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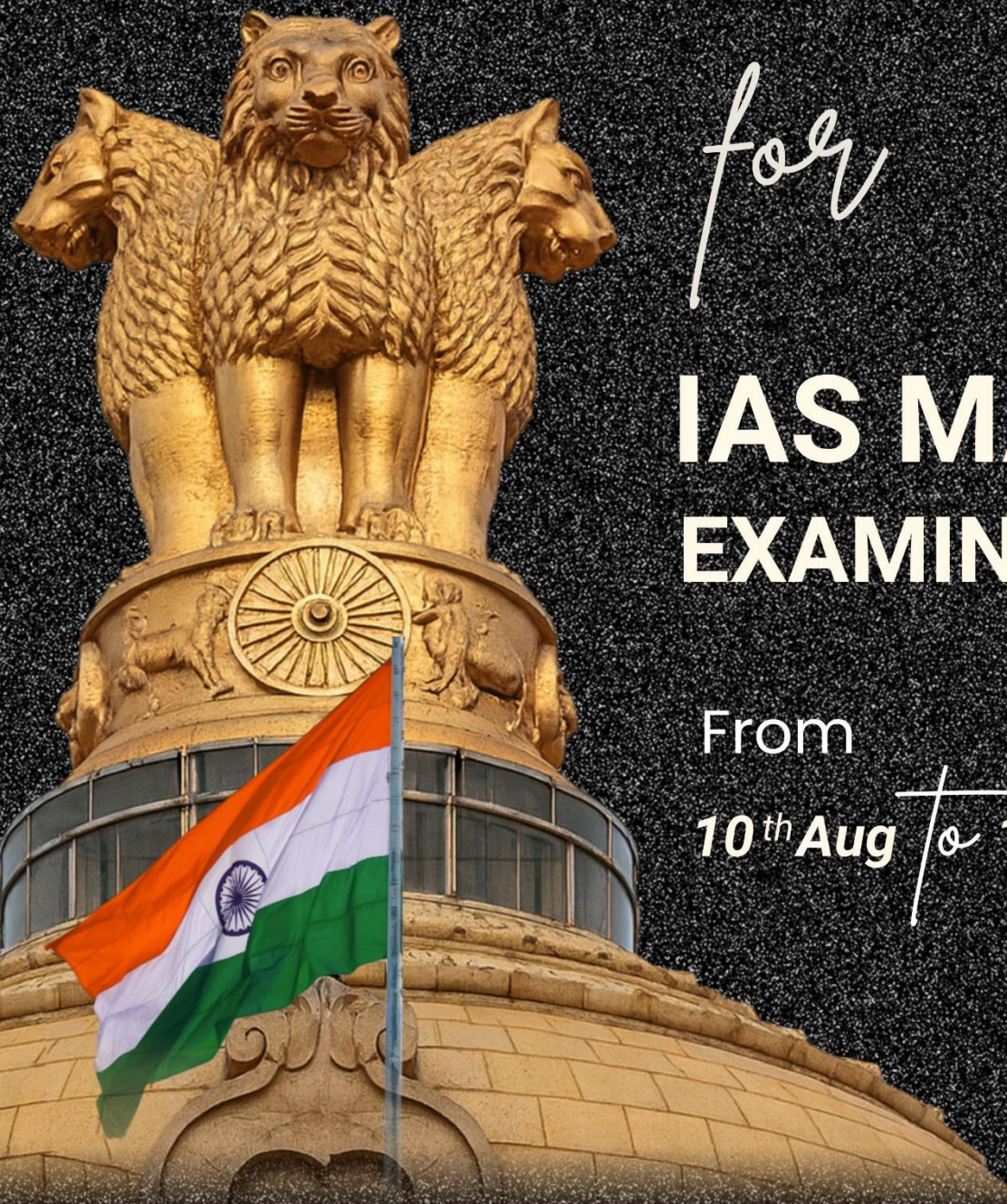
TEXT & CONTEXT / IE EXPLAINED

for

IAS MAINS
EXAMINATION

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GENERAL STUDIES 2

1.1. POLITY & GOVERNANCE

1.1.1. BALANCING POLICE POWER AND PERSONAL LIBERTY

Context

In *Vihaan Kumar v. State of Haryana (2025)*, the Supreme Court ruled that an arrested person must be directly and meaningfully informed of the grounds of arrest, establishing that vague records or informing relatives alone violates **Article 22(1)** and **Section 47 of BNSS, 2023**.



