



OAS HUB



IDEAL FOR
UPSC, OPSC and Other
Competitive Examinations

English

DAILY CHRONICLE CURRENT AFFAIRS

NEWS CREDIT

PIB/ PTI/ News On Air/ The Hindu/ IANS/ Business Standard/ Times Of India/ Deccan Herald/ Hindustan Times/ BBC News/ Aljazeera/ Mirror.Uk/ Times Now/ Economic Times/ Financial Express/ Indian Express...

NEWS COVERED

Business News, financial news, economy news, company news, politics news, India news, breaking news, Indian economy, International News, Sports News, and many more topics...



Friday, October 30, 2026



TABLE OF CONTENT

- **India Considers a National Sentencing Council to Address Judicial Disparities and Strengthen Fairness in Criminal Justice:**
Judicial Reforms / Criminal Justice System / Sentencing Guidelines / Access to Justice / Rule of Law (GS-II)
- **India's Genetically Modified Crop Debate Intensifies Over Biosafety, Farmer Dependence, Regulatory Reforms and Agricultural Innovation:**
Biotechnology / GM Crops / Biosafety & Agriculture / GEAC & Regulatory Framework / Farmers' Welfare (GS-III)
- **Grey-Zone Warfare Along the India-China Border: Strategic Challenges, LAC Disputes and India's Comprehensive Response:**
Border Management / National Security / Grey-Zone Warfare / India-China Relations / Defence Readiness (GS-III)
- **Double Fortified Salt: Strengthening India's Anaemia Control Strategy Through Food Fortification and Public Health Delivery:**
Public Health / Malnutrition & Anaemia / Food Fortification / Issues Related to Hunger / Government Policies (GS-II)
- **Carbon Capture, Utilisation and Storage: Advancing India's Industrial Decarbonisation and Net Zero Target Through Emerging Technologies:**
Climate Change Mitigation / Industrial Decarbonisation / Net Zero Target / CCUS Technology / Sustainable Development (GS-III)

IMPORTANT INSIGHTS

India Considers a National Sentencing Council to Address Judicial Disparities and Strengthen Fairness in Criminal Justice

Recent Developments:

- The debate over establishing an **Indian Sentencing Council** has gained importance because courts may impose substantially different punishments for comparable offences in the absence of comprehensive, uniform sentencing guidelines.
- In **February 2025**, the Supreme Court was informed that the Union Government had referred the feasibility of a **comprehensive sentencing policy** to the **Law Commission of India**.
- The proposed Council would establish **evidence-based sentencing principles**, improve consistency, strengthen judicial accountability and preserve the discretion necessary to consider individual circumstances.
- The reform is relevant to **GS Paper II: Judiciary, Constitutional Governance and Criminal Justice Reforms**, with additional implications for prison administration and ethics.

Understanding Sentencing in India's Criminal Justice System:

Meaning and Objectives of Sentencing:

- **Sentencing** is the judicial process of determining the punishment imposed on an offender after conviction, within the limits established by applicable criminal legislation.
- Criminal statutes generally prescribe **maximum punishments**, sometimes accompanied by mandatory minimum sentences, while courts determine the appropriate punishment according to the circumstances.
- The principal objectives of criminal sentencing include:
 - **Retribution** seeks proportionate punishment reflecting the seriousness of the offence, while **deterrence** aims to discourage the offender and others from committing crimes.
 - **Incapacitation** protects society by restricting an offender's ability to commit further offences, whereas **rehabilitation** seeks behavioural reform and social reintegration.
 - **Restorative justice** emphasises repairing harm, victim participation and offender accountability wherever legally appropriate.

Aggravating and Mitigating Circumstances:

- **Aggravating factors** increase the seriousness of an offence and may include premeditation, extreme violence, abuse of authority, victim vulnerability and repeated offending.
- **Mitigating factors** may justify a comparatively less severe sentence and include genuine remorse, limited culpability, prospects of rehabilitation and relevant personal circumstances.
- Such factors must be assessed through **legally relevant evidence**, without relying on discriminatory stereotypes or assumptions about victims.

Structural Problems in India's Sentencing Framework:

- **Excessive judicial variability** arises when judges assign different importance to comparable aggravating or mitigating circumstances without a common evaluative framework.
- **Absence of comprehensive national guidelines** makes it difficult to identify appropriate sentencing ranges, particularly where statutes provide broad punishment limits.

- **Inconsistent consideration of victims** may result in insufficient recognition of psychological trauma, breach of trust, long-term harm and other legally relevant consequences.
- **Limited sentencing information** restricts systematic comparisons across courts, offences and jurisdictions, weakening evidence-based policymaking.
- **Repeated appellate intervention** becomes necessary when higher courts correct manifestly excessive, inadequate or legally defective sentences, increasing judicial workload.
- **Inadequate individualisation** can produce disproportionate punishment when courts fail to assess the offender's circumstances, prospects of reform and available non-custodial alternatives.

Constitutional Dimensions of Sentencing Reform:

- **Article 14** guarantees equality before the law and equal protection of the laws, requiring sentencing distinctions to rest on rational and legally relevant considerations.
- **Article 21** protects life and personal liberty and requires deprivation of liberty to follow a fair, just and reasonable legal procedure.
- **Article 20(1)** prohibits retrospective enhancement of criminal punishment, while **Article 20(2)** protects against being prosecuted and punished twice for the same offence.
- **Article 39A**, a Directive Principle of State Policy, promotes equal justice and free legal aid, supporting meaningful representation during sentencing proceedings.
- **Article 50** directs the separation of the judiciary from the executive in public services, reinforcing the broader constitutional importance of judicial independence.
- **Proportionality** requires punishment to maintain a reasonable relationship with the gravity of the offence and the offender's culpability, subject to statutory requirements.

Existing Legislative Framework and Judicial Safeguards:

Bharatiya Nagarik Suraksha Sanhita, 2023:

- The **Bharatiya Nagarik Suraksha Sanhita (BNSS), 2023**, which came into force on **1 July 2024**, contains important procedural safeguards and alternatives to imprisonment.
- **Section 258(2)** requires a Sessions Judge, following conviction, to hear the accused on sentencing unless proceeding under Section 401, creating an opportunity to examine relevant circumstances.
- **Section 401**, corresponding broadly to former Section 360 of the CrPC, permits eligible offenders to be released on probation of good conduct or after admonition, subject to statutory conditions.
- **Section 402**, corresponding to former Section 361 of the CrPC, requires courts to record special reasons when they decline applicable probationary or rehabilitative provisions.

Probation of Offenders Act, 1958:

- **Section 3** permits eligible offenders convicted of specified offences to be released after admonition, while **Section 4** provides for release on probation of good conduct in qualifying cases.
- **Section 6** establishes special safeguards concerning imprisonment of offenders below 21 years of age, subject to the Act's conditions and judicial assessment.
- These provisions encourage **rehabilitative sentencing**, particularly for suitable first-time and younger offenders, without creating an unconditional entitlement to probation.

Important Supreme Court Judgments:

- **Bachan Singh v. State of Punjab (1980):** The Supreme Court upheld the constitutional validity of the death penalty while establishing the **rarest of rare doctrine**, requiring exceptional justification for capital punishment.

- **Mithu v. State of Punjab (1983):** The Court invalidated the mandatory death penalty under Section 303 of the former Indian Penal Code, reinforcing the constitutional necessity of individualised sentencing.
- **Soman v. State of Kerala (2012):** The Court examined sentencing considerations, including proportionality, deterrence and rehabilitation, highlighting the importance of reasoned punishment.
- **Sunita Devi v. State of Bihar:** The proceedings concerning sentencing policy led to the Union Government informing the Supreme Court in February 2025 that the issue had been referred to the Law Commission.

