Secure Synopsis compilation for January-2025

General Studies-3

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Indian Economy and issues relating to planning, mobilization, of resources, growth, development and employment.

Q. Discuss the significance of Gross Value Added (GVA) in understanding the structural transformation of the Indian economy. How does it complement GDP as an economic indicator? (10 M)

Introduction

Gross Value Added (GVA) provides a granular view of economic activity, making it critical to understanding sectoral dynamics and structural transformations within the Indian economy.

Body

Significance of GVA in understanding the structural transformation of the Indian economy

1. **Tracks sectoral contributions**: GVA highlights the contributions of primary, secondary, and tertiary sectors individually, enabling better assessment of structural transitions.
    - Eg: **Services sector's share in GVA** rose to **54% in FY23**, reflecting India's shift to a service-dominated economy (Source: MoSPI).
2. **Focuses on productivity**: GVA emphasizes productivity by excluding intermediate consumption, offering a clearer picture of sectoral efficiency.
    - Eg: **Agricultural GVA** grew by just **1.5% in FY23**, despite employing over 45% of the workforce.
3. **Monitors regional disparities**: Disaggregated GVA data helps identify regional economic disparities.
    - Eg: **Gujarat** accounted for **15% of India's industrial GVA** in FY22, showcasing its manufacturing strength.
4. **Drives policy interventions**: Insights from GVA data guide targeted fiscal and sectoral interventions.
    - Eg: **PLI schemes were expanded in 2022** to cover 14 sectors based on lagging GVA trends in manufacturing.
5. **Assesses resilience to shocks**: GVA measures economic resilience by tracking sector-specific recovery trends.
    - Eg: Post-pandemic, **industrial GVA** rebounded by **4.5% in FY22**, highlighting recovery in core sectors (Source: RBI).

How GVA complements GDP as an economic indicator

1. **Explains sectoral dynamics**: While GDP shows aggregate growth, GVA offers sectoral breakdowns, revealing underlying drivers and bottlenecks.
    - Eg: Despite **7.2% GDP growth in FY23**, GVA data showed **stagnation in manufacturing** due to global supply chain issues.
2. **Supports inflation-adjusted analysis**: GVA at basic prices isolates sectoral performance from the effects of taxes and subsidies, aiding in inflation analysis.
    - Eg: In FY22, **8.1% GVA growth** signalled economic recovery after adjusting for tax-induced inflation.
3. **Informs taxation and fiscal policy**: GVA data aids in designing tax policies by highlighting sector-specific growth or decline.
    - Eg: Increased **excise duty on petroleum products** in 2021 was based on GVA trends in energy and manufacturing.
4. **Aligns with global standards**: GVA conforms to the **UN System of National Accounts (SNA)**, improving comparability with international data.
    - Eg: **India's GVA methodology** aligns with that of OECD countries, ensuring accurate global benchmarking.
5. **Aids in employment generation**: GVA insights into labour-intensive sectors guide job creation policies.
    - Eg: **Agriculture and MSMEs,** identified as low-GVA contributors, received priority in **PMEGP** to boost employment in FY23.

Conclusion

GVA complements GDP by providing a nuanced understanding of sectoral dynamics and supporting targeted policymaking. Leveraging these insights effectively can ensure **inclusive and sustainable growth**, aligning with India's long-term economic goals.

Q. "The dichotomy between urban and rural employment in India reflects deeper structural inequalities". Analyze how fiscal and monetary policies can be synchronized to address these disparities. (15 M)

Introduction

The urban-rural employment divide in India underscores significant structural inequalities, including sectoral imbalances, infrastructure deficits, and disparities in education and skills. Addressing these challenges is essential for achieving inclusive and sustainable growth.

Body

Dichotomy between urban and rural employment in India reflects deeper structural inequalities

1. **Sectoral Imbalance**: Rural areas are predominantly dependent on agriculture, which employs a significant portion of the workforce but contributes a smaller share to GDP.

    - Eg: **Agriculture employs approximately 45%** of the workforce but contributes only about **16%** to GDP.
2. **Infrastructure Deficit**: Rural regions often lack adequate infrastructure, limiting economic opportunities and access to markets.
    - Eg: **Urban areas receive a disproportionate share** of industrial investments, exacerbating regional disparities.
3. **Educational and Skill Disparities**: Limited access to quality education and vocational training in rural areas restricts employment opportunities.
    - Eg: **Rural youth constitute a significant portion** of the unskilled labour force, highlighting the need for targeted skill development programs.
4. **Migration and Informal Employment**: Rural-to-urban migration often leads to employment in the informal sector, lacking job security and benefits.
    - Eg: **The 2020 migrant crisis highlighted** the vulnerabilities of rural migrants in urban areas.
5. **Limited access to technology and innovation**: Rural areas lack exposure to advanced technology and innovation, hindering productivity and employment growth.
    - Eg: Only **17% of rural enterprises** use modern technology compared to **45% of urban enterprises**, as reported by NITI Aayog in 2023

Fiscal and monetary policies can be synchronized to address these disparities

Fiscal Policy Measures:

1. **Investment in Rural Infrastructure**: Allocating funds for the development of rural infrastructure to enhance connectivity and economic activities.
    - Eg: The **Pradhan Mantri Gram Sadak Yojana (PMGSY)** has significantly improved rural road connectivity.
2. **Support for Rural Enterprises**: Providing financial incentives and support to promote rural entrepreneurship and small businesses.
    - Eg: Schemes like the **Prime Minister's Employment Generation Programme (PMEGP)** have facilitated the creation of rural employment opportunities.
3. **Enhancing Educational and Skill Development**: Investing in education and vocational training tailored to rural needs to improve employability.
    - Eg: The **Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY)** focuses on skill development for rural youth.
4. **Strengthening Social Security for Migrant Workers**: Implementing policies to provide social security and support for migrant workers.
    - Eg: The **One Nation One Ration Card (ONORC)** scheme ensures food security for migrant workers across states.

Monetary Policy Measures:

1. **Priority Sector Lending**: Mandating banks to allocate a portion of their lending to sectors that generate rural employment.
    - Eg: The Reserve Bank of India's guidelines on **Priority Sector Lending (PSL)** include targets for agriculture and micro-enterprises.
2. **Facilitating Access to Credit**: Ensuring availability of affordable credit to rural entrepreneurs and small businesses.
    - Eg: Initiatives like the **Micro Units Development and Refinance Agency (MUDRA)** provide loans to micro and small enterprises.
3. **Promoting Financial Inclusion**: Expanding banking services in rural areas to facilitate savings, credit, and insurance.
    - Eg: The **Pradhan Mantri Jan Dhan Yojana (PMJDY)** has significantly increased the number of bank accounts in rural regions.
4. **Supporting Rural Employment through Refinance Schemes**: Providing refinance facilities to financial institutions lending to rural employment sectors.
    - Eg: The **National Bank for Agriculture and Rural Development (NABARD)** offers refinance support for rural infrastructure projects.

Synchronization of Fiscal and Monetary Policies:

1. **Coordinated Development Programs**: Aligning fiscal spending on infrastructure with monetary support for credit availability to maximize impact.
    - Eg: Joint efforts in rural housing schemes where fiscal subsidies are complemented by affordable housing loans.
2. **Integrated Skill Development and Employment Initiatives**: Combining fiscal investments in education with monetary incentives for industries to employ skilled rural youth.
    - Eg: Programs that link skill development centers with micro-financing options for self-employment.
3. **Unified Social Security Frameworks**: Developing comprehensive policies that provide both fiscal support and financial products to safeguard migrant workers.
    - Eg: Collaborative schemes offering pension plans and insurance products tailored for the informal sector.

Way Forward

1. **Integrated Rural-Urban Development Planning**: Implementing policies that promote balanced regional development to reduce disparities.
2. **Leveraging Technology for Education and Employment**: Utilizing digital platforms to provide education, skill development, and employment opportunities in rural areas.
3. **Strengthening Cooperative Federalism**: Encouraging collaboration between central and state governments to tailor policies addressing specific regional employment challenges.

Conclusion

Addressing the urban-rural employment divide requires a synchronized approach, integrating fiscal and monetary policies to tackle structural inequalities. Such coordinated efforts are essential for fostering inclusive growth and ensuring equitable economic development across India.

Q. Examine the role of External Commercial Borrowings (ECBs) in India's financing structure. Discuss their potential in bridging investment gaps and ensuring financial stability, along with the associated risks in the current economic scenario. (15 M)

Introduction

External Commercial Borrowings (ECBs) provide Indian corporates with access to global capital markets, enabling long-term financing at competitive rates. Prudent regulation by the **Reserve Bank of India (RBI)** ensures that ECBs contribute to economic growth while maintaining financial stability.

Body

Role of ECBs in India's financing structure

1. **Infrastructure development:** ECBs support large-scale infrastructure projects with long gestation periods, reducing fiscal burden on domestic lenders.
    - **Eg:** The **Mumbai Trans Harbour Link (MTHL)** leveraged ECBs from Japanese banks, ensuring uninterrupted financing for project execution.
2. **Technology upgradation:** ECBs enable the import of advanced technologies, enhancing productivity and global competitiveness.
    - **Eg: Tata Steel** used ECBs to adopt state-of-the-art manufacturing technologies, improving operational efficiency.
3. **Diversification of funding sources:** ECBs reduce reliance on domestic credit markets, enhancing financial resilience.
    - **Eg:** In **FY25**, Indian firms raised **$33.8 billion** via ECBs, ensuring diversified capital inflows (**SBI Report, 2025**).
4. **Cost-effective capital:** Lower global interest rates allow Indian companies to borrow at competitive rates compared to domestic borrowings.
    - **Eg:** The average ECB borrowing cost in **November 2024** was **5.8%**, significantly lower than domestic loan rates of **8-10%**.
5. **Support for private sector growth:** ECBs provide liquidity for corporate expansion, helping businesses scale operations and invest in new ventures.
    - **Eg: Reliance Industries** utilized ECBs to expand its telecom and retail operations, supporting business diversification.
6. **Boost to forex reserves:** ECB inflows help stabilize foreign exchange reserves, strengthening macroeconomic fundamentals.