Introduction

The Indian Constitution balances **state law-enforcement powers with personal liberty**, making arrest subject to strict procedural safeguards. Recent Supreme Court rulings have reinforced these limits to prevent misuse of criminal machinery and uphold **natural justice and the Golden Triangle of Articles 14, 19 and 21**.

What are the Key Dimensions of Arrest and Constitutional Safeguards?

1. The Landmark Vihaan Kumar (2025) Directives

- **Direct Communication of Grounds:** The police must directly inform the arrested individual of the exact grounds in an understandable manner; communicating merely to relatives or using ambiguous records violates **Article 22(1)** and **Section 47 of BNSS, 2023** (formerly Section 50 CrPC).
- **Nullification of Illegal Remand:** If the initial arrest is procedurally unconstitutional, all subsequent **remand orders** are rendered automatically illegal.
- **Mandatory Arrest Memo Timestamping:** The arrest memo must record the precise time of arrest under **Article 22(2)** and **Section 58 of BNSS** (formerly Section 57 CrPC) to ensure strict compliance with the **24-hour magistrate production rule**.
- **Protection of Custodial Dignity:** Condemns humiliating treatment in custody, reaffirming the non-negotiable right to human dignity under **Article 21**.

2. Legal Distinction: Arrest vs. Detention

- **Detention:** A temporary hold for investigation without formal charges framed against the individual.
- **Arrest:** Formal deprivation of liberty under police custody based on probable cause of an offense.
- **Procedural Categorization:** Non-cognizable offenses strictly require a **judicial warrant**, whereas cognizable offenses permit **warrantless arrest**.

3. Restricting Routine Arrests: The Arnesh Kumar (2014) Doctrine

- Mandates that arrest must be an **exception rather than the norm** for offenses punishable by less than seven years of imprisonment.
- Obligates investigating officers to formally assess and justify the necessity of arrest under **Section 35 of BNSS** (formerly Section 41 CrPC).

- Prohibits **routine, mechanical arrests** driven solely by statutory power, treating frivolous prosecutions as an abuse of judicial process.

4. Interlocking with the Constitutional 'Golden Triangle'

- Derives authority from *Maneka Gandhi v. Union of India (1978)*, connecting **Articles 14, 19, and 21**.
- **Article 14** operates as an absolute check against state arbitrariness, forming the bedrock of substantive natural justice.
- **Article 19(1)** mandates procedural fairness, while **Article 21** guarantees personal liberty, establishing that any arbitrary arrest violates the fundamental constitutional fabric.

Significance of Constitutional Safeguards on Arrest

1. **Upholding Human Dignity:** Prohibiting degrading custodial treatment reaffirms that custodial status does not strip an individual of fundamental protections under **Article 21**.
2. **Checking Executive Arbitrariness:** Requiring reasoned justifications on arrest memos limits the **unbridled, mechanical exercise of police power**.
3. **Protecting Individual Reputation:** Preventing routine arrests shields citizens from social stigma and the irreparable loss of personal liberty.
4. **Enforcing Procedural Natural Justice:** Providing clear grounds of arrest allows the accused to immediately consult legal counsel and prepare an **effective legal defense**.
5. **Dismantling Chains of Illegal Custody:** Rendering subsequent remand orders void if the initial arrest was flawed enforces **strict judicial accountability** on lower magistrates.

Challenges in Curbing Arbitrary Arrests

1. **Superficial and Mechanical Compliance:** Investigating officers frequently treat the communication of arrest grounds as a **perfunctory paperwork exercise**.
2. **Falsification of Arrest Timelines:** Deliberate delays or manipulation in logging the formal time of arrest on memos circumvent the **24-hour magistrate production mandate**.
3. **Misuse of Preventive Detention Laws:** Executive authorities often use preventive provisions derived from colonial-era frameworks to bypass **regular bail safeguards**.
4. **Socio-Legal Information Asymmetry:** A significant segment of marginalized undertrials lacks awareness of their statutory rights under **Article 22**.
5. **Weaponization of Frivolous Complaints:** The filing of motivated, false criminal complaints clogs the justice system and results in **unwarranted pre-trial incarcerations**.