International Experience: England and Wales:

- The **Sentencing Council for England and Wales** was established under the **Coroners and Justice Act, 2009** to promote consistent sentencing and improve public understanding of punishment.
- The **Sentencing Code** consolidates important sentencing legislation, while offence-specific guidelines provide structured methods for determining appropriate punishment.
- The general guideline-based approach involves:
 - Assessing **culpability and harm** to identify the seriousness of the offence and the relevant sentencing category.
 - Determining a **starting point and category range**, followed by adjustments for aggravating and mitigating circumstances.
 - Considering applicable guilty-plea reductions, totality principles, ancillary orders and statutory requirements before determining the final sentence.
- The model seeks **consistency of reasoning rather than identical punishments**, allowing judges to account for material differences between cases.

Proposed Indian Sentencing Council: Structure and Functions:

Institutional Design:

- Parliament could establish an **independent statutory Sentencing Council** comprising judicial representatives, criminal-law specialists, criminologists, correctional experts and other relevant stakeholders.
- The Council could formulate **offence-specific sentencing guidelines** after public consultation, empirical research and assessment of constitutional principles.
- Guidelines should operate within statutory punishment limits and require judges to explain significant departures, without transferring the judicial power of sentencing to the Council.

Three-Stage Sentencing Framework:

- **Stage 1 — Assess seriousness:** Determine culpability and harm through relevant factors such as planning, violence, abuse of trust, victim vulnerability and actual consequences.
- **Stage 2 — Identify sentencing range:** Select an indicative starting point and proportionate range consistent with the offence, applicable legislation and relevant judicial precedents.
- **Stage 3 — Individualise punishment:** Consider mitigation, rehabilitation, victim-related considerations and lawful alternatives before recording reasons for the final sentence.

National Sentencing Database:

- A **national sentencing database** could collect anonymised information concerning offence categories, aggravating and mitigating factors, sentencing outcomes and appellate modifications.
- Existing digital judicial infrastructure, including the **National Judicial Data Grid (NJDG)**, could support development of a dedicated sentencing-information system, subject to technical and legal safeguards.
- Such data would enable researchers and policymakers to examine disparities, evaluate sentencing practices and identify possible discriminatory patterns.

Challenges in Establishing a Sentencing Council:

- **Judicial independence:** Excessively rigid guidelines could restrict legitimate judicial discretion and undermine individualised justice.
- **Penal populism:** Political pressure for harsher punishments could encourage punitive policies without adequate evidence of their effectiveness.
- **Federal considerations:** Criminal law and criminal procedure fall under the **Concurrent List**, while prisons and their administration fall under the **State List**, requiring coordination across jurisdictions.
- **Data limitations:** Inconsistent court records, inadequate sentencing statistics and privacy concerns could weaken evidence-based guideline development.
- **Mechanical application:** Overdependence on checklists could replace substantive judicial reasoning with formal compliance.
- **Institutional capacity:** Implementation would require judicial training, reliable digital infrastructure, probation services and regular evaluation.

Way Forward: Building a Fair Sentencing Framework:

- Establish an **independent, research-oriented sentencing institution** through legislation after examining the Law Commission's recommendations and consulting states and the judiciary.
- Develop **proportionate, offence-specific guidelines** that identify relevant factors while protecting judicial discretion and respecting statutory minimum punishments.
- Strengthen **sentencing hearings** through adequate legal representation, reliable information about offenders and appropriate consideration of victims' interests.
- Expand the responsible use of **probation, community-based sanctions and rehabilitative measures** where permitted by law and justified by the circumstances.
- Introduce **periodic guideline reviews, anonymised sentencing statistics and reasoned departures** to improve transparency, consistency and institutional accountability.

Value Addition for UPSC:

Constitutional and Governance Linkages:

- **GS Paper II:** Judicial reforms, rule of law, equality before law, criminal justice administration, separation of powers and Centre–State relations.
- **GS Paper IV:** Fairness, proportionality, accountability, impartiality, compassion and ethical exercise of discretion.
- **Key distinction: Sentencing uniformity** does not mean identical punishment for every offender; it means applying consistent legal principles to materially comparable cases.
- **Important institutional distinction:** A **Sentencing Council** would formulate general sentencing guidance, while courts would retain responsibility for imposing sentences in individual cases.

Mains Examination Practice Question:

“The absence of structured sentencing guidelines may undermine equality before the law and proportionality in criminal justice.” Examine the need for a National Sentencing Council in India, highlighting its constitutional significance and institutional challenges. (15 Marks, 250 Words)

Conclusion:

A carefully designed **Indian Sentencing Council** could reduce arbitrary disparities, improve proportionality and strengthen public confidence in criminal justice. Its effectiveness would depend on combining **structured judicial discretion, empirical evidence, constitutional safeguards and rehabilitative principles**, rather than pursuing mechanical uniformity or indiscriminately harsher punishment.

India's Genetically Modified Crop Debate Intensifies Over Biosafety, Farmer Dependence, Regulatory Reforms and Agricultural Innovation

Recent Developments:

- **Richard J. Roberts**, recipient of the **1993 Nobel Prize in Physiology or Medicine**, has challenged the argument that adopting **genetically modified (GM) crops** would necessarily make Indian farmers dependent on foreign companies.
- The debate concerns agricultural productivity, food security, biodiversity, biosafety, intellectual property rights and technological self-reliance.
- In **July 2024**, the Supreme Court delivered a split verdict on the environmental release of **GM mustard DMH-11**, while unanimously directing the Union Government to formulate a **national policy on GM crops** through stakeholder consultation.
- India has also advanced **genome-editing technology**, including the development of rice varieties through techniques that can modify existing genetic material without introducing foreign DNA.

Introduction of GM Crops in India:

- In **2002**, India approved the commercial cultivation of **Bt cotton**, its first genetically modified crop, developed to resist major cotton bollworm pests.
 - The first approved hybrids contained the **cry1Ac gene** derived from the soil bacterium *Bacillus thuringiensis*, which produces insecticidal proteins targeting susceptible pests.
 - In **2006**, the regulatory authorities approved **Bollgard II**, incorporating **cry1Ac and cry2Ab genes** to provide protection against a broader range of bollworm pests.
- **Bt cotton remains India's only GM crop approved for commercial cultivation** under the conventional genetically modified crop approval framework.
- In **2010**, the Union Government imposed an **indefinite moratorium on the commercial release of Bt brinjal**, citing unresolved concerns regarding biosafety, public consultation and environmental implications.
- In **2022**, the Genetic Engineering Appraisal Committee recommended the conditional environmental release of **GM mustard DMH-11**, developed at the University of Delhi, but its approval became the subject of judicial scrutiny.

Understanding Genetically Modified Crops:

Meaning and Genetic Engineering Process:

- **Genetically modified crops** are plants whose genetic material has been altered through biotechnology to introduce, remove or modify specific characteristics.
- Desired characteristics may include **insect resistance, herbicide tolerance, nutritional enhancement, drought tolerance and improved productivity**, depending on the crop and technology.

- The conventional genetic engineering process involves identifying a desirable trait, selecting the relevant gene, introducing genetic material into plant cells, regenerating plants and evaluating trait expression and biosafety.
- Common gene-transfer methods include **Agrobacterium-mediated transformation, particle bombardment or gene gun technology, electroporation and microinjection.**

Major Types of Genetic Modification:

- **Transgenic modification** involves introducing genetic material from an organism outside the recipient's sexually compatible gene pool, while **cisgenic modification** uses genetic material from the same species or a sexually compatible species.
- **Genome editing** enables targeted changes to existing DNA sequences, while **gene stacking** combines multiple desirable traits within a single crop variety.
- **CRISPR-Cas9**, or Clustered Regularly Interspaced Short Palindromic Repeats-associated protein 9, is a genome-editing system in which guide RNA directs the Cas9 enzyme to a targeted DNA sequence for modification.