- **Eg:** India's forex reserves surged to **$645 billion in 2024**, supported by steady ECB inflows, enhancing investor confidence.

Potential of ECBs in bridging investment gaps and ensuring financial stability

1. **Bridging infrastructure deficits:** ECBs provide long-term funding for capital-intensive projects critical for economic development.
   - **Eg:** ECBs funded the expansion of **NH44**, India's longest highway, facilitating better connectivity and economic activity.
2. **Fostering self-reliance:** ECBs complement domestic financing under initiatives like **Make in India** and **Atmanirbhar Bharat**, boosting manufacturing capabilities.
   - **Eg:** ECBs funded the establishment of **defense manufacturing units**, reducing dependence on imports.
3. **Enhancing corporate liquidity:** ECBs offer businesses immediate liquidity for operational expansion and working capital needs.
   - **Eg: Bharti Airtel** raised ECBs to meet operational costs and fund 5G infrastructure deployment across India.
4. **Mitigating domestic credit constraints:** ECBs help corporates bypass domestic credit limitations and meet their funding needs without crowding out smaller borrowers.
   - **Eg: MSME sector** benefited indirectly as ECBs reduced large corporates' reliance on domestic banks.
5. **Encouraging foreign direct investment (FDI):** Stable ECB inflows boost investor confidence and attract further foreign investments.
   - **Eg:** India's increased ECB inflows contributed to **FDI inflows reaching $84 billion in 2024**, according to the Department for Promotion of Industry and Internal Trade (DPIIT).
6. **Strengthening financial stability:** RBI's regulatory framework ensures ECBs do not pose systemic risks to the economy.
   - **Eg:** ECB borrowings are closely monitored, with hedging requirements protecting firms from currency fluctuations.

Risks associated with ECBs in the current economic scenario

1. **Currency depreciation risk:** A weakening rupee can increase the cost of ECB repayment, affecting profitability.
   - **Eg:** Rupee depreciation to **₹83.50/USD in 2024** led to a rise in debt servicing costs for Indian firms.
2. **Interest rate volatility:** Rising global interest rates can make ECBs more expensive, impacting corporate debt obligations.
   - **Eg:** The US Federal Reserve's rate hike to **5.25% in 2023** increased borrowing costs for Indian firms.
3. **Liquidity risks:** Heavy ECB reliance may lead to refinancing difficulties during economic downturns.

- **Eg:** Several infrastructure firms faced repayment challenges during the **COVID-19 pandemic**, straining their cash flows.

4. **Regulatory risks:** Stricter regulations or sudden policy changes in source countries could impact ECB availability.
    - **Eg:** Tightening of global lending norms post the **2023 financial crisis** limited ECB options for emerging economies.
5. **Hedging cost burden:** While hedging mitigates currency risk, it adds to the overall cost of borrowing.
    - **Eg:** Indian firms hedging 74% of their ECB exposure resulted in higher financial costs despite lower interest rates.
6. **End-use violations:** Misutilization of ECB funds for speculative activities can invite regulatory action and penalties.
    - **Eg:** RBI penalized real estate firms in **2023** for misusing ECBs meant for project financing.

Conclusion

To harness the full potential of ECBs while ensuring financial stability, a **strategic approach** is required. This includes strengthening **hedging frameworks**, promoting **sector-specific ECB utilization**, and enhancing **RBI's monitoring mechanisms** to prevent over-reliance. With proper regulation and strategic deployment, ECBs can continue to be an effective tool for India's economic growth.

Q. Despite being a major employment provider, the unincorporated sector suffers from low capital investment and limited access to institutional credit. Examine the reasons behind this and suggest policy measures for financial resilience and growth. (15 M)

Introduction

The **unincorporated sector** is vital to India's economy, **employing over 12 crore workers and contributing significantly to GDP**. However, it remains largely informal, capital-starved, and credit-deficient, restricting its growth, productivity, and transition to the formal economy.

Body

Issues of low capital investment and limited institutional credit

1. **High informality and lack of credit history**: The sector operates mostly **outside formal financial systems**, making it difficult to access structured credit.
    - **Eg: Only 37.2% of unincorporated enterprises were registered with any authority** (ASUSE 2023-24).
2. **Weak collateral base**: Most enterprises lack **tangible assets**, making them ineligible for collateral-based loans.

- **Eg: Credit rejection rate for micro-enterprises is around 45% compared to 25% for large businesses** (RBI, 2023).

3. **Dependence on informal credit sources**: Due to **complex banking procedures and high rejection rates**, businesses rely on **moneylenders and local financiers at high interest rates**.
    - **Eg: Over 84% of MSMEs depend on informal credit, with interest rates as high as 36% annually** (NSSO, 2018-19).
4. **Delayed payments and liquidity issues**: **Large corporations and government agencies delay payments**, disrupting working capital flow.
    - **Eg: Over ₹10,000 crore in pending MSME dues reported under MSME Samadhaan** (2021).
5. **Low financial literacy and digital access**: Many business owners **lack awareness of credit schemes, digital payments, and banking processes**.
    - **Eg: Only 26.7% of unincorporated businesses used the internet for entrepreneurial activities** (ASUSE 2023-24).

Reasons behind financial constraints

1. **Limited rural banking penetration**: Lack of financial infrastructure and digital banking solutions restricts **credit access for rural enterprises**.
    - **Eg: Only 8.9 bank branches** per lakh population in rural areas compared to 28.2 in urban areas (RBI, 2023).
2. **Risk-averse banking system**: Banks **hesitate to lend to micro-enterprises** due to **uncertain revenues and high default risks**.
    - **Eg: Credit-to-GDP ratio of Indian** MSMEs is just 13% compared to 40% in China (RBI, 2023).
3. **Underutilization of financial schemes**: Many government schemes remain **underutilized due to complex procedures and lack of awareness**.
    - **Eg: Only 16% of eligible MSMEs accessed** formal credit under CGTMSE (2023).
4. **Lack of customized financial products**: Small businesses often require **flexible credit solutions** suited to their business cycles.
    - **Eg: Only 5% of micro-businesses in India have access to venture capital or structured financing options** (Economic Survey, 2023).
5. **Absence of credit rating mechanisms**: Many enterprises lack credit ratings, making it difficult to secure loans at reasonable interest rates.
    - **Eg: Only 10% of small businesses in India** have formal credit scores under CIBIL or equivalent agencies (SBI Research, 2023).

Policy measures for financial resilience and growth

1. **Expansion of Udyam and GST registration**: Promote easy digital registration and **link credit access to compliance records.**

- **Eg: Only 1.6 crore out of 6 crore MSMEs are Udyam-registered** (MSME Ministry, 2023).

2. **Strengthening credit guarantee and microfinance schemes**: Expand **CGTMSE** coverage, Mudra Loans, and microfinance lending to high-risk enterprises.
    - **Eg: MUDRA loans disbursed ₹4.5 lakh crore in 2023**, but outreach in rural areas remains low.
3. **Promoting fintech-based lending and digital credit scoring**: Leverage **UPI-based** transactions and Aadhaar-linked credit profiling to improve financing access.
    - **Eg: RBI's Account Aggregator system** aims to integrate small businesses into **formal credit networks**.
4. **Enforcement of MSME payment timelines**: Strengthen legal mechanisms to **ensure timely payments from corporates and government entities**.
    - **Eg: MSME Samadhaan scheme recovered ₹6,000 crore** in delayed payments since 2017 but needs stronger enforcement.
5. **Encouraging alternative financing mechanisms**: Develop crowdfunding, invoice discounting, and venture capital models tailored for micro-enterprises.
    - **Eg: TReDS (Trade Receivables Discounting System) facilitates invoice discounting for MSMEs** but remains underutilized.

Conclusion

The unincorporated sector's growth and employment potential remain constrained by capital shortages and limited formal credit access. **Strengthening financial inclusion, digital lending, and timely payment enforcement** is essential to ensure sustainable expansion and economic resilience.

Q. Examine the relationship between household consumption expenditure and fiscal policy. How can targeted government interventions enhance household purchasing power without fuelling inflationary pressures? (15 M)

Introduction

Household **consumption expenditure is a key driver of economic growth**, influencing demand, investment, and employment. Fiscal policy, through **taxation, public spending, and subsidies**, directly affects purchasing power, necessitating **targeted interventions to prevent inflationary risks**.

Body

Relationship Between Household Consumption Expenditure And Fiscal Policy

1. **Direct impact on disposable income**: Taxation and government transfers determine household purchasing power.
    - **Eg:** The **PM Kisan Scheme (2019)** provides **income support to farmers**, boosting rural consumption (Economic Survey 2022-23).