Way Forward

1. **Mandate Digital Timestamps and Body Cameras:** Integrate mandatory **body-worn video recording** and digital time-stamping during arrests to ensure absolute adherence to Section 58 of BNSS.
2. **Institutionalize Strict Judicial Scrutiny:** Magistrates must critically inspect arrest memos and necessity justifications before granting **custodial remand**, rejecting mechanical orders.
3. **Enforce Departmental Accountability:** Impose strict penalties, departmental inquiries, and financial liabilities on police personnel who execute **unconstitutional or malicious arrests**.

4. **Reform Preventive Detention Protocols:** Shorten the statutory period required for **Advisory Board reviews** and limit the subjective discretion of executive magistrates.
5. **Continuous Police Sensitization:** Conduct regular, structured capacity-building training on **human rights jurisprudence** and necessity parameters under Section 35 of BNSS.
6. **Strengthen Last-Mile Legal Aid:** Deploy active legal aid defense counsels at the police station level to assist arrested individuals at the **immediate point of apprehension**.

Conclusion

Arrest is a profound deprivation of personal liberty that demands strict constitutional accountability rather than routine executive execution. By enforcing rigorous procedural safeguards, eliminating arbitrary custody, and adhering to the **Golden Triangle of Articles 14, 19, and 21**, India's criminal justice system can protect democratic freedoms and ensure that the rule of law prevails over arbitrary authority.

***Q.** The power of arrest must be balanced against the constitutional guarantee of personal liberty. In light of recent judicial pronouncements, evaluate the procedural safeguards under Article 22 and the challenges in curbing arbitrary arrests. 15 Marks*

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2.1. ECONOMY

2.1.1. INDUSTRIAL HEAT ELECTRIFICATION IN INDIA

Context

India's next energy-transition frontier is **industrial heat**, especially in MSMEs dependent on fossil-fuel-based boilers. India needs a **coordinated shift to renewable-powered industrial heat** through suitable technology, finance, skills and cluster-level planning.



Why Industrial Heat Electrification Matters?

1. Decarbonising Industry

- Industrial heating is a major source of **fossil-fuel consumption and GHG emissions**.
- Electrification using renewable power can significantly reduce the **carbon intensity of manufacturing**.

2. Energy Security

- Reduces dependence on fossil fuels and exposure to **volatile fuel prices and imports**.
- Greater use of domestic renewable electricity strengthens India's energy resilience.

3. Manufacturing Competitiveness

- Efficient electric heating and waste-heat recovery can reduce **energy and operating costs**.
- Cleaner production can improve India's competitiveness in **global green supply chains**.

4. MSME Transformation

- MSMEs often have limited capital, technical expertise and energy monitoring systems.
- A structured transition can help them adopt **efficient technologies without excessive upfront costs**.

Technology Pathways

Technology	Suitable Application
Heat Pumps	Low/medium-temperature processes and waste-heat recovery
Electric Boilers	Steam generation, including higher-temperature applications
Mechanical Vapour Recompression	Evaporation-intensive processes
Thermal Energy Storage	Store surplus renewable/recovered heat and release when needed
Waste-Heat Recovery	Improve energy efficiency before additional electrification

Challenges of Industrial Heat Electrification

1. Diverse Industrial Processes

- Industries have different **temperature, heat-load, steam and operating requirements**.
- Hence, a **one-size-fits-all electrification technology** is impractical.

2. Poor Energy Data

- Many units lack proper monitoring of **steam flow, process temperature, waste heat and boiler efficiency**.
- This makes it difficult to identify the **most efficient and cost-effective transition pathway**.

3. High Upfront Costs

- MSMEs often face **limited capital, technology risks and inadequate technical expertise**.
- High initial investment discourages adoption despite potential long-term savings.

4. Electricity Constraints

- Grid charges, open-access rules, banking provisions and infrastructure gaps** can raise renewable electricity costs.
- Unreliable or expensive power can weaken the economic case for industrial electrification.

5. Skill Deficit

- Electrification requires expertise in **system design, installation, automation and maintenance**.
- Shortage of skilled manpower can delay adoption and reduce system efficiency.

Government Policy

- National Green Hydrogen Mission** – promotes clean-energy transition in hard-to-abate sectors.
- Perform, Achieve and Trade (PAT) Scheme** – promotes energy efficiency in energy-intensive industries.
- Bureau of Energy Efficiency (BEE)** – important institutional actor for energy-efficiency standards and programmes.
- PM-KUSUM and renewable-energy expansion** – demonstrate India's broader shift towards renewable electrification.
- Green Energy Open Access Rules** – can facilitate industrial access to renewable electricity.