Genome Editing and Recent Indian Innovations:

- In **March 2022**, the Ministry of Environment, Forest and Climate Change exempted **SDN-1 and SDN-2 genome-edited plants without externally introduced DNA** from Rules 7–11 of the 1989 genetically engineered organism regulations.
- The **Department of Biotechnology** subsequently issued the **Guidelines for the Safety Assessment of Genome Edited Plants, 2022**, followed by regulatory standard operating procedures.
- **SDN-1** generally produces targeted genetic changes without a supplied repair template, while **SDN-2** uses a repair template to introduce predetermined small modifications.
- **SDN-3** may involve inserting larger DNA sequences and does not receive the same regulatory exemption.
- The **Indian Council of Agricultural Research (ICAR)** has developed genome-edited rice varieties, including **DRR Rice 100 (Kamala)** and **Pusa DST Rice 1**, demonstrating applications in productivity and stress tolerance.
- **Genome-edited crops are not automatically equivalent to conventional transgenic crops**, making the distinction important for regulatory and examination purposes.

Regulatory Framework for GM Crops in India:

Important Legislation and Regulatory Institutions:

- The **Environment (Protection) Act, 1986**, and the **Rules, 1989**, provide the principal regulatory framework for genetically engineered organisms, including research, handling, import and environmental release.
- The **Genetic Engineering Appraisal Committee (GEAC)**, functioning under the Ministry of Environment, Forest and Climate Change, is responsible for appraising proposals involving environmental release of genetically engineered organisms.
- The **Review Committee on Genetic Manipulation (RCGM)** under the Department of Biotechnology monitors specified research and development activities, while **Institutional Biosafety Committees (IBSCs)** oversee biosafety compliance at the institutional level.
- Other relevant legal instruments include the **Biological Diversity Act, 2002**, **Plant Quarantine Order, 2003**, **Food Safety and Standards Act, 2006**, and applicable foreign trade regulations.
- Regulatory approval involves **case-specific biosafety assessment**, including potential environmental effects, food and feed safety where relevant, and compliance with prescribed conditions.

Supreme Court Verdict on GM Mustard, 2024:

- In **Gene Campaign v. Union of India (2024)**, the Supreme Court delivered a **split verdict** concerning the conditional environmental release of transgenic mustard **DMH-11**.
- **Justice B.V. Nagarathna** found serious deficiencies in the approval process, particularly regarding biosafety assessment, transparency and consultation with affected states.
- **Justice Sanjay Karol** upheld the conditional approval, recognising the role of scientific evaluation and regulatory safeguards.
- Both judges agreed that the Union Government should formulate a **national GM crop policy** covering research, cultivation, trade and commerce after consulting scientists, farmers, state governments and other stakeholders.
- The Court also emphasised **transparency, management of conflicts of interest, food-labelling compliance and judicial review of regulatory decisions**.

Potential Benefits of GM Crops:

- **Agricultural productivity:** Pest-resistant crops can reduce losses caused by susceptible insect pests, although actual yield benefits depend on local agricultural conditions.
- **Reduced pesticide application:** Insect-resistant varieties may reduce spraying against targeted pests, but do not eliminate the need for integrated pest management.
- **Climate resilience:** Biotechnology may support the development of varieties better adapted to drought, salinity and other environmental stresses.
- **Nutritional improvement:** Biofortification through genetic engineering can potentially increase specific nutrients in food crops.
- **Agricultural self-reliance:** Public-sector research, domestic seed development and appropriate technology licensing can reduce dependence on imported agricultural technologies.

Major Concerns Associated with GM Crops:

- **Biodiversity risks:** Gene flow to compatible wild relatives, effects on non-target organisms and changes in agricultural practices may create ecological concerns requiring crop-specific evaluation.
- **Resistance development:** Repeated exposure to insecticidal proteins or herbicides can encourage resistant pests and weeds, particularly where resistance-management practices are inadequate.
- **Human health:** Potential allergenicity, toxicity and unintended compositional changes require scientific assessment; however, the presence of an antibiotic-resistance marker does not itself establish that consuming a GM crop causes antibiotic-resistant infections.
- **Farmer dependence:** Proprietary seeds, licensing restrictions, seed pricing and limited alternatives may increase dependence on technology providers, although these outcomes depend on intellectual property rules and market structures.
- **Corporate concentration:** Concentration of patents, seed distribution and agricultural biotechnology expertise may affect competition and farmers' access to technology.
- **Regulatory transparency:** Limited public access to biosafety information, inadequate consultation and potential conflicts of interest can weaken confidence in regulatory decisions.
- **International trade:** Differences in national approval, traceability and labelling requirements may complicate agricultural exports and consumer choice.

Way Forward: Balancing Innovation and Biosafety:

- Strengthen **independent, transparent and scientifically rigorous biosafety assessments**, supported by publicly accessible findings and appropriate peer review.

- Promote **participatory decision-making** involving farmers, scientists, state governments, consumer organisations and environmental experts.
- Protect **indigenous crop diversity** through gene-flow monitoring, suitable containment measures, conservation programmes and crop-specific environmental safeguards.
- Expand **public-sector biotechnology research**, affordable seed access and transparent licensing arrangements to strengthen technological self-reliance.
- Establish **post-release monitoring and resistance-management systems** to identify ecological changes and assess long-term agricultural outcomes.
- Develop a coherent **national biotechnology policy** integrating food security, environmental protection, farmer welfare and responsible scientific innovation.

Value Addition for UPSC:

Constitutional and International Linkages:

- **Article 21:** The right to life provides a constitutional foundation for protecting human health and environmental quality.
- **Article 48A:** Directs the State to protect and improve the environment and safeguard forests and wildlife.
- **Article 51A(g):** Establishes the fundamental duty of citizens to protect and improve the natural environment.
- **Cartagena Protocol on Biosafety:** An international agreement under the **Convention on Biological Diversity (CBD)** addressing safe handling, transport and use of living modified organisms, particularly their transboundary movement.
- **Precautionary Principle:** Supports preventive measures where credible risks of serious or irreversible environmental harm exist despite scientific uncertainty.
- **GS Paper III:** Biotechnology, agricultural productivity, food security, biodiversity conservation, environmental governance and intellectual property rights.

Mains Examination Practice Question:

"Genetically modified crops offer opportunities for agricultural innovation but raise concerns regarding biosafety, biodiversity and farmers' technological dependence." Critically examine India's regulatory approach to GM crops and suggest measures for balancing innovation with environmental protection. (15 Marks, 250 Words)

Conclusion:

India's GM crop policy must balance **scientific innovation, food security, environmental sustainability and farmers' autonomy** through transparent regulation and independent risk assessment. A differentiated approach to transgenic and genome-edited crops, supported by public-sector research and effective biosafety oversight, can strengthen responsible agricultural biotechnology.

Grey-Zone Warfare Along the India-China Border: Strategic Challenges, LAC Disputes and India's Comprehensive Response

Recent Developments:

- On **27 October 2026**, reports highlighted renewed Indian and Chinese troop face-offs at multiple locations along the **Line of Actual Control (LAC)** in Arunachal Pradesh, underlining the continuing challenge of grey-zone warfare. The reported encounters in Upper Subansiri district involved deviations from established patrolling patterns.
- Although India and China reached an agreement on **21 October 2024** on patrolling arrangements in Depsang and Demchok in eastern Ladakh, the underlying boundary dispute remains unresolved. The agreement facilitated disengagement from the remaining friction points associated with the 2020 crisis.
- The issue is relevant to **GS Paper II** (India-China relations, border management and diplomacy) and **GS Paper III** (internal security, defence preparedness and emerging forms of warfare).