2. **Subsidies and welfare programs**: Reduce essential expenses, allowing higher discretionary spending.
    - **Eg: Food Security Act (2013)** ensures **low-cost food grains**, reducing inflationary stress on poor households.
3. **Infrastructure and employment generation**: Fiscal spending on infrastructure and social sectors raises incomes.
    - **Eg: MGNREGA (2005)** provides **rural employment**, leading to higher **consumption multipliers** (Ministry of Rural Development, 2023).
4. **Impact on inflation**: Excessive spending can create demand-pull inflation, necessitating balanced fiscal policy.
    - **Eg:** The **2010 stimulus post-GFC** led to **high inflation and fiscal deficit** (RBI Report, 2015).
5. **GST and consumption patterns**: Tax reforms influence consumption trends by altering product affordability.
    - **Eg: GST rate cuts on essential goods in 2019** improved **rural demand and FMCG sales** (NITI Aayog, 2020).
6. **Monetary-fiscal policy coordination**: Ensuring fiscal prudence alongside monetary tightening prevents overheating.
    - **Eg: RBI's inflation targeting framework (2016)** has helped **maintain price stability while ensuring demand growth** (RBI, 2023).
7. **Consumption-driven revenue generation**: Higher consumption improves GST and indirect tax revenues, supporting fiscal health.
    - **Eg: GST collections hit ₹1.87 lakh crore in December 2023**, reflecting strong **domestic demand growth** (Finance Ministry, 2024).

Targeted Government Interventions To Enhance Purchasing Power Without Inflation

1. **Targeted direct benefit transfers (DBT):** Income support without market distortions ensures spending on essentials.
    - **Eg: DBT in LPG Subsidy (PAHAL Scheme, 2014)** saved ₹50,000 crore in leakages while ensuring affordability (Finance Ministry, 2021).
2. **Counter-cyclical fiscal policies**: Public spending during slowdowns and withdrawal during booms prevent demand shocks.
    - **Eg: Atmanirbhar Bharat (2020)** combined **income support with supply-side reforms**, preventing excessive inflation.
3. **Supply-side measures**: Boosting domestic production and logistics efficiency controls inflationary risks.
    - **Eg: PM Gati Shakti (2021)** aims to **reduce supply bottlenecks**, keeping price rises in check (Economic Survey 2022-23).
4. **Progressive taxation to balance wealth distribution**: Reduces regressive tax burdens on low-income groups.
    - **Eg: Higher exemption limits in Budget 2023** provided **₹7 lakh tax-free income under the new regime**, enhancing middle-class spending.

5. **Public investment in essential services**: Reduces out-of-pocket expenditure on health and education.
    - **Eg: Ayushman Bharat (2018)** covers **₹5 lakh per family**, lowering healthcare costs and increasing disposable income.
6. **Expansion of rural non-farm employment**: Reducing dependence on agriculture diversifies income sources.
    - **Eg: PM Vishwakarma Yojana (2023)** supports **small artisans**, increasing rural disposable incomes (MoRD, 2023).
7. **Strengthening PDS and social security nets**: Ensures stable access to essentials, preventing inflationary spikes from demand surges.
    - **Eg: One Nation One Ration Card (ONORC, 2020)** has **enhanced food security for migrant workers** (Ministry of Consumer Affairs, 2023).

Conclusion

A **balanced fiscal policy** combining **targeted welfare, tax reforms, and infrastructure investment** can enhance purchasing power **without overheating inflation**, ensuring **sustainable and inclusive growth**.

Inclusive growth and issues arising from it.

Government Budgeting.

Major crops-cropping patterns in various parts of the country, - different types of irrigation and irrigation systems storage, transport and marketing of agricultural produce and issues and related constraints; e-technology in the aid of farmers.

Q. Despite its potential for sustainable growth and employment generation, the Indian jute industry grapples with several challenges. Examine the factors affecting the industry and suggest a roadmap for its revival. (15 M)

Introduction

Jute, known as the "golden fiber," holds immense potential for **economic growth, environmental sustainability, and rural employment.** However, the industry is plagued by various challenges, necessitating strategic interventions for its revival.

Body

Potential for Sustainable Growth and Employment Generation

1. **Eco-friendly substitute for plastic:** Jute's biodegradable nature aligns with India's sustainability goals and global environmental commitments.

- Eg: The **Plastic Waste Management Rules, 2016**, encourage the use of eco-friendly alternatives like jute-based packaging.

2. **Employment generation in rural areas:** The jute sector supports millions of farmers and mill workers, particularly in states like West Bengal, Bihar, and Assam.
    - Eg: Over **170,000 farmer households** and about **4 lakh mill workers** are directly dependent on jute cultivation and processing.
3. **Export potential:** India is the largest producer of jute and has the opportunity to tap into global demand for sustainable fiber products.
    - Eg: India's jute exports stood at **$350 million in 2023**, primarily to countries like the US, UK, and Australia.
4. **Government support through policies:** Various policies promote the growth of jute through price assurance, research support, and marketing initiatives.
    - Eg: The **Jute Packaging Materials Act, 1987**, mandates 100% packaging of food grains in jute bags, ensuring steady demand.
5. **Integration with sustainable industries:** Jute can support emerging industries like bio-composites, geotextiles, and agro-based packaging.
    - Eg: The demand for **jute geo-textiles** in infrastructure projects like **riverbank protection and road construction** is increasing.

Challenges Facing the Indian Jute Industry

1. **Declining production and profitability:** Farmers are shifting to other crops due to low profitability, fluctuating prices, and high input costs.
    - Eg: Raw jute production fell from **2.03 million tonnes in 2011-12 to 1.44 million tonnes in 2024-25** (Ministry of Agriculture, 2024).
2. **Inadequate infrastructure and outdated technology:** The majority of jute mills operate with obsolete machinery, leading to low productivity and high operational costs.
    - Eg: Over **50% of jute mills** are using pre-independence era machines, reducing global competitiveness.
3. **Competition from synthetic alternatives:** The availability of cheap synthetic substitutes such as polypropylene bags is a major challenge to jute demand.
    - Eg: Plastic packaging continues to dominate despite government policies favoring jute packaging.
4. **Limited value addition and product diversification:** Lack of innovation in product development restricts jute's market potential beyond packaging.
    - Eg: The absence of R&D in high-value jute products like **furnishings, fashion items, and composites** hampers market growth.
5. **Inefficient procurement and marketing systems:** Farmers often face delays in MSP procurement and exploitation by intermediaries.
    - Eg: Less than **30% of jute farmers** benefit from direct government procurement mechanisms.

Roadmap for Revival of the Jute Industry

1. **Modernization of jute mills:** Upgrading infrastructure and adopting new technologies to enhance productivity and reduce costs.
    - Eg: The **Technology Upgradation Fund Scheme (TUFS)** should be extended to jute mills for financial assistance.
2. **Diversification of jute products:** Expanding the product range to include eco-friendly home decor, technical textiles, and fashion products to attract new markets.
    - Eg: Promoting **jute-based apparel and footwear** through MSME clusters and e-commerce platforms.
3. **Policy support and financial incentives:** Ensuring favourable policies, subsidies, and credit access to farmers and entrepreneurs to encourage jute cultivation and processing.
    - Eg: Providing special incentives under **NABARD's Rural Infrastructure Development Fund** for jute clusters.
4. **Enhancing marketing and global outreach:** Strengthening branding and promotion of Indian jute in international markets through trade fairs and export incentives.
    - Eg: Establishing a **'Brand India Jute' initiative** to boost export competitiveness.
5. **Sustainable farming practices:** Introducing climate-resilient jute varieties and organic farming methods to improve yield and sustainability.
    - Eg: Collaboration with **ICAR-Central Research Institute for Jute and Allied Fibres** to develop pest-resistant jute strains.

Conclusion

A holistic approach involving **modernization, diversification, policy reforms, and sustainable farming** can revive India's jute industry and position it as a global leader in eco-friendly fibres. Investing in innovation and enhancing market access will ensure long-term growth and livelihood security.

Q. Evaluate the significance of the National Mission on Natural Farming (NMNF) in India's agricultural transformation. What are the key challenges faced in implementing the mission effectively? (10 M)

Introduction

Natural farming, through the **National Mission on Natural Farming (NMNF)**, aims to transform Indian agriculture by promoting chemical-free, climate-resilient, and sustainable farming practices to ensure long-term food security and environmental sustainability.

Body

Significance of NMNF in India's agricultural transformation

1. **Soil health improvement:** Reduces dependence on synthetic fertilizers, restoring soil fertility and microbial diversity.

- **Eg:** NMNF targets to convert **7.5 lakh hectares** to natural farming, improving soil quality.

2. **Cost reduction for farmers:** Minimizes input costs by promoting indigenous techniques like cow-based farming and bio-inputs.
    - **Eg:** Studies by **ICAR** indicate a 25-30% reduction in input costs through natural farming adoption.
3. **Climate resilience:** Enhances adaptability to climate change by improving soil moisture retention and reducing greenhouse gas emissions.
    - **Eg:** The **2023 IPCC Report** highlights natural farming's role in reducing carbon footprints in agriculture.
4. **Improved nutritional security:** Provides chemical-free, safe food, enhancing public health and reducing health-related expenditures.
    - **Eg:** Gujarat's natural farming initiatives have led to increased demand for organic produce in local markets.
5. **Self-reliance in agriculture:** Aligns with **Atmanirbhar Bharat** by reducing dependency on imported chemical fertilizers.
    - **Eg:** NMNF **promotes 10,000 Bio-Input Resource Centers (BRCs)** to support local production of organic inputs (Source: Ministry of Agriculture).