Way Forward: Industrial Heat Electrification

Key Principle: *"Efficiency first, electrification next."* India should first optimise industrial processes and recover waste heat, and then electrify the **residual heat demand** using the most suitable technology.

1. Audit & Optimise

- Conduct **facility-level thermal-energy audits** covering boilers, steam, process temperatures and waste heat.
- Use **pinch analysis** to maximise heat recovery before electrification.

2. Technology-Specific Electrification

- Choose technologies based on **temperature, heat load and process requirements** rather than a blanket approach.

- Promote **heat pumps, electric boilers, mechanical vapour recompression and thermal energy storage** where appropriate.

3. Cluster-Level Planning

- Develop **industrial heat profiles** for major MSME clusters and map thermal demand with local renewable potential.
- Integrate industrial electrification with **grid capacity, renewable generation and infrastructure planning**.

4. Affordable & Reliable Green Power

- Streamline **green open access**, rationalise network and banking charges, and strengthen transmission infrastructure.
- Align industrial heat demand with periods of **abundant renewable generation**.

5. Innovative Finance & Demand Aggregation

- Scale **technology leasing, Heat-as-a-Service, ESCO models and blended finance** to reduce upfront costs.
- Aggregate MSME demand at the cluster level to achieve **economies of scale and cheaper financing**.

6. Demonstration & Skill Development

- Establish **first-of-a-kind demonstration projects** across sectors and temperature ranges to reduce technology and investment risks.
- Build a skilled workforce of **engineers, technicians and operators** in system design, automation and maintenance.

7. Demonstrate, Standardise & Scale

- Use pilot experience to develop **national engineering standards, financing frameworks and institutional mechanisms**.
- Gradually scale successful models through **cluster-based industrial transition plans**, rather than imposing blanket mandates.

Conclusion

Industrial heat electrification can simultaneously advance **decarbonisation, energy security and manufacturing competitiveness**. India should adopt a **technology-neutral, cluster-based and finance-enabled approach**, prioritising efficiency before electrification.

A coordinated transition can make Indian industry **cleaner, more resilient and globally competitive**.

Q. Industrial heat electrification can be a critical pathway for achieving India's decarbonisation goals while enhancing manufacturing competitiveness. Examine the challenges and suggest a suitable roadmap for its large-scale adoption, particularly among MSMEs. 15 Marks

2.1.2. CULTURAL HERITAGE TO A COMPETITIVE CREATIVE ECONOMY

Context

The article comes at a significant juncture for India's handloom sector. **National Handloom Day is observed on 7 August**, commemorating the launch of the **Swadeshi Movement in 1905**, which placed indigenous production and self-reliance at the centre of India's economic nationalism. The contemporary debate, however, has moved beyond simply preserving handloom towards making it **economically viable, globally competitive and attractive to younger consumers**.



Introduction

- India's **handloom sector is not merely a traditional craft; it is a labour-intensive, decentralised and culturally embedded economic activity**.
- According to the **Handloom Census 2019–20**, India has about **35.22 lakh handloom workers, of whom more than 72% are women**, making the sector particularly important for **rural employment and women's economic empowerment**.

Handloom Craft in India: Key Features & Significance

A. Key Features of Indian Handloom

1. Traditional and Skill-Intensive Craft

- Relies primarily on **manual weaving techniques** rather than mechanised production.
- Requires **specialised craftsmanship and inherited skills**.

2. Decentralised and Household-Based

- Production is largely organised in **households, small workshops and cooperatives**.
- Concentrated in rural and semi-rural regions enables employment without requiring large industrial infrastructure.

3. Culturally Diverse

- Every region has distinctive **Weaving techniques**, Designs and motifs, Colours, Fibres, Cultural symbolism.
- Examples: **Banarasi, Kanchipuram, Pochampally Ikat, Chanderi, Sambalpuri, Kota Doria and Jamdani**.

4. High Product Differentiation

- Variations arising from manual production can enhance their **artistic and aesthetic value**.
- Competes primarily through **quality, authenticity and uniqueness**, rather than mass production.

5. Geographically Embedded

- Strongly connected with **local ecology, raw materials and community traditions**.
- Many products derive their identity from their place of origin creates scope for **Geographical Indication (GI)** protection.

6. Labour-Intensive

- Generates significant employment relative to the capital invested.
- Particularly important for **rural non-farm employment**.
- Provides opportunities for workers with limited access to formal industrial employment.