Understanding Grey-Zone Warfare:

Meaning and Key Characteristics:

- **Grey-zone warfare (GZW)** refers to coordinated actions that remain below the threshold of conventional armed conflict but seek to achieve strategic objectives through **ambiguity, coercion, gradual pressure and plausible deniability**.
- Unlike conventional warfare, which generally involves overt military confrontation, grey-zone operations exploit the gap between peace and war to alter the strategic situation without provoking a full-scale military response.
- Its principal instruments include **political influence, economic pressure, cyber operations, information manipulation, legal claims and the use of civilian or non-state actors**.
- The central objective is to change facts on the ground incrementally while keeping the target uncertain about the adversary's intentions, the legality of its actions and the appropriate level of retaliation.

China's Strategic Concepts:

- **Unrestricted Warfare:** A strategic concept associated with Chinese military thinkers that considers the use of military and non-military instruments, including economic, technological, informational and political means, to achieve strategic objectives.
- **Three Warfares:** A concept associated with the People's Liberation Army (PLA) that combines **public opinion warfare, psychological warfare and legal warfare**.
 - Public opinion warfare seeks to shape domestic and international perceptions of a dispute.
 - Psychological warfare aims to influence the adversary's confidence, decision-making and willingness to resist.
 - Legal warfare, often called lawfare, uses legal interpretations, domestic legislation and official claims to legitimise strategic positions.
- These concepts help explain how China can combine military pressure with diplomatic messaging, infrastructure development and territorial narratives.

China's Grey-Zone Tactics Along the LAC:

Infrastructure Development and Strategic Access:

- China has expanded roads, railways, airfields and heliports near disputed border areas to improve **military mobility, logistics, reinforcement and sustained operational readiness**.
- Strategic road projects, including the **G695 and G580 highways**, and upgraded air facilities near the Himalayan frontier can reduce the time required to move troops and equipment to sensitive locations.
- Such infrastructure may serve both civilian and military purposes, making it difficult to distinguish routine development from activities intended to strengthen strategic control.

Incremental Territorial Pressure:

- The **“nibble and negotiate” strategy** involves small, cumulative changes through patrols, temporary deployments, construction or altered patterns of activity, followed by negotiations over the resulting situation.
- Each individual action may appear too limited to justify a major military response, but repeated actions can gradually shift the operational status quo in the adversary's favour.
- This approach exploits uncertainty over the LAC's alignment and creates the risk that previously contested activities may eventually be treated as an established reality.

Border Villages and Administrative Assertions:

- China has developed approximately **628 Xiaokang, or moderately prosperous, border villages** along its frontier with India, many of them opposite Arunachal Pradesh. Such settlements can support civilian habitation, local administration, logistics and potential dual-use activities.
- China's **2022 Land Borders Law** provides a domestic legal framework for protecting and managing its land boundaries, including border development. India must assess its implications in the context of the unresolved bilateral boundary dispute.
- Renaming places in Arunachal Pradesh and publishing official maps are forms of **cartographic assertion**, intended to reinforce territorial claims through administrative and public narratives. Such unilateral actions do not, by themselves, determine international sovereignty.

Information Operations and Wider Strategic Pressure:

- China's broader economic, diplomatic and security partnerships across Asia, Africa and the Indian Ocean region expand its strategic influence and may constrain India's freedom of action.
- The China-Pakistan partnership adds a **two-front security challenge**, requiring India to plan for simultaneous pressure along its western and northern borders.
- Information campaigns and selective diplomatic engagement may also create a gap between perceptions of improving bilateral relations and the actual situation along the border.

Why Grey-Zone Warfare Is Difficult to Counter:

- **Unclear territorial alignment:** India and China have not mutually delineated the entire LAC on maps or demarcated it on the ground, producing overlapping perceptions in several areas.
- **Escalation dilemma:** Responding militarily to every minor incident could trigger a wider confrontation, while insufficient responses may encourage further incremental changes.
- **Intelligence and surveillance limitations:** Difficult terrain, severe weather, long supply lines and gaps in persistent surveillance complicate the early detection of changing ground conditions.

- **Diplomacy without normalisation:** High-level meetings and disengagement at selected friction points do not automatically resolve the boundary dispute or eliminate future face-offs.
- **Changing reference points:** The operational relevance of established patrolling points has become contested in some areas following the 2020 crisis, complicating the assessment of changes on the ground.

LAC and Line of Control: Key Differences:

Basis	Line of Actual Control (LAC)	Line of Control (LoC)
Countries involved	India and China	India and Pakistan
Nature	A line reflecting differing perceptions of actual control in several areas	A military control line in Jammu and Kashmir
Legal and cartographic status	Not mutually delineated along its entire length	Delineated on maps associated with bilateral arrangements
Historical framework	Boundary dispute and differing interpretations of territorial claims	Evolved from the 1949 ceasefire line and redesignated under the 1972 Simla Agreement
Key challenge	Differing perceptions, patrol confrontations and unresolved boundary alignment	Ceasefire violations, infiltration and territorial disputes

- The **LoC** originated in the ceasefire arrangements following the 1947–1948 India-Pakistan conflict and was re-designated following the **Simla Agreement of 1972**. It is distinct from the international boundary.
- The **LAC** is not a mutually agreed international boundary. The two countries maintain differing perceptions of its alignment in several areas, making clarification and confidence-building measures important.

Historical Evolution of the India-China Boundary Dispute:

Origins and Differing Claims:

- In **1959**, Chinese Premier Zhou Enlai referred to a proposed line of actual control in correspondence with Prime Minister Jawaharlal Nehru; China subsequently referred to its interpretation of the line in the aftermath of the **1962 India-China War**.
- India rejected China's unilateral conception of the 1959 line as a definitive basis for the boundary, arguing that the Chinese description did not adequately reflect India's understanding of the actual ground position.
- The dispute differs across three broad sectors: the **western sector**, including Aksai Chin in Ladakh; the **middle sector**, covering parts of Himachal Pradesh and Uttarakhand; and the **eastern sector**, including Arunachal Pradesh.
- The **McMahon Line**, agreed between British India and Tibet in 1914 under the Simla Convention, forms the basis of India's boundary claim in much of the eastern sector, but China disputes its validity.

Bilateral Agreements and Confidence-Building Measures:

- The **1993 Agreement on the Maintenance of Peace and Tranquillity** established a framework for maintaining stability along the LAC without prejudicing either side's boundary claims.
- The **1996 Agreement on Confidence-Building Measures** provided additional military safeguards, including restrictions and procedures intended to reduce the risk of armed confrontation.
- Further arrangements included the **2005 protocols and guiding principles**, the **2012 Working Mechanism for Consultation and Coordination**, and the **2013 Border Defence Cooperation Agreement**.
- The two countries undertook efforts to clarify and confirm their respective perceptions of the LAC, but the process did not produce a mutually agreed alignment for the entire border.

- In **October 2024**, an agreement on patrolling arrangements in Depsang and Demchok facilitated disengagement from the remaining friction points associated with the 2020 crisis. Continued implementation and confidence-building remain essential.

India's Strategic Response:

Integrated National China Strategy:

- India needs a coherent strategy linking **military preparedness, border infrastructure, intelligence, diplomacy, economic policy and technological resilience** rather than treating each border incident in isolation.
- Strategic planning should assess the cumulative impact of small territorial or operational changes and establish clear thresholds for diplomatic, operational and military responses.