Key challenges in implementing NMNF effectively

1. **Lack of awareness and adoption resistance:** Farmers are often hesitant to transition from conventional methods due to deep-rooted practices.
    - **Eg:** A 2024 study by **NITI Aayog** found that **only 20% of farmers** are aware of the benefits of natural farming.
2. **Yield concerns:** Short-term yield reduction acts as a deterrent for farmers transitioning to natural farming.
    - **Eg:** Farmers in Punjab **reported a 15-20% decline in yield during initial years** of natural farming adoption (Source: Punjab Agricultural University, 2023).
3. **Market linkages and certification:** Lack of proper certification and marketing infrastructure affects the profitability of naturally grown produce.
    - **Eg:** The absence of an accessible **organic certification framework** delays market access for farmers.
4. **Inadequate extension services:** Limited outreach and insufficient technical support hinder large-scale adoption.
    - **Eg: Currently, only 90 resource persons** are available across 7 Centers of Natural Farming (CoNF) for farmer training .
5. **Policy and financial support:** Financial incentives and subsidies predominantly favor conventional farming methods, discouraging transition.
    - **Eg:** The **Union Budget 2024-25** allocated significantly higher subsidies for chemical fertilizers compared to natural farming initiatives.

Conclusion

For NMNF to succeed, a multi-pronged approach involving policy support, farmer-centric incentives, and robust market linkages is essential to ensure widespread adoption and long-term sustainability in Indian agriculture.

Issues related to direct and indirect farm subsidies and minimum support prices; Public Distribution System-objectives, functioning, limitations, revamping; issues of buffer stocks and food security; Technology missions; economics of animal-rearing.

Q. "India has a rich diversity of indigenous cattle breeds, yet they are underutilized compared to exotic breeds". Examine the factors responsible for this trend and suggest measures to promote their usage. (10 M)

Introduction

India possesses a diverse range of **43 registered indigenous cattle breeds**, known for their adaptability and resilience. However, their potential remains underutilized due to the dominance of high-yielding exotic breeds, impacting sustainability and economic viability.

Body

Factors responsible for underutilization of indigenous breeds

1. **Lower milk productivity:** Indigenous breeds generally produce lower milk yields compared to exotic breeds, making them less preferred for commercial dairy farming.
    - **Eg: Holstein Friesian cows** produce an average of **20-25 liters/day**, whereas indigenous breeds like **Gir** yield around **10-12 liters/day**.
2. **Market-driven preferences:** The dairy industry favours exotic breeds due to higher milk output and better fat content, leading to reduced demand for indigenous breeds.
    - **Eg: Amul and other major cooperatives** primarily source milk from high-yield exotic breed farmers to meet commercial demand.
3. **Lack of awareness:** Farmers have limited knowledge about the long-term benefits of indigenous breeds, such as disease resistance and lower maintenance costs.
    - **Eg:** A study by **National Bureau of Animal Genetic Resources (NBAGR)** found that **70% of farmers** lack awareness of indigenous breed advantages.
4. **Inadequate breeding programs:** Government and private sector efforts have focused more on crossbreeding rather than the conservation and promotion of indigenous breeds.
    - **Eg:** The **National Dairy Plan (NDP)** emphasized crossbreeding to improve productivity, side-lining pure indigenous breed programs.
5. **Limited availability of quality genetic stock:** Poor access to superior indigenous breed germplasm and artificial insemination facilities restricts their wider adoption.

- **Eg:** Indigenous breeds like **Kankrej** and **Sahiwal** face genetic dilution due to crossbreeding practices.

Measures to promote usage of indigenous cattle breeds

1. **Breed improvement programs:** Implement focused genetic improvement initiatives to enhance milk productivity while retaining the natural resilience of indigenous breeds.
    - **Eg:** The **Rashtriya Gokul Mission (RGM)** aims to improve indigenous breeds through scientific breeding and conservation efforts.
2. **Financial incentives and subsidies:** Provide direct financial assistance to farmers adopting indigenous breeds to offset lower productivity and promote economic viability.
    - **Eg:** The government launched the **Gokul Gram Yojana**, offering subsidies to indigenous cattle farmers.
3. **Awareness and capacity building:** Conduct farmer awareness programs on the long-term benefits of indigenous breeds, including their disease resistance and adaptability.
    - **Eg: ICAR-Krishi Vigyan Kendras (KVKs)** organize awareness camps on indigenous cattle rearing benefits.
4. **Developing niche markets:** Create premium branding for indigenous milk and milk products, highlighting their nutritional and organic value to attract consumers.
    - **Eg: A2 milk from Gir cows** is marketed as a healthier alternative and commands a higher price in urban markets.
5. **Strengthening veterinary infrastructure:** Enhance healthcare and breeding facilities to ensure better management and productivity of indigenous cattle.
    - **Eg:** The **National Animal Disease Control Programme (NADCP)** focuses on eradicating diseases like Foot and Mouth Disease (FMD), benefiting indigenous breeds.

Conclusion

Promoting indigenous cattle breeds requires a **multi-pronged approach**, combining **genetic conservation, market incentives, and awareness** to ensure their economic viability and sustainability. A balanced approach can safeguard India's **livestock biodiversity** while contributing to **sustainable rural growth**.

Food processing and related industries in India- scope' and significance, location, upstream and downstream requirements, supply chain management.

Land reforms in India.

Q. "India's land reforms have failed to adapt to the modern challenges of urbanization and industrialization". Analyze the need for reimagining land use policy in light of these trends". (15 M)

Introduction

India's land reforms, initially focused on agrarian equity and redistribution, have failed to evolve with the changing dynamics of **urbanization and industrialization**, leading to inefficiencies in land use and conflicts between competing needs.

Body

India's land reforms have failed to adapt to the modern challenges of urbanization

1. **Unplanned urban growth**: Land reforms have not addressed the rapid pace of urbanization, leading to haphazard development and slums.
    - Eg: **Mumbai's Dharavi**, one of the largest slums in Asia, highlights poor urban land planning.
2. **Encroachment on agricultural land**: Urban sprawl often consumes fertile agricultural land, threatening food security.
    - Eg: Rapid urbanization in **Haryana** has encroached on productive agricultural zones, impacting farm outputs.
3. **Inadequate affordable housing**: Existing land policies fail to prioritize land for affordable urban housing, leading to housing shortages.
    - Eg: The **Affordable Housing Scheme (2015)** has struggled due to unavailability of land in urban centers.
4. **Weak urban land governance**: Lack of efficient urban land policies and record-keeping fosters corruption and delays.
    - Eg: **Bengaluru's land disputes** often involve outdated records, stalling critical infrastructure projects.

India's land reforms have failed to adapt to the modern challenges of industrialization

1. **Fragmented landholdings**: Small and scattered land parcels hinder large-scale industrialization.
    - Eg: The **Posco Project in Odisha** was delayed due to fragmented land parcels and resistance from local communities.

2. **Conflict between land uses**: Absence of clear zoning laws creates disputes between residential, agricultural, and industrial land use.
    - Eg: Protests against **Sterlite Copper Plant in Tamil Nadu** highlighted clashes between industrialization and residential safety.
3. **Slow and complex acquisition processes**: Bureaucratic hurdles in acquiring land for industrial projects discourage investors.
    - Eg: The **Mumbai-Ahmedabad Bullet Train Project** faced significant delays due to land acquisition issues in Maharashtra.
4. **Neglect of backward regions**: Industrial corridors often focus on developed regions, leaving backward areas underutilized.
    - Eg: The **Delhi-Mumbai Industrial Corridor (DMIC)** has concentrated on developed areas, ignoring potential in less-developed states.

Need for reimagining land use policy in light of these trends

1. **Integrated land use framework**: A national policy integrating urban, industrial, and agricultural needs is vital for balanced development.
    - Eg: **NITI Aayog's Draft National Land Use Policy** proposes spatial planning for sustainable allocation.
2. **Efficient and transparent land acquisition**: Streamlined processes with fair compensation and community participation reduce delays and conflicts.
    - Eg: The **Shah Commission recommendations** suggest faster acquisition through a consultative approach.
3. **Digitization and modernization of land records**: Accessible and updated digital land records prevent disputes and facilitate planning.
    - Eg: **Telangana's Dharani Portal** provides real-time land transaction monitoring.
4. **Promotion of mixed-use zoning**: Flexible zoning policies ensure synergy between housing, industries, and green spaces.
    - Eg: **Amaravati Master Plan (Andhra Pradesh)** emphasizes mixed-use zones for holistic urban growth.
5. **Focus on sustainable practices**: Policies should promote eco-industrial parks and urban green belts to balance growth with environmental preservation.
    - Eg: **Draft National Resource Efficiency Policy 2019** encourages sustainable industrial practices.
6. **Redistribution of industrial growth**: Allocating industries to backward regions reduces regional imbalances while preserving fertile agricultural land.
    - Eg: **Chhattisgarh's industrial growth policy** focuses on using barren lands for industries.

Conclusion

Reimagining land use policy is essential to meet the modern challenges of **urbanization and industrialization** while ensuring sustainable and equitable growth. A robust framework

prioritizing **spatial planning, transparency**, and **sustainability** can drive India's development in harmony with social and environmental needs.

Effects of liberalization on the economy, changes in industrial policy and their effects on industrial growth.

