

Similar to biotechnology and semiconductor missions.

e) Strengthen Research Funding & Industry Collaboration

To accelerate innovation and attract global partnerships.

Conclusion

Neurotechnology represents a transformative frontier with the potential to redefine healthcare, disability support, mental health treatment, and human–machine interaction. For India, the opportunity is both medical and economic. With its growing expertise in AI, engineering, and life sciences, India is well positioned to emerge as a global leader—provided it builds a robust regulatory framework, fosters innovation, and ensures ethical safeguards. Investing now can help India address its rising neurological disease burden and shape a future where cutting-edge science contributes directly to national well-being and technological leadership.

UPSC Mains Practice Question

Ques : What is neurotechnology? Discuss how Brain-Computer Interfaces (BCIs) can transform healthcare in India, especially in the context of rising neurological disorders. **(250 Words)**

Page 10 : GS 2 : Governance

India Post has proposed a major new digital public infrastructure called DHRUVA (Digital Hub for Reference and Unique Virtual Address). It aims to standardise, digitise, and tokenise physical addresses—essentially giving every citizen a unique "address label," similar in concept to UPI IDs or email addresses. This initiative builds on DIGIPIN, India's recently launched 10-digit geocoded address identifier. The government has released draft amendments to the Post Office Act, 2023 to enable DHRUVA.

What is the India Post's DHRUVA framework?

What will be the use cases of the Digital Hub for Reference and Unique Virtual Address (DHRUVA)?

Aroon Deep

The story so far:

The Department of Posts in May proposed a framework called Digital Hub for Reference and Unique Virtual Address, or DHRUVA, which would allow for the standardisation and sharing of physical addresses through "labels" that resemble email addresses. DHRUVA will also help with "effective governance, inclusive service delivery, and enhanced user experience," the postal department said. The government has put out a draft amendment to the Post Office Act, 2023 to enable DHRUVA. This follows the release of DIGIPIN, a 10-digit alphanumeric pin code based on location coordinates.

What is DHRUVA?

DHRUVA is being proposed as a Digital Public Infrastructure (DPI) along the lines of Aadhaar and UPI. The service would allow a range of players – from logistics players like India Post to e-commerce and gig platforms like Amazon and Uber – to receive a "label" instead of users having to fill out an address. The label would then be authorised by the end user, which would then allow the platform in question to receive both the "descriptive" address, and the "geo-coded" DIGIPIN.

DIGIPIN is an open-sourced location pin system, which India Post developed in-house. Every 12 square metre block in India has its own unique DIGIPIN. India Post hopes that, at least within the postal network, it can be useful in rural areas where precise descriptive addresses may not always be available (or possible), and would help mail delivery personnel with a precise location as a fallback, in addition to the PIN code.

DHRUVA's ecosystem envisions entities like Address Service Providers who would generate a proxy address or label (like amit@dhruva); Address Validation Agencies who would be able to authenticate addresses; Address Information Agents who would act as intermediaries where users would be able to manage consent for providing their addresses; and a governance entity, along the lines of the National Payments Corporation of India, that would oversee the whole framework.

How will DHRUVA be used?

India Post said that a key use case would be consent-based data sharing, where people tokenising their addresses (like UPI addresses tokenise bank accounts) can "regulate when their address information can be accessed, and the duration for which it can be accessed through a consent framework." Another useful feature will be updating addresses, allowing users to shift routine deliveries seamlessly when they move houses.

DHRUVA would thus allow users to share their addresses with digital platforms, public and private. The Department said that this would also help users with "service discovery," by allowing intermediaries to show what doorstep services are available at their location. Since the architecture of such a framework would require data collection, Dvara Research, a non-profit policy research group focusing on issues like financial inclusion, said that a draft law would be needed to authorise it.

Will it help urban governance?

Beni Chugh, who leads Dvara's Future of Finance Initiative, argued that it was unclear if the system would be helpful in enabling urban governance, as the addresses it envisioned were linked to people, and not independently surveyed structures. "The current design relies on collecting personal information along the addresses, which, makes it necessary to have a consent-based mechanism for address sharing," Ms. Chugh pointed out.

"However, if citizens consented not to share addresses or generate address codes, it could result in incomplete datasets of built infrastructure or population. This could reduce the effectiveness of this DPI for urban planning and governance mechanisms. In most parts of the world, digitisation of addresses does not include personal information which preempts the need for users' consent and allows for richer datasets."