B. Importance of Handloom Craft

1. Economic Significance

- **Employment Generation** - provides livelihoods to millions of people.
- **Rural Economic Development** - creates opportunities in the **rural non-farm economy** and supports local economic activity in weaving clusters.
- **Labour-Intensive Manufacturing** - relevant for India's challenge of creating **large-scale non-farm employment**.
- **Export Potential** - Indian handloom products have demand in international markets due to Craftsmanship, Authenticity, Cultural uniqueness, Sustainable-fashion appeal.

2. Social Significance

- **Women's Empowerment** - Women constitute about **72% of India's handloom workforce** opportunities for **home-based income generation**.
- **Inclusive Livelihoods** - Supports economically vulnerable rural households.
- **Intergenerational Skill Transfer** - Traditional weaving knowledge is transferred from **one generation to another**.

3. Cultural Significance

- **Preservation of Cultural Heritage** - Handloom embodies India's **civilisational and regional diversity**. Designs and motifs often reflect Local traditions , Religious beliefs
- **Regional Identity** - Handloom acts as a **cultural marker of regions and communities**. Examples Banarasi — Varanasi , Kanchipuram silk — Tamil Nadu
- **GI Heritage** - GI can help establish **authenticity, reputation and geographical identity**.

C. Strategic Significance for India

1. Atmanirbhar Bharat

- Promotes indigenous production and local value chains.
- Symbolically connected with the **Swadeshi movement**.

2. Vocal for Local to Global

- Provides an opportunity to convert traditional Indian products into globally recognised brands.
- Can strengthen India's **soft power**.

3. Creative Economy

- Handloom lies at the intersection of **Culture , Design , Fashion , Technology and Commerce**.
- Can therefore become part of India's expanding **creative economy**.

4. Sustainable Development

- Supports:

- **SDG 1:** No Poverty
- **SDG 5:** Gender Equality
- **SDG 8:** Decent Work and Economic Growth
- **SDG 12:** Responsible Consumption and Production
- **SDG 11:** Sustainable Communities

Major Challenges of the Indian Handloom Sector

1. Competition from Powerlooms and Mechanisation.

- Handloom products, being labour-intensive and decentralised, find it difficult to compete with machine-made textiles purely on price and volume.
- This can eventually lead to the erosion of traditional skills and intergenerational transmission of indigenous weaving knowledge.

2. Low Productivity and Technological Constraints

- Handloom production requires considerable human effort at different stages, including yarn preparation, weaving, dyeing and finishing, which increases production time and labour costs.
- Low productivity can therefore reduce the competitiveness and profitability of individual weavers.

3. Raw Material Constraints

- Fluctuations in the prices of cotton, silk, wool and other yarns directly increase the cost of production for handloom weavers.
- Since many weavers operate on narrow profit margins, even moderate increases in raw-material prices can significantly affect their income.

4. Lack of Access to Institutional Finance

- A large part of handloom production is organised through households and small units, which can make it difficult for weavers to satisfy formal lending requirements.
- Limited documentation, collateral and formal financial records can restrict their access to institutional credit.

5. Weak Design Innovation and Changing Consumer Preferences

- Contemporary consumers increasingly demand new designs, colour combinations, functional clothing, home décor products and fusion wear.
- Traditional products that do not adapt to changing preferences may gradually lose relevance among younger and urban consumers.

Government Initiatives for the Development of the Handloom Sector

1. National Handloom Development Programme (NHDP)

- The **National Handloom Development Programme** is a comprehensive intervention aimed at strengthening the handloom sector through **infrastructure development, cluster-based development, marketing support, credit and welfare measures**.

2. Raw Material Supply Scheme (RMSS)

- The **Raw Material Supply Scheme** addresses one of the major structural problems faced by handloom weavers—the **availability and affordability of quality yarn**.

Way Forward for the Indian Handloom Sector

A. Shift from Subsidy-Centric to Value-Chain-Centric Policy

- Government policy should gradually move beyond providing only **subsidies, loans and equipment** and focus on improving the entire economic ecosystem surrounding the weaver.
- The objective should be to ensure that government assistance ultimately translates into **higher productivity, better market access and increased income for weavers**.

B. Build a Globally Recognisable "Brand India Handloom"

- India should develop a strong global identity for its handloom products based on **authenticity, craftsmanship, sustainability and Indian cultural heritage**.
- A common identity can help individual regional products gain visibility in international markets while retaining their unique geographical identities.