Infrastructure: Energy, Ports, Roads, Airports, Railways etc.

Investment models.

Q. Discuss the challenges and opportunities associated with integrating private investment into India's port and maritime sector under public-private partnership (PPP) models. (10 M)

Introduction

India's strategic location and 7,500 km-long coastline provide immense potential for the port and maritime sector. However, integrating private investment through Public-Private Partnership (PPP) models faces both challenges and opportunities in modernizing the sector.

Body

Challenges of integrating private investment into India's port and maritime sector

1. **Policy and regulatory hurdles**: Conflicting regulations and lack of streamlined policies create uncertainty for investors.
    - Eg: **Mumbai Port Trust redevelopment** was delayed for three years due to conflicting Coastal Regulation Zone (CRZ) and Environmental Protection Act guidelines.
2. **Infrastructure bottlenecks**: Poor connectivity and inadequate last-mile infrastructure reduce operational efficiency.
    - Eg: **Paradip Port** faces logistical delays due to limited rail connectivity, increasing turnaround times for shipments.
3. **Revenue-sharing disputes**: Ambiguities in concession agreements lead to conflicts between the government and private investors.
    - Eg: The **Jawaharlal Nehru Port Trust (JNPT)** experienced delays in terminal expansion due to disagreements over revenue-sharing terms with private operators.
4. **Environmental clearances**: Lengthy and cumbersome processes discourage private participation.
    - Eg: **Vizhinjam Port Project** in Kerala was delayed for years due to protests and complex environmental clearance requirements.
5. **High financial risks**: Many smaller or underutilized ports fail to attract investments due to uncertain returns.

- Eg: **Dighi Port** in Maharashtra remained loss-making, discouraging further private investments in the region.

Opportunities of integrating private investment into India's port and maritime sector

1. **Enhanced operational efficiency**: Private players bring expertise, technology, and modern practices to improve port performance.
   - Eg: **Mundra Port**, operated by **Adani Ports**, became India's largest commercial port, reducing turnaround time significantly.
2. **Global trade competitiveness**: Upgraded ports attract international shipping lines, boosting trade.
   - Eg: The **Sagarmala Programme** projects logistics cost reduction by 30%, improving export competitiveness.
3. **Adoption of advanced technology**: Private partnerships introduce automation and digital solutions for efficient operations.
   - Eg: **Krishnapatnam Port** implemented AI-based cargo handling systems, improving throughput and reducing costs.
4. **Employment generation**: Large-scale projects create job opportunities directly and indirectly in allied sectors.
   - Eg: **Kakinada SEZ Port**, under PPP, is expected to generate 10,000 jobs by 2025 through expanded operations.
5. **Sustainability and green initiatives**: Private investment drives eco-friendly practices and renewable energy use in ports.
   - Eg: **Kamarajar Port** adopted solar power systems and implemented green port initiatives, reducing its carbon footprint.

Conclusion

By addressing policy bottlenecks, ensuring transparency in agreements, and leveraging private sector expertise, India can transform its port and maritime sector into a globally competitive hub, aligning with **blue economy goals** and **economic sustainability**.

Science and Technology- developments and their applications and effects in everyday life.

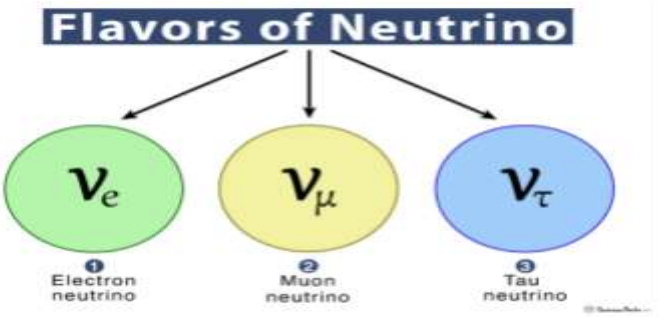
Q. "Neutrinos are often referred to as "ghost particles". Why are they significant in understanding the universe, and how is India contributing to their research? (10 M)

Introduction

Neutrinos, called "ghost particles" due to **their weak interaction with matter, are crucial to understanding cosmic mysteries like the Big Bang, dark matter, and astrophysical phenomen**a. Their elusive nature makes them both a challenge and an opportunity for research.

Body

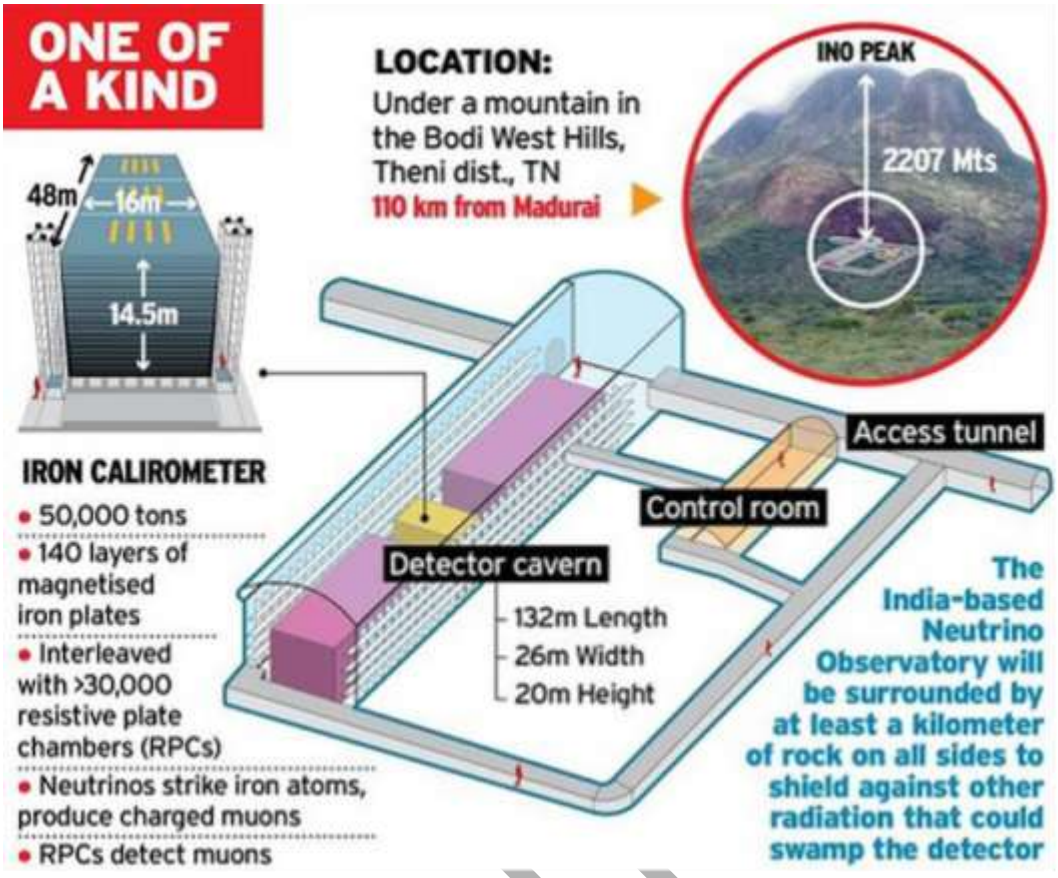
Significance of neutrinos in understanding the universe



Flavors of Neutrons

1. **Probing the early universe**: Neutrinos provide a window into the universe's conditions shortly after the Big Bang.
    - **Eg**: Neutrinos from the **SN1987A supernova** helped understand stellar explosions and neutron star formation.
2. **Understanding dark matter and energy**: Neutrinos play a critical role in studying the composition and expansion of the universe.
    - **Eg**: Research on **sterile neutrinos** explores their potential as candidates for dark matter, addressing 27% of the universe's mass-energy composition.
3. **Particle physics breakthroughs**: Observing neutrino oscillation—where neutrinos change types—reveals physics beyond the Standard Model.
    - **Eg**: The discovery of neutrino oscillation by **Takaaki Kajita and Arthur B. McDonald** earned the **2015 Nobel Prize in Physics**.
4. **Astrophysical insights**: High-energy neutrinos serve as cosmic messengers from extreme events like gamma-ray bursts and black holes.
    - **Eg**: The **IceCube Neutrino Observatory** traced neutrinos to a blazar 4 billion light-years away, identifying their origin.
5. **Earth's interior studies**: Geo-neutrinos reveal heat production from radioactive decay in the Earth's core, aiding geothermal research.
    - **Eg**: **KamLAND experiment in Japan** detected geo-neutrinos, advancing knowledge of Earth's energy dynamics.

India's contributions to neutrino research



INO Project Layout

1. **India-based Neutrino Observatory (INO):** INO will be among the world's largest underground labs to study atmospheric neutrinos.
    - **Eg**: INO's **50,000-ton Iron Calorimeter (ICAL)** in Tamil Nadu is designed to detect neutrino mass hierarchy and properties.
2. **Global collaborations**: Indian scientists contribute to international neutrino research projects, enhancing India's scientific reputation.
    - **Eg**: India's involvement in the **Super-Kamiokande experiment (Japan)** and CERN's **DUNE project** highlights its global role.
3. **Indigenous technology development**: India is advancing in detector development for neutrino experiments.
    - **Eg**: **Tata Institute of Fundamental Research (TIFR)** developed key components for INO's instrumentation, ensuring self-reliance.
4. **Scientific capacity building**: INO will foster cutting-edge research and train future scientists in particle physics.
    - **Eg**: The INO is projected to train over **500 researchers**, promoting innovation in neutrino science.
5. **Balancing development with environmental concerns**: India is addressing ecological concerns to ensure sustainable progress in neutrino research.