THE GIST

- DHRUVA will help with "effective governance, inclusive service delivery, and enhanced user experience," the postal department said.
- The service would allow a range of players — from logistics players like India Post to e-commerce and gig platforms like Amazon and Uber — to receive a "label" instead of users having to fill out an address.
- DHRUVA would allow users to share their addresses with digital platforms, public and private.

What is DHRUVA?

DHRUVA is envisioned as a Digital Public Infrastructure (DPI) similar to Aadhaar, UPI, DigiLocker, etc.

Key features:

- Creates standardised digital address labels, e.g., amit@dhruva
- A label acts as a proxy for the descriptive physical address and the geo-coded DIGIPIN
- Users control access through a consent framework
- Designed for use by:
    - Logistics firms
    - E-commerce platforms
    - Gig-economy apps (Uber, Swiggy, etc.)
    - Government service delivery systems

DIGIPIN: The Foundation

- **10-digit alphanumeric code**
- Each 12 sq. metre area in India has a unique DIGIPIN
- Provides precise location—especially useful in rural or hard-to-map areas

Proposed Ecosystem Participants

1. Address Service Providers (ASPs) – generate proxy addresses like *xyz@dhruva*
2. Address Validation Agencies (AVAs) – verify and authenticate addresses
3. Address Information Agents (AIAs) – manage user consent for sharing addresses
4. Governance Entity – similar to NPCI, to oversee standards and operations

Use Cases: What Will DHRUVA Enable?

1. Consent-based Address Sharing

Similar to how UPI does not expose full bank details, DHRUVA will allow:

- Tokenisation of physical addresses
- User-controlled permissioning
- Access limited by purpose, time, or platform

This improves privacy, security, and user autonomy.

2. Seamless Address Updates

When a person moves houses:

- They can update the address once in the DHRUVA system
- All service providers (banks, delivery apps, e-commerce, KYC systems, etc.) get updated automatically

This removes the need for repeated changes across multiple services.

3**. Improved Logistics & Delivery Efficiency**

Particularly useful for:

- Rural and remote areas
- Dense urban informal settlements
- Locations with ambiguous or non-standard addresses

Delivery agencies get:

- A precise geo-coordinate (DIGIPIN)
- A vastly improved fulfilment accuracy

4. Better Service Discovery

Platforms can show users the services available at their precise location:

- Public services (ration, water supply, health schemes)
- Commercial deliveries
- Gig-economy services

This helps target inclusion, outreach, and last-mile service delivery.

5. Potential Use in Governance

DHRUVA theoretically helps with:

- Property-linked services
- Disaster response
- Emergency services
- Location-based entitlements
- Infrastructure planning

But this depends on successful adoption and data completeness (discussed below).

Will DHRUVA Help Urban Governance? — Concerns

Experts raise doubts about governance benefits due to:

1. Addresses linked to people, not structures

Urban planning needs building-level datasets, not individual proxy identities.

2. Consent requirement may reduce dataset completeness

If citizens opt out:

- Built-infrastructure mapping becomes incomplete
- Planning datasets remain insufficient

Most countries digitise addresses as public infrastructure, not tied to personal information.

3. Privacy and Data Protection Risks

Since DHRUVA links individuals to precise geolocations:

- Strong privacy safeguards are essential
- A dedicated enabling law is needed (as recommended by Dvara Research)

Challenges and Regulatory Needs

1. Legal clarity on data usage, retention, and sharing
2. Interoperability standards across State and private systems
3. Preventing commercial misuse of location data
4. Ensuring inclusion for low-digital-literacy populations
5. A robust institutional framework akin to NPCI

Conclusion

DHRUVA represents a transformative attempt to build a national digital address infrastructure, much like UPI revolutionised digital payments. Its potential benefits—better logistics, seamless address updates, privacy-preserving sharing, improved rural service delivery—are significant. However, its success will depend on strong regulation, privacy protections, public trust, and broad adoption. If implemented carefully, DHRUVA could become a foundational layer of India's digital governance ecosystem, improving efficiency across public and private services.

UPSC Mains Practice Question
Ques : DHRUVA has the potential to become the UPI of digital address infrastructure, but its success hinges on consent, privacy, and adoption. **(150 words)**

Page : 08 : Editorial Analysis

The real story of the India-Russia summit

Pankaj Saran

is Convener, NatStrat, a former Deputy National Security Adviser and a former Ambassador to Russia

The 23rd India-Russia Summit, which was held in New Delhi last week, once again brought to the fore the treacherous geopolitical terrain that defines today's world. The Ukraine war has pitted India's most important partners against each other. Navigating this quagmire is no easy task, but India has led the way for the world.