C. Strengthen Cooperatives and Producer Organisations

- Individual weavers often have weak bargaining power because they purchase inputs and sell products in small quantities.
- Strong cooperatives and producer organisations can aggregate production and enable weavers to negotiate **better prices for both inputs and finished products**.

D. Adopt a Digital-First Marketing Strategy

- Dedicated digital platforms can connect weavers directly with consumers and reduce the geographical barriers traditionally faced by rural producers.
- Direct sales can improve **market access, price transparency and producer margins**.

E. Integrate Design with Technology

- Traditional weaving knowledge should be combined with modern design capabilities to develop products that appeal to contemporary consumers without destroying their cultural identity.
- This can create a bridge between **traditional craftsmanship and modern fashion markets**.

F. Improve Export Competitiveness

- Handloom producers should receive greater support to meet **international quality, safety and product standards**.
- Consistent quality is essential for building long-term relationships with global buyers.

Conclusion

- **The future of Indian handloom lies not in protecting it from modernisation but in modernising it without destroying its traditional identity.**
- A **weaver-centric, value-chain-oriented strategy** combining technology, design, collective institutions, digital markets, GI protection and global branding can transform handloom from a vulnerable traditional livelihood into a **competitive creative industry, while preserving India's cultural heritage and advancing inclusive growth**.

Q. Indian handloom represents a unique convergence of cultural heritage, rural livelihoods and women's economic empowerment. However, structural challenges have constrained its competitiveness and the income of weavers. Discuss the major challenges facing the Indian handloom sector and suggest measures to make it globally competitive while preserving its traditional character. 15 marks

2.1.3. THE MISSING 'REUSE' PRINCIPLE IN INDIA'S EV TRANSITION

Context

India's EV transition is accelerating, but policy remains focused on **new EVs and scrappage**. **Retrofitting structurally sound vehicles** can extend their life, reduce waste and resource use, and make EV adoption more **circular and sustainable**.



Introduction

A **circular economy** prioritises **reduce → reuse → recycle**. India has strengthened vehicle recycling through the **2021 Scrapping Rules** and **2025 End-of-Life Vehicle Rules**, but EV transition needs a **continue-retrofit-recycle** approach based on a vehicle's **condition, not just age**.

Circular Economy and Vehicle Transition

1. **Reduce Resource Consumption:** Extending vehicle life reduces the need for new materials, energy and water required to manufacture replacement vehicles.
2. **Reuse Existing Assets:** EV retrofitment preserves usable components like the **chassis and body**, extending their economic and functional value.
3. **Recycle at End-of-Life:** Vehicles that are unsafe or structurally damaged should be **scrapped and recycled** to recover valuable materials.

Key Principle: Reduce → Reuse → Repair/Refurbish → Recycle → Dispose

What is Vehicle Retrofitment?

- **Meaning:** Replacing an existing vehicle's **ICE, fuel system and related components** with a certified electric powertrain.
- **Core Principle:** Retains the vehicle's **structurally sound components** such as the chassis and body.
- **Process:** **Old ICE Vehicle → Safety Assessment → EV Retrofitment → Extended Vehicle Life**
- **Benefit:** Reduces emissions, resource consumption and premature vehicle scrappage.
- **Significance:** Acts as the **"missing middle"** between continued ICE use and complete scrappage.

Significance of Vehicle Retrofitment

1. Promotes Circular Economy

- Extends the **functional life** of existing vehicles.
- Preserves embedded material and economic value.
- Prevents premature conversion of usable assets into waste.

2. Reduces Material Demand

- Reduces the need to manufacture entirely new vehicles.
- Saves **raw materials, critical minerals and energy**.
- Lowers pressure on industrial resources and supply chains.

3. Reduces Waste Generation

- Scrapping generates both recyclable and landfill waste.
- A two-wheeler may generate around **90 kg recyclable material + 18 kg landfill waste**.
- Retrofitment reduces waste by extending the life of suitable vehicles.

4. Supports Sustainable Consumption

- Advances **SDG 12: Responsible Consumption and Production**.
- Promotes **resource efficiency and longer product life**.
- Reduces waste through reuse rather than premature disposal.

5. Accelerates Electrification

- Electrifies existing vehicles without complete replacement.
- Can bring more vehicles into the **EV ecosystem**.
- Makes electrification faster and potentially more resource-efficient.

6. Reduces Fossil-Fuel Dependence

- Replaces ageing **ICE powertrains with electric systems**.
- Reduces petrol/diesel consumption and vehicular emissions.
- Supports India's **clean mobility and energy-transition goals**.