- **Eg**: INO faced delays due to **environmental clearance issues in Tamil Nadu**, underscoring the importance of sustainable practices.

Conclusion

Neutrinos unlock profound insights into the cosmos, offering answers to unsolved mysteries like dark matter and stellar evolution. India's efforts, led by the **India-based Neutrino Observatory (INO)** and global collaborations, position the nation as a key player in neutrino research, bridging the gap between scientific ambition and sustainability.

Q. Analyze the challenges posed by emerging zoonotic diseases to India's healthcare system. Suggest measures to strengthen the "One Health" approach in the country. (15 M)

Introduction

Emerging zoonotic diseases such as **Nipah, Zika, and COVID-19** underscore the interconnectedness of human, animal, and environmental health. India's dense population and extensive interaction with animals amplify the risks, challenging its healthcare infrastructure.

Body

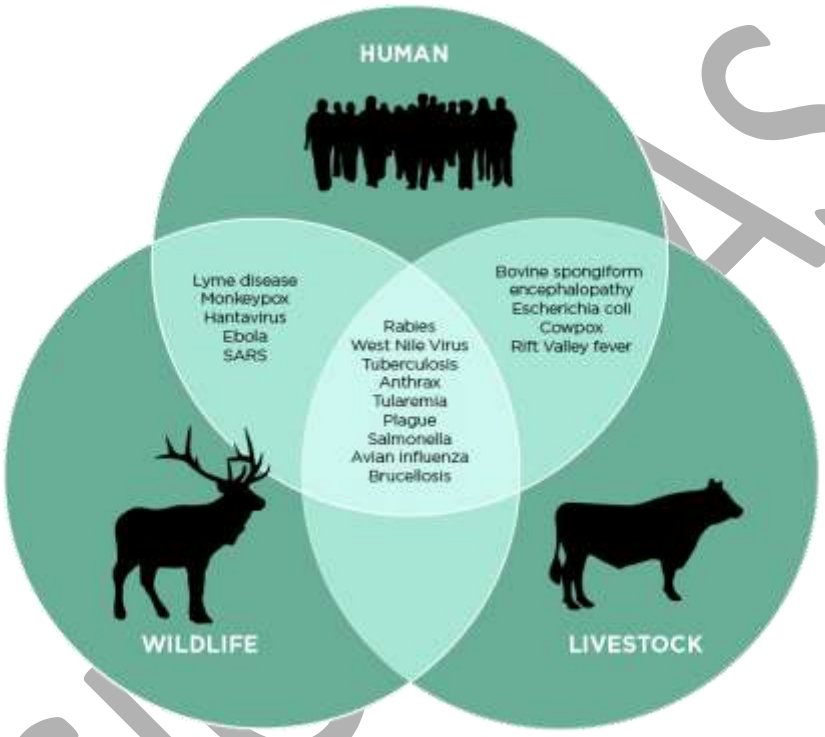
Challenges posed by emerging zoonotic diseases

1. **Inadequate surveillance systems**: Poor integration of animal and human health monitoring systems delays early detection and containment of outbreaks.
    - **Eg**: The **2018 Nipah outbreak in Kerala** exposed the lack of systematic monitoring of bats as disease reservoirs.
2. **Limited laboratory infrastructure**: Insufficient advanced diagnostic facilities delay identification and management of zoonotic pathogens.
    - **Eg**: Only a few labs like the **National Institute of Virology (NIV)** in Pune are equipped to handle high-risk pathogens like Nipah and SARS-CoV-2.
3. **Human-animal interaction in agriculture**: Extensive farming and wet markets heighten exposure to zoonotic pathogens.
    - **Eg**: **Unregulated wet markets in northeast India** serve as potential hotspots for disease spillovers.
4. **Weak inter-sectoral coordination**: Lack of collaboration between public health, veterinary, and environmental sectors hinders integrated responses.
    - **Eg**: **Livestock disease mismanagement in Bihar** contributed to outbreaks of Japanese Encephalitis in humans.
5. **Climate change and habitat destruction**: Deforestation and urbanization force wildlife into closer contact with human populations.
    - **Eg**: **Encroachments in Western Ghats** have increased human-wildlife interactions, heightening zoonotic risks.
6. **Underfunded public health system**: Resource constraints limit outbreak preparedness and response capacities.

- **Eg**: **India's health expenditure is only 1.28% of GDP (2023)**, far below the WHO-recommended 4-5%.

7. **Cultural practices and hygiene issues**: Traditional practices like open-air meat markets increase zoonotic risks.
    - **Eg**: The **unregulated poultry slaughter during avian flu outbreaks** exacerbates virus transmission risks.

Measures to strengthen the "One Health" approach



1. **Integrated surveillance systems**: Create a unified platform to monitor human, animal, and environmental health data.
    - **Eg**: Expand the **National Digital Health Mission** to include zoonotic disease surveillance under "One Health."
2. **Strengthening laboratory networks**: Establish more regional BSL-3 and BSL-4 labs to improve diagnostic capacity.
    - **Eg**: **Develop high-security labs** in **zoonotic hotspots like northeast India** to handle diseases like Japanese Encephalitis.
3. **Policy alignment and collaboration**: Formulate a **National One Health Framework** to coordinate policies across agriculture, health, and environment ministries.
    - **Eg**: Align with the **Standing Committee on Agriculture's 2021 recommendations** on inter-sectoral coordination.
4. **Capacity building and training**: Train veterinarians, public health officials, and environmental scientists in zoonotic disease management.

- **Eg**: **Conduct integrated workshops** under **ICMR-ICAR collaborations** for effective multi-sectoral responses.

5. **Promoting sustainable practices**: Encourage sustainable agriculture and restrict deforestation to minimize human-animal interaction.
    - **Eg**: Implement reforestation programs under **CAMPA (Compensatory Afforestation Management and Planning Authority)** to restore habitats.
6. **Community awareness programs**: Educate communities about zoonotic risks and preventive measures.
    - **Eg: Awareness campaigns in tribal areas** about **safe handling of bushmeat** to reduce spillover risks.
7. **Enhanced funding for health**: Increase public health investment to build robust infrastructure for zoonotic disease management.
    - **Eg**: **Align budget allocations** under the **Ayushman Bharat Digital Mission** to integrate zoonotic disease surveillance.
8. **Global partnerships and research**: Collaborate with international organizations like WHO, FAO, and OIE for capacity building and research.
    - **Eg**: **India's partnership with WHO's Global Virome Project** aids in identifying and mitigating emerging zoonotic threats.

Conclusion

Strengthening India's response to zoonotic diseases requires an integrated **One Health approach** that addresses gaps in surveillance, infrastructure, and inter-sectoral coordination. Investing in awareness, policy alignment, and global collaborations will enhance India's resilience to zoonotic outbreaks while ensuring sustainable health practices.

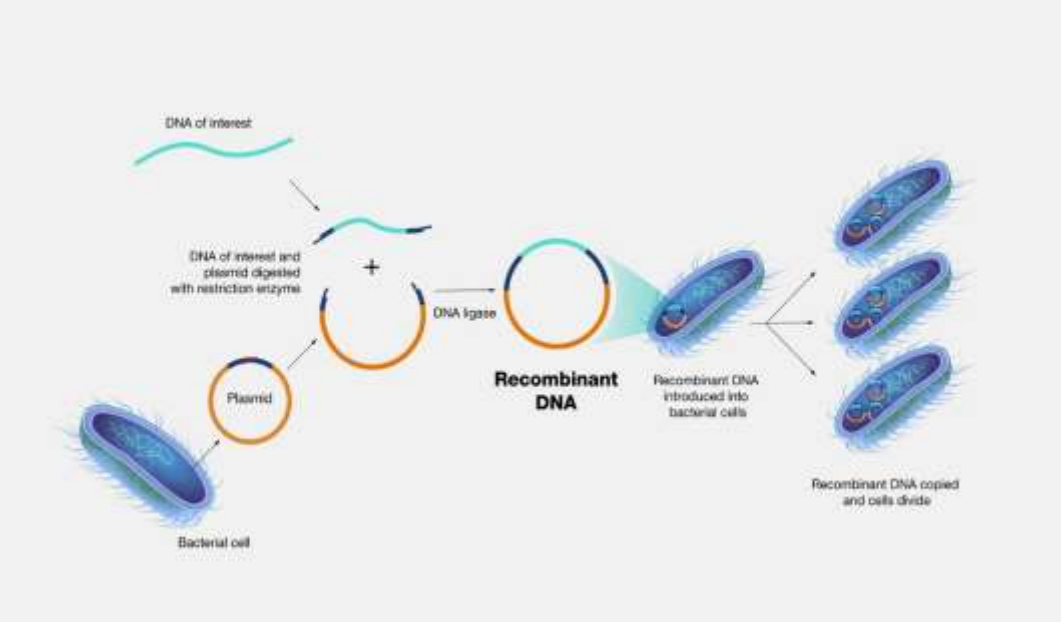
Q. "Recombinant DNA technology is pivotal in combating global health challenges". Examine its applications in vaccine development and genetic disorder treatment. (10 M)

Introduction

Recombinant DNA technology has emerged as a pivotal tool in modern biotechnology, enabling precise genetic modifications to address global health challenges such as infectious diseases and genetic disorders, significantly advancing medical science.