Surveillance, Logistics and Infrastructure:

- India should strengthen **satellite surveillance, unmanned aerial systems, ground sensors, intelligence fusion and secure communications** to identify changes in adversary activity at an early stage.
- All-weather roads, bridges, tunnels, forward logistics bases and air mobility should improve rapid reinforcement and sustain operations in difficult Himalayan terrain.
- Border infrastructure should also support civilian livelihoods, communications and essential services, strengthening local communities and reducing vulnerability in remote frontier areas.

Command and Border Management:

- India should improve coordination between the **Indian Army, Indo-Tibetan Border Police (ITBP), intelligence agencies and civilian authorities** through clear operational responsibilities and reliable information-sharing mechanisms.
- Proposals for stronger Army operational coordination with border-guarding forces require careful institutional assessment, including their legal mandates, command responsibilities, equipment and inter-agency coordination.
- Credible deterrence should be maintained across land and maritime domains, while established communication channels and crisis-management mechanisms reduce the risk of unintended escalation.

Value Addition for UPSC:

Important Concepts and Mains Linkages:

- **Grey-zone warfare versus hybrid warfare:** Grey-zone warfare emphasises competition below the threshold of open war, whereas hybrid warfare combines conventional and irregular methods with cyber, information and other instruments; the concepts overlap but are not identical.
- **Whole-of-government approach:** Defence, diplomacy, economic policy, infrastructure, technology and information security should operate within a coordinated national strategy.
- **International relations linkage:** The issue demonstrates the relationship between territorial sovereignty, strategic deterrence, confidence-building measures and the management of great-power competition.
- **GS Paper II:** India-China relations, bilateral agreements, border disputes and diplomatic engagement.
- **GS Paper III:** Border management, defence modernisation, intelligence coordination and emerging security threats.

Mains Practice Question:

“Grey-zone warfare enables states to alter the strategic status quo without triggering conventional armed conflict.” Examine China's use of grey-zone tactics along the India-China border and suggest a comprehensive Indian response. (15 marks, 250 words)

Conclusion:

India's response to grey-zone warfare must combine **credible deterrence, persistent surveillance, resilient border infrastructure, coordinated command structures and sustained diplomacy**. The objective is not merely to respond to individual face-offs but to prevent incremental changes from becoming an accepted strategic reality while preserving stability and avoiding unnecessary escalation.

Double Fortified Salt: Strengthening India's Anaemia Control Strategy Through Food Fortification and Public Health Delivery

Recent Developments:

- In June 2026, the Ministry of Health and Family Welfare released revised operational guidelines for the **Anaemia Mukh Bharat Abhiyaan**, expanding the earlier 6×6×6 framework into a 7×7×7 strategy.
- The revised programme adopts the **T4 approach — Test, Treat, Talk and Track** — to strengthen screening, appropriate treatment, counselling, referral and follow-up. **Double Fortified Salt (DFS)** can complement this strategy by delivering iron and iodine through a commonly consumed food.
- India's anaemia challenge requires more than iron supplementation because dietary inadequacy, poor treatment adherence, infections and inherited blood disorders also contribute to anaemia. Food fortification is therefore one component of a comprehensive public-health response.

Understanding Anaemia and Its Public Health Significance:

What is Anaemia?

Best Institute for OAS/IAS

- **Anaemia** occurs when haemoglobin concentration or the number of healthy red blood cells is insufficient to meet the body's physiological needs, reducing the blood's capacity to carry oxygen to tissues.
- According to the **National Family Health Survey-5 (2019–21)**, anaemia affected approximately **67.1% of children aged 6–59 months** and **57.0% of women aged 15–49 years** in India.
- Anaemia can impair children's cognitive and physical development, reduce productivity, increase maternal and perinatal risks, and contribute to low birth weight and intergenerational cycles of undernutrition.
- **Iron deficiency** is an important cause, but anaemia may also result from folate or vitamin B12 deficiency, infections, inflammation, blood loss, malaria, inherited haemoglobin disorders and other medical conditions. Iron supplementation alone cannot address every case.

Double Fortified Salt: Concept and Working Mechanism:

What is Double Fortified Salt?

- **Double Fortified Salt (DFS)** is edible salt enriched with **iron and iodine** to help prevent iron-deficiency anaemia and iodine deficiency disorders through a regularly consumed food product.
- Iron supports haemoglobin formation, while iodine is essential for thyroid hormone production and normal neurological development. Inadequate iodine intake can cause goitre and other iodine deficiency disorders.
- Salt provides a practical fortification vehicle because it is consumed regularly across many population groups. Unlike tablets, DFS does not require a separate supplementation routine, although its impact depends on product quality, consistent use and adequate iron absorption.
- DFS can complement **iron-folic acid (IFA) supplementation**, dietary diversification and clinical treatment, but it cannot replace prescribed supplements or the diagnosis and management of established anaemia.

Why Does DFS Matter for India?

- Food fortification can incorporate micronutrient delivery into existing food-processing and distribution systems, potentially reducing the additional effort required from beneficiaries.
- India's established **iodised-salt production and distribution infrastructure** offers a foundation for expanding DFS, provided that manufacturing capacity, quality assurance, affordability and procurement arrangements are adequate.
- Its public-health value depends on reaching nutritionally vulnerable households with a safe, acceptable and affordable product rather than merely increasing production or distribution volumes.

Regulatory and Institutional Framework:

Food Safety and Standards Authority of India:

- The **Food Safety and Standards Authority of India (FSSAI)** regulates food-fortification standards, including the permitted nutrient sources and specified levels for iron-fortified iodised salt.
- Appropriate encapsulation and manufacturing controls can reduce undesirable interactions between iron and iodine, improve product stability and limit changes in salt colour or the sensory characteristics of cooked food.
- Regular testing is necessary to ensure that micronutrient levels remain within prescribed limits and that product quality is maintained during storage, transportation and distribution.

Anaemia Mukht Bharat Abhiyaan: The 7×7×7 Framework

The revised framework consists of **7 beneficiary groups, 7 interventions and 7 institutional mechanisms**. These are three distinct components of one programme, not seven steps to be followed sequentially.

1. Seven Beneficiary Groups:

1. **Children aged 6–59 months**, covering infancy and early childhood.
2. **Children aged 5–9 years**, supporting nutrition during middle childhood.
3. **Adolescents aged 10–19 years**, addressing nutritional requirements during growth and development.
4. **Pregnant women**, reducing risks associated with maternal anaemia.
5. **Lactating mothers**, supporting maternal health during the postnatal period.
6. **Women of reproductive age aged 20–49 years**, addressing anaemia beyond pregnancy and lactation.

7. **Low-birth-weight babies aged 0–6 months**, recognising the importance of early-life intervention in breaking intergenerational cycles of undernutrition.

2. Seven Interventions:

1. **Prophylactic IFA supplementation**, providing iron and folic acid according to the prescribed schedule for each eligible beneficiary group.
2. **Testing for anaemia**, strengthening haemoglobin screening and identification of affected individuals.
3. **Therapeutic management of anaemia**, providing treatment according to the diagnosed severity and applicable clinical protocols.
4. **Deworming and delayed cord clamping**, reducing worm-related blood loss where relevant and improving newborn iron stores through appropriate delivery practices.
5. **Jan Bhagidari communication**, encouraging community participation, improving compliance with supplementation and challenging the normalisation of anaemia.
6. **Addressing non-nutritional causes of anaemia**, including appropriate identification and management of conditions such as malaria, haemoglobinopathies and other relevant disorders.
7. **Eating Right**, promoting locally available iron-rich foods and dietary diversification as regular dietary practices.