7. Can Improve Affordability

- Provides an alternative to purchasing a completely new EV.
- Can lower the upfront cost of electrification for suitable vehicles.
- Makes the EV transition potentially **more inclusive and accessible**.

Why Scrappage Alone is Not Enough?

Age ≠ End of Useful Life: An old vehicle may still have a **sound chassis, body and usable components**; scrapping such vehicles prematurely wastes embedded material and economic value.

Challenges in Scaling EV Retrofitment

1. Safety Risks

- Improper conversion can compromise **battery, electrical and vehicle safety**.
- Poor weight distribution may affect **stability and crashworthiness**.

2. Certification & Standards

- Need **uniform national standards** for retrofit kits, batteries, motors and controllers.
- Strict **testing and certification** are essential for road safety and consumer confidence.

3. Battery Lifecycle Management

- Batteries create new environmental challenges through **mining, production and disposal**.
- Strong systems are needed for **second-life use and recycling**.

4. Economic Viability

- Retrofitment may not be viable for **very old, damaged or low-value vehicles**.
- Cost-benefit assessment is essential before conversion.

5. Skilled Ecosystem

- Large-scale adoption requires **trained technicians and certified retrofit centres**.
- Reliable components and after-sales services are equally important.

6. Finance & Insurance

- Uncertainty over **vehicle valuation, insurance, warranty and resale** can deter users.
- Banks and insurers need suitable products for retrofitted vehicles.

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Way Forward

1. For Government

- **Adopt a condition-based vehicle hierarchy**: Classify vehicles into continue, retrofit and scrap categories based on safety and structural integrity.
- **Develop stringent retrofit standards**: Ensure certified conversion kits, battery safety and testing protocols.
- **Provide targeted incentives**: Encourage certified retrofitment, particularly for two-wheelers, three-wheelers and commercial fleets.
- **Integrate retrofitment with scrappage policy**: Treat both as complementary components of circular mobility.

- **Create digital vehicle-health assessment:** Use standardised testing to determine whether a vehicle should continue, be retrofitted or scrapped.

2. For Industry

- Develop standardised and safe retrofit kits.
- Build certified conversion and testing centres.
- Promote modular and repairable EV components.
- Develop battery second-life and recycling ecosystems.

3. For Sustainable Mobility

Retrofitment → Battery reuse → Second-life applications → Recycling

- This can create a broader **circular EV ecosystem** rather than merely replacing one propulsion technology with another.

Conclusion

India's EV transition must go beyond "replace and scrap" towards "Continue-Retrofit-Recycle." Integrating electrification with circularity can make mobility cleaner, resource-efficient, affordable and sustainable.

Q. India's transition towards electric mobility must go beyond replacing internal combustion engine vehicles with new EVs and incorporate circular economy principles. Discuss the significance of vehicle retrofitment in achieving a resource-efficient and sustainable EV transition.
15 Marks

2.1.4. RECONCILING ENERGY SECURITY, AGRICULTURE AND SUSTAINABILITY

Context

India's **E20 programme**, involving 20% ethanol-blended petrol, achieved the blending target in **2025**, rising from ~1.5% in 2014. It seeks to strengthen **energy security, reduce oil imports, boost farmer incomes and cut emissions**, with the government reporting over **₹1.90 lakh crore in forex savings**. However, concerns remain over **vehicle compatibility, mileage, food-fuel competition, water use and long-term sustainability**.



Introduction

- India's **Ethanol Blended Petrol (EBP) Programme** aims to reduce crude-oil dependence by blending domestically produced ethanol with petrol.
- India achieved the **20% ethanol-blending target (E20) in 2025, five years ahead of the original 2030 target**, making it an important component of India's energy-transition strategy.

Significance of E20 fuel

1. Energy Security

- Reduces dependence on **imported crude oil**.
- Provides a degree of insulation from **global oil-price volatility and geopolitical shocks**.

2. Economic Benefits

- Saves **foreign exchange**.
- Creates a domestic market for ethanol-producing agricultural commodities.
- Strengthens the **biofuel industry and rural economy**.

3. Agricultural Benefits

- Creates additional demand for **sugarcane, maize and other approved feedstocks**.
- Provides an alternative market for agricultural produce.

4. Environmental Benefits

- Ethanol is a **renewable fuel** and can reduce lifecycle greenhouse-gas emissions compared with fossil fuels.
- According to government data, the programme had resulted in substantial **net CO₂ reduction** and crude-oil substitution.