The signal sent, the timing

The red carpet treatment given to Russian President Vladimir Putin on his first visit to India since the Ukraine war began, and his decision to bring a large high-powered Russian delegation, were significant. The delegation included Kirill Dmitriev, the face of peace efforts (who has been functioning along with special U.S. envoy Steve Witkoff, and the U.S. President Donald Trump's son-in-law Jared Kushner). In diplomacy, optics matter. For India, it was meant to remove any ambiguity about the Russia relationship, thereby signalling confidence in dealing with the world. For Russia, it signalled the importance of India in its foreign policy priorities.

On matters of war and peace, timing is no less important. The India-Russia summit took place at a time when Russia's stranglehold on the battlefield is very tight, Ukraine is staring at military defeat and the U.S. has, for all practical purposes, turned its back on Ukraine. Since the only peace effort in town is the one being driven by Mr. Trump, Mr. Modi's unambiguous support to the peace efforts on Ukraine in general should rightly be read as being a full and strong endorsement of the Trump initiative, and should be welcomed by the U.S.

India and the U.S. are on the same page here. If there is anyone who has a stake in the success of Mr. Trump's efforts, it is India. The outlier at this point is Europe and India's challenge will be to preserve the major gains with Europe.

> There has been a re-engineering of the relationship between Moscow and New Delhi

The pillars of ties

On the bilateral front, the Summit's adoption of a Programme for the Development of Strategic Areas of India-Russia Economic Cooperation till 2030 (Programme 2030) and the enabling decisions to strengthen arrangements for bilateral settlements and trade in national currencies are steps in the right direction. This together with removal of non-tariff barriers, diversification of the trade basket and investments in non-energy sectors can enable the achievement of the $100 billion trade target by 2030. Areas such as fertilizers, railways, pharmaceuticals, mineral resources and critical raw materials are essential for India's growth needs, for which Russia's huge untapped potential is an invaluable fit.

On the energy front, India is the second largest importer of fossil fuel globally. Assured and affordable availability of energy is quite simply a national security imperative. Russia's resources dwarf the rest of the world. China understood this early on, and has worked, with single-minded purpose, to capture a large chunk of them. Today, companies in the United States are waiting in the wings to do so for energy and all critical minerals. If India does not play its cards right, it risks being pushed out from what is its natural preserve, and at great cost to its economic security. Therefore, the focus on energy cooperation is likely to be a foundational pillar of the relationship going forward.

Three new areas that are maturing well are maritime connectivity involving the Chennai-Vladivostok Maritime Corridor, the Northern Sea Route and, relatedly, the shipbuilding sector; second, cooperation in the Arctic, especially the Russian offer to train Indian seafarers; and third, and most importantly, the export of Indian skilled workers to Russia. The last agreement has come about after years of negotiation. The structural demographic crisis in Russia, including in its Far East, hastened by war losses, curtailment of workers from Central Asia and unease over a growing Chinese presence have contributed to making this agreement a reality. The agreement to ease tourist visas is another quick yielding and long overdue initiative.

Science and technology, and space, nuclear and defence cooperation are all areas of long-standing cooperation built over generations. Russia has been a generous partner in all these areas, with much less strings attached than the West. The Indo-Russian BrahMos has emerged as one of the mainstays of India's missile force, while the S400 air defence system proved its indispensability during Operation Sindoor (May 2025). Due to persistent Indian efforts, levels of localisation, technology transfer and joint production have increased significantly. India still needs support to maintain its Russian origin military inventory even as it shifts to indigenisation. Future defence cooperation is likely to be concentrated on niche technologies and systems.

In perspective

The real story of the summit is the re-engineering of the relationship, the determination to move ahead despite many hurdles, and the eye being kept on the geopolitical shifts underway between the U.S. and China which draw India and Russia closer. As far as Europe is concerned, the road to peace does not lie through New Delhi. It lies in dialogue between Europe and Russia. India's point is that history contains enough examples to emulate and mistakes to avoid. India believes it is, and can be a valuable partner and friend to both.

GS - 2 : International Relations

UPSC Mains Practice Question : In the context of the 23rd India–Russia Annual Summit, discuss how India is navigating the complex geopolitical landscape created by the Ukraine war. How does the summit reflect India's strategic autonomy? **(250 words)**

Context :

The 23rd India–Russia Annual Summit in New Delhi has come at a moment of profound geopolitical flux shaped by the Ukraine war, shifting U.S.–Russia dynamics, and China's rising influence. The article argues that the summit marks not just continuity but strategic re-engineering of the India–Russia partnership. For India—caught between its key partners Washington, Moscow, and Europe—this summit signals confidence, autonomy, and strategic clarity.