Body

About recombinant DNA technology



1. **Definition and principle**: It involves combining DNA from different sources to create new genetic combinations, enabling targeted solutions to health issues.
    - **Eg:** Production of **human insulin** using recombinant E. coli (first approved in 1982 by the FDA).
2. **Enabling genetic precision**: Allows for targeted modifications at the molecular level, offering high specificity and efficiency in therapeutic interventions.
    - **Eg:** Creation of **monoclonal antibodies** for diseases like rheumatoid arthritis and certain cancers.
3. **Significance in scalability**: Reduces dependency on animal models or traditional biological sources, making treatments more affordable and scalable.
    - **Eg:** Recombinant vaccines like **Gardasil** (HPV vaccine) have improved global vaccination programs.

Applications in vaccine development

1. **Subunit vaccines**: Recombinant DNA technology enables the production of vaccines using only specific antigens, reducing risks of adverse effects.
    - **Eg:** The **Hepatitis B vaccine**, developed using yeast cells, was among the first recombinant vaccines.
2. **Rapid pandemic response**: Accelerates vaccine development during emergencies by reducing production timelines.
    - **Eg:** The **Covovax vaccine** uses recombinant protein nanoparticles, approved for COVID-19 globally.
3. **Broad-spectrum vaccine production**: Allows for scalable production of vaccines for emerging pathogens.

    - **Eg:** Research on **Ebola virus vaccines** with recombinant vesicular stomatitis virus (rVSV).
4. **DNA and mRNA vaccines**: The technology underpins innovations in mRNA vaccines, allowing rapid production with adaptability to mutations.
    - **Eg: Pfizer-BioNTech** and **Moderna COVID-19 vaccines** are based on recombinant mRNA.
5. **Customizable solutions**: Enables precise antigen identification and vaccine tailoring for specific populations or pathogens.
    - **Eg:** Trials for **personalized cancer vaccines** using recombinant neoantigens.

Applications in genetic disorder treatment

1. **Gene therapy**: Provides tools to replace or repair defective genes in patients with genetic disorders.
    - **Eg: Zolgensma**, a recombinant AAV-based therapy, treats **spinal muscular atrophy**, approved in 2019.
2. **Enzyme replacement therapy (ERT)**: Facilitates the production of specific enzymes for metabolic disorders.
    - **Eg: Recombinant Gaucher enzyme (imiglucerase**) treats **Gaucher's disease**.
3. **Production of therapeutic proteins**: Enables mass production of proteins that replace missing or defective ones.
    - **Eg: Recombinant clotting factor VIII** for **hemophilia A** patients.
4. **Stem cell engineering**: Improves genetic modifications in stem cells to correct hereditary diseases.
    - **Eg:** CRISPR-engineered stem cells used in **beta-thalassemia trials** (ongoing in the US and Europe, 2023).
5. **Targeted therapies for rare diseases**: Development of treatments for orphan genetic diseases that lacked cures.
    - **Eg: Recombinant treatment** for **cystic fibrosis** using CFTR-modifying drugs.
6. **Somatic cell gene editing**: Modifies genes in specific tissues, reducing systemic risks.
    - **Eg: CRISPR-based gene therapy** for **sickle cell anemia** showing promising results in 2023.

Conclusion

Recombinant DNA technology has proven instrumental in addressing some of the most pressing global health challenges, from rapid vaccine development to curing genetic disorders. As tools like **CRISPR-Cas9** and **synthetic biology** evolve, its potential to transform healthcare solutions and make them more accessible will only expand, paving the way for a healthier and more equitable future.

Q. "The discovery of graphene has been a game-changer in material science". Analyze the unique properties of graphene and discuss its potential applications in developing sustainable technologies. (15 M)

Introduction

The discovery of **graphene** in 2004 by Andre Geim and Konstantin Novoselov, which earned them the **Nobel Prize in Physics in 2010**, revolutionized material science. Its unique combination of exceptional strength, conductivity, and flexibility has opened new frontiers in technology, enabling innovative solutions to global challenges.

Body

Graphene as a game-changer in material science

1. **Revolutionary physical properties**: Graphene is **200 times stronger than steel** but incredibly lightweight, making it ideal for various applications.
    - **Eg:** Used in **aerospace components**, reducing aircraft weight and improving fuel efficiency, a major step toward sustainable aviation.
2. **Unmatched electrical conductivity**: With an electron mobility 10 times that of silicon, graphene has become a cornerstone for advanced electronics.
    - **Eg:** Used in **high-speed processors** for quantum computing and AI systems.
3. **Exceptional thermal properties**: Graphene can conduct heat at rates up to **5000 W/m·K**, far surpassing copper.
    - **Eg:** Used in **heat management systems** for 5G and electric vehicles, ensuring optimal performance.
4. **Two-dimensional structure**: Graphene is just one atom thick, making it both lightweight and flexible, with applications in wearable technology.
    - **Eg:** Flexible **graphene-based touchscreens** for foldable smartphones and fitness wearables.
5. **Broad applicability**: Its ability to integrate seamlessly across various technologies has made it indispensable for modern innovation.
    - **Eg:** Used in **photonic devices**, biosensors, and energy storage solutions.

Unique properties of graphene

1. **High mechanical strength**: Graphene's tensile strength exceeds **130 GPa**, making it stronger than steel while maintaining flexibility.
    - **Eg:** Utilized in **bulletproof vests** and protective gear, offering lightweight and robust safety solutions.
2. **Superior electrical conductivity**: Graphene's zero bandgap and high electron mobility make it ideal for next-gen electronic circuits.
    - **Eg:** Enables **ultra-fast transistors** that operate at GHz frequencies, crucial for 6G communications.

3. **Optical transparency**: It allows **97.7% of light to pass through**, enabling its use in optical and photovoltaic devices.
    - **Eg: Graphene transparent conductive films** are replacing indium tin oxide in solar cells, boosting efficiency and durability.
4. **Impermeability to gases**: Graphene forms a perfect barrier, blocking even the smallest helium atoms.
    - **Eg:** Used in **graphene membranes** for industrial gas separation and water purification.
5. **Exceptional thermal properties**: It prevents overheating in compact electronic systems due to its superior heat conduction.
    - **Eg: Graphene-cooled batteries** in electric vehicles extend battery life and efficiency.
6. **Surface reactivity**: Despite being chemically stable, graphene's surface can be modified for specific applications.
    - **Eg:** Used in **targeted drug delivery systems**, where drugs are bound to graphene oxide for precise release.

Potential applications in developing sustainable technologies

1. **Clean energy storage and generation**:
    - **Eg: Graphene-based supercapacitors** offer quick charge-discharge cycles and high energy density, aiding in renewable energy storage for solar and wind power grids.
2. **Water purification and desalination**:
    - **Eg: Graphene oxide membranes** are being tested by MIT (2021) for low-cost desalination, addressing the global freshwater crisis.
3. **Sustainable transportation**: Graphene composites reduce vehicle weight, enhancing fuel efficiency and reducing carbon emissions.
    - **Eg: Graphene-enhanced EV batteries** increase range and durability, used by companies like Tesla and Tata Motors.
4. **Agricultural innovation**: Enhances soil health and precision farming through nanofertilizers and pest control systems.
    - **Eg:** Trials in **India's Green Revolution 2.0 initiatives** use graphene-based pesticides for eco-friendly farming.
5. **Waste recycling and management**: Plastic waste can be converted into graphene using pyrolysis.
    - **Eg:** Indian startups like **Log9 Materials** are exploring this process to address plastic pollution.
6. **Air quality improvement**: Adsorption of greenhouse gases like CO_2 to combat climate change.
    - **Eg: Graphene aerogels** used in carbon capture pilot projects in the UK.
7. **Renewable construction materials**: Enhances strength and reduces cement use, lowering the carbon footprint of buildings.

- **Eg: Graphene-enhanced cement** by Nationwide Engineering in the UK reduces emissions by up to 30%.

8. **Low-energy electronics**: Graphene-based circuits require less energy, paving the way for sustainable electronics.
    - **Eg:** Used in **low-power IoT devices**, promoting energy efficiency in smart cities.

Conclusion

Graphene, with its transformative properties and vast applications, stands as a beacon of hope for addressing sustainability challenges. With nations investing in **material science R&D**, including India's **National Mission on Nanotechnology**, graphene could drive innovations across sectors, heralding a future that is both technologically advanced and environmentally sustainable.

Achievements of Indians in science & technology; indigenization of technology and developing new technology.

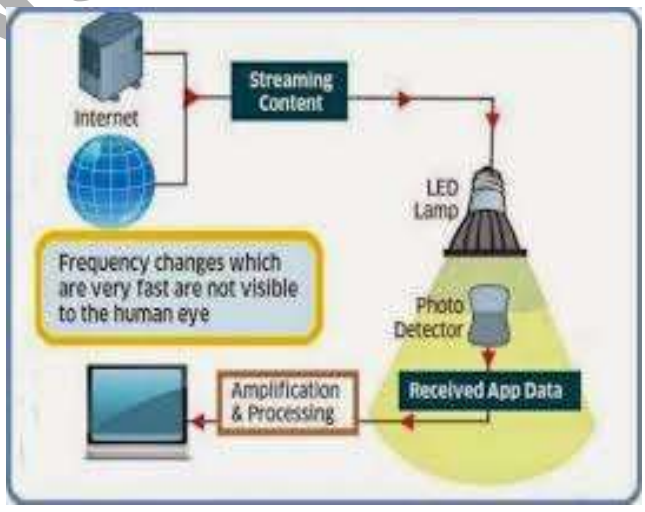
Q. Explain the working principles of Li-Fi technology and its potential applications in high-security environments such as defence and healthcare. (10 M)

Introduction

Li-Fi (Light Fidelity) technology uses **visible light communication (VLC)** for ultra-fast, interference-free, and secure data transmission, offering transformative potential in high-security sectors like defence and healthcare.