Key Issues / Concerns

1. Vehicle Compatibility

- Older vehicles designed for E10 may not perform optimally with E20.
- Concerns include lower mileage, accelerated wear of some components, higher maintenance costs.
- Government/industry evidence indicates that older E10-designed vehicles can experience some reduction in fuel efficiency.

2. Consumer Cost

- Even if E20 is cheaper per litre, **lower mileage** can increase the effective cost per kilometre for some vehicles.
- This creates a question of **distributional justice**, as consumers with older vehicles bear adjustment costs.

3. Food vs Fuel Debate

- Increased diversion of **sugarcane, maize and rice** towards ethanol can potentially compete with food availability, livestock feed, water resources.
- Hence, ethanol policy must not undermine **food security**.

4. Water Intensity

- Sugarcane is a highly **water-intensive crop**.
- Expansion of sugarcane-based ethanol in water-stressed regions can aggravate: **groundwater depletion + regional ecological stress**.

5. Sustainability of Feedstocks

- Ethanol is not automatically "green".
- Its sustainability depends on:
feedstock → cultivation → water use → processing → transportation → lifecycle emissions.

6. Policy Transition Problem

- India has a large existing fleet of vehicles designed around lower ethanol blends.
- A rapid transition without adequate testing, consumer awareness, retrofitting, servicing infrastructure can create public resistance.

Way Forward

1. Adopt a Lifecycle Sustainability Approach

- Evaluate ethanol not merely by blending percentage but through: **carbon intensity + water footprint + land use + food-security impact.**

2. Feedstock Diversification

- India should **reduce excessive dependence on sugarcane-based ethanol** by promoting **2G ethanol produced from agricultural residues, crop waste, cellulosic biomass and municipal waste.**
- This will help **reduce pressure on food crops, conserve water resources and minimise the food-versus-fuel conflict**, while making the ethanol programme more sustainable.

3. Protect Consumers

- Provide clear information about **E10/E20 compatibility.**
- Ensure affordable replacement of vulnerable components.
- Strengthen warranty and servicing mechanisms for affected vehicles.

4. Technology-Neutral Mobility Strategy

- E20 should not become a substitute for broader decarbonisation.
- India should simultaneously promote:
EVs + hybrids + CNG + public transport + green hydrogen + sustainable biofuels.

5. Promote Flex-Fuel Vehicles

- Develop a gradual ecosystem for **flex-fuel vehicles**, allowing consumers to use different ethanol-petrol blends according to availability.

6. Regional Crop Planning

- Promote ethanol feedstocks according to **agro-climatic and water availability conditions**, rather than encouraging water-intensive crops uniformly across India.

Conclusion

- India's E20 programme represents a significant **energy-security and agricultural-policy intervention**, but its sustainability cannot be judged merely by the quantity of ethanol blended.
- A durable strategy must reconcile **energy security, farmer welfare, environmental sustainability and consumer interests.**
- Thus, India should pursue a **technology-neutral, feedstock-diversified and lifecycle-based biofuel transition** rather than treating E20 as an end in itself.

Q. India's E20 ethanol blending programme can strengthen energy security, but it also raises concerns related to food security, water use and vehicle compatibility. Critically examine the opportunities and challenges associated with the E20 transition. Suggest measures to ensure a sustainable and inclusive biofuel policy. 15 marks

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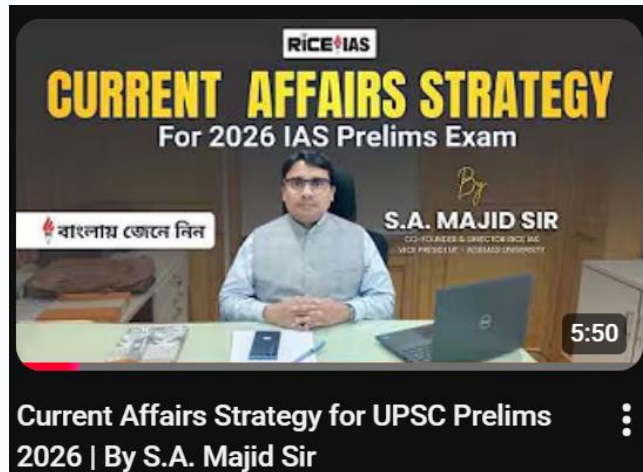
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