3. Seven Institutional Mechanisms:

1. **Intra-ministerial coordination**, improving coordination among relevant departments and units within the health ministry.
2. **National Centre of Excellence and Advanced Research on Anaemia**, supporting research, technical expertise and capacity-building for anaemia control.
3. **National Anaemia Mukh Bharat Abhiyaan Unit**, coordinating programme implementation and operational oversight.
4. **Strengthening supply chains and logistics**, ensuring the reliable availability of supplements, diagnostic supplies and other programme requirements.
5. **Convergence with other ministries**, enabling a whole-of-government response involving relevant sectors beyond health.
6. **Anaemia Mukh Bharat Abhiyaan Portal**, consolidating programme information to support analysis, planning and service monitoring.
7. **Digital monitoring and evaluation through the T4 approach**, tracking beneficiaries and strengthening referral, follow-up and continuity of care.

How DFS Fits into the Framework:

- DFS supports the **Eating Right and dietary-diversification objective** by providing iron and iodine through food. It is a complementary nutrition intervention, not a substitute for any of the seven interventions.
- Its effectiveness depends on product quality, affordability, consumer acceptance and reliable distribution. The framework does not, by itself, establish universal DFS distribution through every state or nutrition scheme.
- The **T4 approach — Test, Treat, Talk and Track** — helps connect screening with appropriate treatment, awareness, referral and follow-up. Food fortification must operate alongside this clinical and preventive framework.

Major Challenges and Implementation Bottlenecks:

Distribution and Affordability:

- The availability of DFS through the **Public Distribution System (PDS)** varies with state-level priorities, procurement decisions, funding and distribution arrangements. Its potential reach through the PDS does not establish actual nationwide coverage.
- Limited retail availability and price premiums can restrict access for households that do not receive fortified salt through public programmes, while inconsistent procurement can weaken supply reliability.
- Wider adoption requires dependable manufacturing capacity, standardised procurement, appropriate storage and monitoring at distribution points.

Product Stability and Consumer Acceptance:

- Poorly stabilised formulations can cause iron–iodine interactions, salt discolouration and undesirable changes in the colour or taste of cooked food, reducing consumer confidence and regular use.
- Moisture, unsuitable packaging and poor storage conditions can affect product stability and micronutrient retention, making quality control necessary throughout the supply chain.
- Consumers may reject unfamiliar formulations if changes in food colour or taste are interpreted as signs of contamination. Community demonstrations and clear communication can address such concerns when the product meets safety and quality standards.

Clinical Limitations and Haemoglobin Disorders:

- Since anaemia has multiple causes, population-level iron fortification cannot substitute for haemoglobin testing, diagnosis and cause-specific treatment. Unnecessary iron intake may also be inappropriate for individuals with iron overload or certain medical conditions.
- People with **transfusion-dependent thalassaemia** may develop iron overload, while iron status varies among people with sickle cell disease. Clinical assessment is more appropriate than assuming that every person with a haemoglobin disorder must either receive or avoid iron.
- Public-health programmes should strengthen screening, referral and counselling in areas with a high prevalence of haemoglobin disorders, following applicable clinical guidance.

Sodium Reduction and Public Health Communication:

- DFS remains a source of sodium even when fortified with micronutrients. Excessive sodium intake increases the risk of hypertension and cardiovascular disease, requiring fortification policies to remain consistent with salt-reduction objectives.
- Public campaigns should encourage the replacement of regular salt with quality-assured fortified salt where appropriate, without recommending increased salt consumption. Total salt intake must remain within recommended limits.

Way Forward:

Improve Distribution, Affordability and Quality:

- The government should assess the feasibility of integrating DFS into suitable public food-distribution and nutrition programmes, considering state capacity, fiscal costs, beneficiary needs and existing scheme guidelines.

- Established salt-processing infrastructure can support economies of scale, consistent fortification and standardised quality control. Targeted subsidies and reliable procurement may improve access among vulnerable households.
- Manufacturers and implementing agencies should use validated iron compounds, appropriate encapsulation and moisture-resistant packaging, supported by regular testing of micronutrient content, product safety and shelf stability.

Integrate Fortification with Comprehensive Anaemia Management:

- ASHA workers, Anganwadi workers, schools and local institutions can explain the purpose of DFS, demonstrate its use and address concerns about food colour or taste through evidence-based community communication.
- Fortification should be coordinated with the **T4 approach** by strengthening screening, appropriate treatment, dietary counselling, referral and follow-up rather than treating DFS as a substitute for clinical care.
- Programmes should continue to address infections, haemoglobinopathies and other non-nutritional causes that cannot be resolved through iron fortification.
- Monitoring should measure actual coverage, affordability, consumer acceptance, micronutrient retention and changes in anaemia prevalence instead of relying only on the quantity of salt distributed.
- Communication on fortified salt must remain consistent with sodium-reduction guidance, promoting replacement rather than increased consumption.

Conclusion:

Double Fortified Salt offers a practical means of delivering iron and iodine through an established food vehicle, but its impact depends on quality assurance, affordability, consumer acceptance and reliable distribution. It should complement, rather than replace, IFA supplementation, diagnostic testing and treatment under the **Anaemia Mukh Bharat Abhiyaan**. Combining food fortification with dietary diversification, clinical care and rigorous monitoring can strengthen India's response to anaemia while addressing its multiple causes.

Value Addition for UPSC:

Prelims Pointers:

- **DFS:** Edible salt fortified with iron and iodine.
- **FSSAI:** Food-safety regulator responsible for applicable food-fortification standards.
- **7×7×7 framework:** Seven beneficiary groups, seven interventions and seven institutional mechanisms.
- **T4 approach:** Test, Treat, Talk and Track.
- **NFHS-5 (2019–21):** Anaemia prevalence of 67.1% among children aged 6–59 months and 57.0% among women aged 15–49 years.

Mains Linkages:

- **GS Paper II:** Public health, nutrition governance, health-service delivery, Centre–State coordination and vulnerable sections.
- **GS Paper III:** Food fortification, food-processing technology, supply-chain management and preventive healthcare.
- **Essay:** Nutrition security, equitable access to healthcare, evidence-based policymaking and preventive public health.

Carbon Capture, Utilisation and Storage: Advancing India's Industrial Decarbonisation and Net Zero Target Through Emerging Technologies

Recent Developments:

- **Union Budget 2026–27:** The Government of India proposed an outlay of **₹20,000 crore over five years** to promote Carbon Capture, Utilisation and Storage (CCUS) across five sectors: power, steel, cement, refineries and chemicals.
- **CCUS research roadmap:** The Department of Science and Technology (DST) launched its **CCUS Research and Development Roadmap in December 2025**, outlining priorities for indigenous technology development, research funding, industrial demonstration and commercial deployment.
- **Integrated pilot facility:** India's first integrated CCUS field laboratory was inaugurated at **IIT Bombay in May 2026**. Its pilot facility can capture up to **3 tonnes of carbon dioxide per day** and convert it into carbonate and bicarbonate products, while scientific drilling in Deccan Traps basalt formations supports research into geological storage.
- **Strategic significance:** CCUS can help India reduce emissions from industrial processes that are difficult to decarbonise through renewable energy and electrification alone, supporting its commitment to achieve **Net Zero emissions by 2070**.

Understanding Carbon Capture, Utilisation and Storage:

What is CCUS?