1. Geopolitical Optics and Timing: Why the Summit Mattered Now

India's Message

- The red carpet welcome for President Putin—his first visit since the Ukraine war—signals India's willingness to maintain strong ties despite Western pressure.
- By removing ambiguity, India asserts strategic autonomy and reassures Russia of the partnership's value.

Russia's Message

- Putin's large, high-level delegation reflects Russia's prioritisation of India in its foreign policy at a time when it is isolated from the West.
- Presence of key figures involved in peace efforts indicates Russia's desire to showcase diplomatic credibility.

The Timing

- Russia currently holds significant battlefield advantage in Ukraine.
- The U.S. is increasingly disengaged from Ukraine.
- The only viable peace initiative is driven by Donald Trump's team.

Thus, PM Modi's support for peace efforts is effectively a backing of the Trump initiative, aligning India with the U.S. position more than Europe's.

2. Bilateral Economic Strategy: A Shift to Long-Term Structural Design

Programme 2030

The adoption of the Programme for Strategic Economic Cooperation till 2030 marks a shift from ad hoc interactions to long-term goals.

Focus areas:

- Trade in national currencies
- Removal of non-tariff barriers
- Greater investment diversification
- Expansion in non-energy sectors
- Trade target: $100 billion by 2030

Critical Sectors for India

- Fertilizers
- Railways
- Pharmaceuticals
- Minerals & critical raw materials

Russia's vast untapped resources offer a strategic fit for India's growth needs.

3. Energy: The Foundational Pillar

India is the world's second-largest fossil fuel importer. Energy security is a national security imperative.

- Russia is one of the world's largest resource holders.
- China has already secured major long-term access to Russian energy.
- The U.S. is also seeking footholds.

If India does not deepen cooperation, it risks being strategically sidelined in Eurasia's energy landscape.

Therefore, energy cooperation—oil, gas, LNG, nuclear, and critical minerals—will remain a cornerstone of the partnership.

4. Emerging Areas of Cooperation

i. Maritime Connectivity

- Chennai–Vladivostok Maritime Corridor
- Northern Sea Route (NSR)
- Potential Russian role in Indian shipbuilding

These reduce dependence on chokepoints like Malacca and diversify India's logistics routes.

ii. Arctic Cooperation

- Russia's offer to train Indian seafarers
- Access to Arctic shipping and resources aligns with India's Polar Vision

iii. Skilled Workforce Mobility

A breakthrough agreement to send skilled Indian workers to Russia, driven by:

- Russia's demographic crisis
- Worker shortages in Far East

- Decline in Central Asian labour supply
- Russian discomfort with Chinese presence

This could replicate India's success in the Gulf labour market.

iv. Tourism

Easing tourist visas is a long-needed step that could expand people-to-people ties.

5. Defence, Nuclear, Space & S&T: Legacy Pillars with New Priorities

Russia remains India's most reliable source of:

- Aerospace technology
- Nuclear reactors
- Missile systems
- Submarine platforms
- Critical spare parts

Examples:

- BrahMos = mainstay of India's missile force
- S-400 system proved crucial during Operation Sindoor (2025)

Future defence cooperation

Will focus on:

- Niche technologies
- Localisation & joint production
- Technology transfers
- Upgrading existing Russian-origin inventory

Russia remains a less restrictive and more generous defence partner compared to Western countries.

6. The Strategic Big Picture: Re-Engineering the Relationship

The summit reveals:

i. The India–Russia relationship is being rebalanced, not abandoned

Despite Western narratives, India seeks a modern, diversified, mutually beneficial structure.

ii. U.S.–China dynamics shape Indo-Russian convergence

Both countries face challenges from China's rise—though differently. Both want autonomy in an increasingly bipolar world.

iii. Europe remains a challenge

India supports peace but recognises that Europe–Russia dialogue, not India, holds the key.

iv. India aims to remain a bridge

India positions itself as a partner who can engage with all—Washington, Moscow, Europe, and the Global South.

Conclusion

The real story of the 23rd India–Russia Summit is not in the agreements alone but in the strategic recalibration of the partnership. India is ensuring access to critical energy, technology, connectivity, labour opportunities, and geopolitical space—all while balancing ties with the U.S., Europe, and Russia amid the Ukraine conflict. The summit showcases India's ability to navigate multipolar complexities, maintain strategic autonomy, and secure long-term national interests.