- **Carbon Capture, Utilisation and Storage (CCUS)** refers to a group of technologies that capture carbon dioxide (CO₂) from industrial processes, energy production or other sources, subsequently using it in industrial applications or storing it in suitable geological formations to prevent its release into the atmosphere.
- CCUS supports **industrial decarbonisation, emissions management and resource efficiency**, particularly in sectors where process-related emissions cannot be eliminated entirely through conventional energy-efficiency measures or renewable electricity.
- The technology does not automatically make an industrial process carbon-neutral. Its climate benefits depend on capture efficiency, energy requirements, transportation, storage permanence and emissions across the entire lifecycle.

How Does CCUS Work?

- **Carbon capture:** CO₂ is separated from industrial exhaust gases or other sources using suitable chemical, physical or membrane-based processes, followed by purification and compression where required.
- **Transportation:** Captured CO₂ is transported to utilisation facilities or storage sites through pipelines, ships, road tankers or other appropriate infrastructure.
- **Carbon utilisation:** Captured CO₂ is used as a feedstock or converted into products such as chemicals, fuels, building materials and industrial compounds.
- **Geological storage:** CO₂ is injected into suitable deep geological formations and monitored to ensure long-term containment.

Geological Storage Options:

- **Depleted oil and gas reservoirs** offer potentially suitable storage sites because their geological characteristics and subsurface properties may already be relatively well understood.

- **Deep saline aquifers** can accommodate CO₂ in porous rock formations beneath impermeable caprock, which helps prevent upward migration.
- **Basalt formations** can enable CO₂ mineralisation through reactions with suitable minerals, converting it into stable carbonate compounds over time.
- Safe geological storage requires detailed site characterisation, well-integrity assessment, groundwater protection, leakage monitoring and long-term liability arrangements.

Major Applications of CCUS:

Decarbonising Hard-to-Abate Industries:

- **Steel, cement, refineries, chemicals and fertilisers** generate emissions from fuel combustion and industrial processes. CCUS can capture a portion of these emissions where electrification, renewable energy and material-efficiency improvements are insufficient.
- In cement manufacturing, CO₂ is released not only through fuel combustion but also through the chemical conversion of limestone into clinker, making process-related emissions particularly difficult to eliminate.
- In steel and chemical production, CCUS can complement energy efficiency, electrification, renewable hydrogen and other low-carbon production methods.

Hydrogen Production and Industrial Products:

- **Blue hydrogen** is produced from fossil fuels, such as natural gas or coal, with carbon capture applied to some of the resulting emissions. Its actual emissions intensity depends on capture rates, upstream methane leakage and energy requirements.
- **Green hydrogen** is produced through water electrolysis powered by renewable electricity. Unlike blue hydrogen, its production does not inherently require fossil-fuel-based hydrogen generation or associated carbon capture.
- Captured CO₂ can be used to manufacture **methanol, synthetic fuels, polymers, chemicals and building materials**, supporting industrial resource efficiency and a circular carbon economy.
- **Enhanced oil recovery (EOR)** involves injecting CO₂ into oil reservoirs to increase oil extraction. Its net climate benefit depends on the quantity of CO₂ retained underground and the lifecycle emissions associated with additional oil production and consumption.

Carbon Mineralisation and Biological Utilisation:

- **Carbon mineralisation** converts CO₂ into stable carbonate compounds through reactions with suitable minerals. The resulting materials may be used in construction products, although their climate benefits depend on the process and energy inputs.
- **Biological utilisation** uses CO₂ in processes such as algae cultivation to produce biomass, biofuels and other useful materials. The quantity of carbon retained depends on the product's subsequent use and lifecycle.
- CO₂ utilisation is not necessarily equivalent to permanent carbon removal because many products release the captured carbon again during use or decomposition.

Major CCUS Demonstration Projects in India:

Industrial Testbeds and Pilot Facilities:

- **IIT Bombay integrated CCUS field laboratory:** Inaugurated in May 2026, the facility integrates carbon capture, utilisation and geological storage research. Its pilot plant can capture up to 3 tonnes of CO₂ per day and convert captured carbon into carbonate and bicarbonate products.

- **Cement-sector testbeds:** The DST established a cluster of **five CCU testbeds in May 2025**, using a public-private partnership model involving cement companies and research institutions to demonstrate capture, mineralisation and the production of concrete-based materials.
- **Coal-gasification projects:** DST-supported industry-research collaborations involving IIT Delhi and Thermax Limited, and CSIR-IICT Hyderabad and BHEL, are exploring CO₂ utilisation for products including methanol and dimethyl ether (DME).
- **International research collaboration:** India participates in multilateral research platforms, including Accelerating CCUS Technologies (ACT) and the Clean Energy Transition Partnership (CETP), to advance technological development and commercial readiness.

Expansion of the Project Pipeline:

- As reported by the Government of India in April 2026, the national carbon-capture-and-utilisation project pipeline included **3 operational projects, 6 under execution and 16 proposed projects**.
- The operational projects were located in **Madhya Pradesh, Tamil Nadu and Maharashtra**. Projects under execution included three in Andhra Pradesh, two in Telangana and one in Maharashtra.
- Proposed projects included four each in Assam and Odisha, two each in Gujarat and Rajasthan, and one each in Andhra Pradesh, Madhya Pradesh, Haryana and Tamil Nadu.
- These figures indicate a developing project pipeline, but proposed projects should not be treated as operational capacity or as evidence of emissions reductions already achieved.

Government Initiatives to Promote CCUS:

Policy, Funding and Research:

- **Union Budget 2026-27:** The proposed ₹20,000-crore allocation over five years aims to advance CCUS technologies towards greater commercial readiness and deployment across power, steel, cement, refineries and chemicals.
- **DST CCUS Research and Development Roadmap, 2025:** The roadmap identifies research priorities, funding pathways, indigenous technology development and requirements for commercial deployment. It also emphasises skilled human resources, regulatory and safety standards, and shared infrastructure.
- **NITI Aayog CCUS Policy Framework, 2022:** The framework outlines sector-specific approaches for deep decarbonisation and highlights the importance of coordinated policy, common infrastructure and mechanisms that can improve the economic feasibility of CCUS.
- **National CCUS research centres:** DST-supported centres at IIT Bombay and the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, support research, pilot demonstrations, technology development and industry collaboration.
- **Mission Innovation collaboration:** International research partnerships involving DST and the Department of Biotechnology (DBT) support the development of technologies for CO₂ capture, separation, utilisation and secure storage.

Regional CCUS Hubs and Clusters:

- **CCUS hubs** connect multiple industrial emitters with shared transportation networks, utilisation facilities and geological storage sites, potentially reducing infrastructure costs and improving economies of scale.
- The Gujarat coast offers opportunities associated with refineries and chemical industries, the Odisha-Jharkhand belt has major steel and cement industries, and northeastern India has oil and gas-related industrial activity.
- Regional planning must consider emission sources, geological suitability, transport distances, water and energy requirements, environmental safeguards and the availability of long-term storage sites.

Challenges in Scaling Up CCUS:

Economic and Technological Constraints:

- **High capital and operating costs** can make CCUS less competitive than alternative decarbonisation measures, particularly where carbon pricing, financial incentives or markets for low-carbon products are limited.
- Capture, purification, compression and transportation require additional energy, potentially reducing the net emissions benefit if the energy supply is carbon-intensive.
- Many technologies remain at the pilot or demonstration stage, and performance established under laboratory conditions may not translate directly into reliable, cost-effective industrial operation.

Storage, Regulation and Accountability:

- Geological storage requires robust monitoring, reporting and verification to establish that CO₂ remains contained over long periods.
- Leakage risks, groundwater contamination, land-use conflicts and uncertainty over long-term liability can create environmental and regulatory challenges.
- Clear rules are needed for project approval, safety standards, emissions accounting, storage-site closure, liability allocation and independent verification.

Risk of Overdependence on Carbon Capture:

- CCUS should not become a substitute for readily available emissions-reduction measures, including renewable energy, energy efficiency, electrification, material efficiency and cleaner industrial processes.
- Utilisation pathways may provide only temporary carbon retention, while enhanced oil recovery can create additional emissions through increased fossil-fuel production.
- Public funding should therefore prioritise applications with demonstrable net climate benefits and compare CCUS with alternative technologies on a lifecycle basis.

Way Forward:

- **Prioritise high-impact sectors:** Direct support towards industrial processes with substantial unavoidable emissions, while requiring efficiency improvements and other feasible emissions-reduction measures.
- **Strengthen indigenous research:** Improve capture materials, separation technologies, low-energy processes, carbon mineralisation and geological monitoring through partnerships among research institutions and industry.
- **Develop shared infrastructure:** Establish regional hubs with common CO₂ pipelines, suitable storage sites, monitoring systems and transparent access arrangements to reduce project costs.
- **Create a robust regulatory framework:** Establish clear standards for storage-site selection, safety, measurement, reporting, verification, leakage management and long-term liability.
- **Link funding to measurable outcomes:** Evaluate projects using verified capture volumes, permanent storage, lifecycle emissions reductions, cost per tonne of CO₂ avoided and commercial viability.
- **Adopt a balanced decarbonisation strategy:** Integrate CCUS with renewable energy, green hydrogen, electrification, energy efficiency and circular-economy practices rather than relying on any single technology.

Conclusion:

Carbon Capture, Utilisation and Storage can contribute to India's industrial decarbonisation and **Net Zero target by 2070**, particularly in sectors where process emissions are difficult to eliminate. However, its effectiveness depends on technological maturity, economic viability, secure storage, transparent emissions accounting and enforceable environmental safeguards. Combining targeted public investment with indigenous research, shared infrastructure and alternative low-carbon technologies can help India scale CCUS while ensuring genuine and measurable climate benefits.

Value Addition for UPSC:

Prelims Pointers:

- **CCUS:** Carbon Capture, Utilisation and Storage.
- **Union Budget 2026–27:** Proposed ₹20,000 crore over five years across five sectors.
- **DST CCUS Roadmap:** Launched in December 2025.
- **IIT Bombay:** Integrated CCUS field laboratory inaugurated in May 2026, with a pilot capture capacity of up to 3 tonnes of CO₂ per day.
- **India's long-term climate target:** Net Zero emissions by 2070.

Mains Linkages:

- **GS Paper II:** Government policy, institutional coordination, public–private partnerships and international cooperation.
- **GS Paper III:** Climate-change mitigation, clean-energy technology, industrial development, research and innovation.
- **Essay:** Balancing economic growth with environmental sustainability and technological innovation.

Mains Practice Question:

“Carbon Capture, Utilisation and Storage can support India's industrial decarbonisation, but its contribution to climate mitigation depends on lifecycle emissions and long-term storage integrity.” Examine the opportunities, challenges and policy measures required to scale CCUS in India.

Best Institute for OAS/IAS

QUESTIONS

1. With reference to the constitutional safeguards in criminal procedure and sentencing under the Constitution of India, consider the following statements:

- (1) Article 14 requires that any classification or distinction in sentencing between offenders must rest on an intelligible differentia with a rational nexus to a legitimate penal object.
- (2) Article 20(1) operates as an absolute bar against the retrospective enhancement of criminal punishment beyond what was applicable at the time of the commission of the offence.
- (3) Article 39A imposes a enforceable Fundamental Right mandating the suspension of custodial sentences whenever free legal counsel is delayed during trial.
- (4) Article 50 reinforcing the constitutional principle that judicial discretion in sentencing cannot be usurped by executive decree.

Which of the statements given above are correct?

- (A) 1, 2 and 3 only
- (B) 2, 3, and 4 only
- (C) 1, 3, and 4 only
- (D) 1, 2, and 4 only

2. In the context of international environmental law and biosafety regimes applicable to India, consider the following international agreements and their core domains:

- (1) Cartagena Protocol — Biosafety and transboundary movement of Living Modified Organisms (LMOs).
- (2) Nagoya Protocol — Access to genetic resources and fair and equitable sharing of benefits.
- (3) Convention on Biological Diversity (CBD) — Overarching international treaty for biodiversity conservation.

Which of the following represents the correct hierarchical alignment of these agreements?

- (A) The Nagoya and Cartagena Protocols are independent treaties completely unaffiliated with the CBD.
- (B) Both Cartagena and Nagoya Protocols are supplementary protocols established under the framework of the CBD.
- (C) Cartagena Protocol is an independent treaty under the UN Food and Agriculture Organization (FAO), whereas Nagoya is under UNEP.
- (D) CBD was created as an amendment to the Cartagena Protocol following the 1992 Rio Earth

3. Consider the following statements regarding the McMahon Line:

Statement 1: India regards the McMahon Line, agreed during the 1914 Simla Convention between British India and Tibet, as the legitimate basis for its boundary in the Eastern Sector.

Statement 2: China rejects the validity of the 1914 Simla Convention on the ground that Tibet was not a sovereign state empowered to conclude international boundary treaties.

Which one of the following is correct in respect of the above statements?

- (A) Both Statement 1 and Statement 2 are correct, and Statement 2 is the correct explanation for Statement 1.
- (B) Both Statement 1 and Statement 2 are correct, but Statement 2 is NOT the correct explanation for Statement 1.

- (C) Statement 1 is correct, but Statement 2 is incorrect.
(D) Statement 1 is incorrect, but Statement 2 is correct.

4. Consider the following target beneficiary groups:

- (1) Low-birth-weight babies (0–6 months)
- (2) Children aged 6–59 months and 5–9 years
- (3) Adolescents aged 10–19 years
- (4) Pregnant women and lactating mothers
- (5) Women of reproductive age (20–49 years)

How many of the above are explicitly included among the Seven Beneficiary Groups under the revised Anaemia Mukh Bharat Abhiyaan?

- (A) Only three
- (B) Only four
- (C) All five
- (D) None

5. With reference to hydrogen production pathways in industrial decarbonisation, what does "Blue Hydrogen" specifically refer to?

- (A) Hydrogen produced via water electrolysis powered entirely by grid-connected renewable energy.
- (B) Hydrogen produced from fossil fuel feedstocks coupled with carbon capture and storage technologies.
- (C) Hydrogen produced via coal gasification or steam reforming without any carbon abatement mechanisms.
- (D) Hydrogen produced through methane pyrolysis that yields solid carbon instead of gaseous carbon dioxide.

Best Institute for OAS/IAS

ANSWER KEY

1 – Answer (D), 2 – Answer (B), 3 – Answer (A), 4 – Answer (C), 5 – Answer (B)



OAS HUB

DAILY CHRONICLE CURRENT AFFAIRS

In today's fast-changing world, staying updated with current affairs is essential for both academic success and professional growth. Awareness of national and international events not only broadens general knowledge but also sharpens critical and analytical thinking skills. It enables individuals to form well-informed opinions, which are crucial for competitive examinations, group discussions, interviews, and impactful essay writing.

Being well-informed reflects adaptability, awareness, and intellectual curiosity—qualities that are highly valued in a competitive environment. A strong grasp of contemporary issues enhances confidence, widens perspective, and prepares individuals to tackle real-world challenges effectively, ultimately opening the door to better opportunities and long-term personal and career advancement.

-  oashub19  oashub19
 OASHUB22  oashub19@gmail.com
 M5/17, Acharya Vihar Bhubaneswar 751022