Body

Working principles of Li-Fi technology



1. **Use of light waves**: Li-Fi transmits data using visible light emitted from LED bulbs, modulating light intensity at high speeds.
    - Eg: **LED bulbs modulate light signals, enabling data transmission up to 100 times faster than Wi-Fi** (Source: **Harald Haas' Li-Fi research, University of Edinburgh**).
2. **Photodetector reception**: The modulated light signals are captured by a photodetector and converted into digital data.
    - Eg: **Photoelectric sensors decode signals, enabling real-time transmission in secure environments.**
3. **GPS augmentation**: Li-Fi complements GPS for navigation in enclosed or signal-restricted areas, like tunnels or bunkers.
    - Eg: **Military bases and submarines** can use Li-Fi for local navigation where GPS signals are weak (Source: **Defence Technology Research, 2023**).
4. **Bidirectional communication**: LEDs equipped with data transmission and reception capabilities allow simultaneous data transfer.
    - Eg: **Li-Fi prototypes showcased at CES 2022** demonstrated two-way data flow, improving speed and reliability in communication systems.
5. **Line-of-sight dependency**: Li-Fi's reliance on direct light paths ensures minimal interference, enhancing data security.
    - Eg: **This characteristic makes it suitable for secure hospital rooms and military zones.**

Applications in high-security environments

Defence

1. **Secure military communication**: Light-based transmission restricts data to physical spaces, reducing interception risks.
    - Eg: **Naval command rooms on INS Vikramaditya** tested Li-Fi for secure inter-departmental communication (Source: **DRDO pilot, 2022**).
2. **GPS-independent navigation**: Li-Fi augments GPS, enabling navigation in signal-blocked environments.
    - Eg: **Li-Fi trials in submarines like INS Kalvari** showed enhanced underwater communication (Source: **DRDO, 2021**).
3. **Underwater data transfer**: Li-Fi ensures communication for underwater drones and naval units.
    - Eg: **US Navy experiments with underwater drones using Li-Fi** highlight its potential for seamless operations (Source: **Naval Research Laboratory, 2022**).

Healthcare

1. **Interference-free medical devices**: Li-Fi avoids RF interference, ensuring uninterrupted device operation.

- Eg: **AIIMS Delhi is experimenting with Li-Fi for ICUs and critical care units** (Source: **AIIMS Report, 2023**).

2. **Real-time data sharing**: Li-Fi supports rapid transfer of large files like MRI and CT scans, improving diagnostics.
    - Eg: **Apollo Hospitals trialed Li-Fi systems** to accelerate cross-departmental data transmission (Source: **Hospital Research Journal, 2023**).
3. **Enhanced data privacy**: Li-Fi's confined light-based communication protects patient data from unauthorized access.
    - Eg: **Li-Fi-equipped smart wards in Medanta Hospital, Gurugram** improved data security and real-time communication (Source: **Medanta Internal Report, 2022**).

Conclusion

Li-Fi technology promises **secure, high-speed communication** in critical sectors like defence and healthcare, addressing current gaps in wireless systems. By scaling infrastructure and reducing costs, Li-Fi can complement existing systems to create a more robust and secure communication network.

Q. The deployment of artificial satellites has increased manifold, leading to concerns regarding space debris management". Evaluate India's preparedness in tackling this emerging challenge. (10 M)

Introduction

The surge in satellite launches, **propelled by advancements in space technology and increased private sector participation, has intensified concerns over space debris**, posing significant risks to operational spacecraft and the sustainability of outer space.

Body

Deployment of artificial satellites and concerns about space debris

1. **Proliferation of satellite launches:** The advent of cost-effective launch technologies and miniaturization has led to a substantial increase in satellite deployments.
    - **Eg:** India's **PSLV-C56 mission** (2023) successfully placed multiple satellites into orbit.
2. **Accumulation of defunct objects:** Non-functional satellites and spent rocket stages contribute to the growing space debris problem.
    - **Eg:** The **European Space Agency (ESA)** estimates over 36,500 objects larger than 10 cm are currently in orbit.
3. **Collision hazards:** The dense orbital environment heightens the risk of collisions, potentially creating more debris.
    - **Eg:** The **2009 collision** between Iridium 33 and Cosmos 2251 satellites resulted in significant debris.

4. **Operational challenges:** Space debris threatens the safety and longevity of active satellites, affecting services like communication and navigation.
    - **Eg:** ISRO conducts regular collision avoidance maneuvers for its satellites.
5. **Environmental and safety risks:** Uncontrolled re-entry of debris poses hazards to both space operations and terrestrial life.
    - **Eg:** Debris from China's **Long March 5B** rocket re-entered Earth's atmosphere unpredictably in 2020.

India's preparedness in tackling space debris

Positives	Challenges
1. Project NETRA: ISRO's **Network for Space Object Tracking and Analysis (NETRA)** aims to enhance space situational awareness by tracking debris and safeguarding Indian satellites.	**1. Pending legislation:** The **Space Activities Bill**, intended to regulate space activities and ensure compliance with international standards, is still under consideration and has not been enacted.
2. IS4OM initiative: The **ISRO System for Safe and Sustainable Space Operations Management (IS4OM)** focuses on spaceflight safety and debris mitigation, consolidating efforts to manage space congestion.	**2. Limited active debris removal capabilities:** India currently lacks indigenous technologies for active debris removal, relying primarily on tracking and avoidance measures.
3. International collaborations: India has engaged in agreements for space situational awareness data sharing, enhancing global cooperation in debris management.	**3. Resource constraints:** Allocating sufficient funding and resources for comprehensive space debris mitigation remains a challenge.
4. Adherence to international guidelines: ISRO follows the **Inter-Agency Space Debris Coordination Committee (IADC)** guidelines for debris mitigation in its missions.	**4. Growing private sector participation:** The increasing involvement of private entities in satellite launches necessitates robust regulatory frameworks to manage potential debris generation.
5. Development of collision avoidance protocols: ISRO has established standard operating procedures for collision avoidance, ensuring timely maneuvers to protect assets.	**5. Public awareness and policy advocacy:** There is a need for greater public awareness and policy advocacy regarding space debris issues to foster a culture of responsibility among stakeholders.

Conclusion

While India has initiated significant measures like **Project NETRA** and **IS4OM** to address space debris challenges, the enactment of comprehensive legislation such as the **Space**

Activities Bill and the development of active debris removal technologies are imperative to enhance preparedness and ensure the long-term sustainability of space operations.

Q. "The integration of smart grids and renewable energy sources is crucial for India's energy transition". Examine the challenges in implementing smart grids in India and suggest policy measures to overcome them. (15 M)

Introduction

India's ambitious renewable energy targets and commitment to **net-zero emissions by 2070** necessitate the integration of **smart grids**, which can enhance efficiency, reliability, and sustainability in power distribution.

Body

Importance of integrating smart grids and renewable energy for India's energy transition

1. **Enhanced grid reliability:** Smart grids can manage the variability of renewable energy, ensuring a stable power supply.
    - **Eg:** India's **Green Energy Corridor Project** aims to strengthen grid stability.
2. **Reduction in transmission and distribution losses:** Automation and real-time monitoring reduce technical and commercial losses.
    - **Eg:** India's aggregate technical and commercial (AT&C) losses stand at **17% (CEA, 2023).**
3. **Decentralized energy generation:** Facilitates distributed renewable energy sources like rooftop solar and microgrids.
    - **Eg: KUSUM scheme** supports decentralized solar energy production for farmers.
4. **Peak load management:** Smart grids optimize demand-side management, reducing stress on the grid.
    - **Eg: Time-of-Day (ToD) tariffs** encourage off-peak power usage.
5. **Climate resilience:** Helps in adapting to climate change impacts by ensuring energy efficiency and reducing fossil fuel dependence.
    - **Eg:** India's commitment to reducing carbon intensity by **45% by 2030 (UNFCCC, 2022).**

Challenges in implementing smart grids in India

1. **High capital investment:** Deployment of advanced grid infrastructure requires substantial funding.
    - **Eg:** India requires **$30 billion** for smart grid infrastructure by 2030 (IEA, 2022).
2. **Outdated infrastructure:** Existing power transmission systems are not compatible with modern smart grid technologies.

- **Eg:** India's aging grid infrastructure leads to frequent power outages.

3. **Cybersecurity threats:** Increased digitization poses risks of cyberattacks and data breaches.
    - **Eg:** The **CERT-In 2023 report** highlighted vulnerabilities in India's energy sector.
4. **Regulatory inconsistencies:** Different state-level policies and lack of a unified framework create implementation hurdles.
    - **Eg:** States have varying policies on smart meter rollouts and grid modernization.
5. **Limited consumer awareness:** Resistance to smart meters and ToD tariffs due to lack of understanding and trust.
    - **Eg:** Low adoption rates of smart meters under the **Smart Meter National Programme (SMNP).**

Policy measures to overcome challenges

1. **Financial support and incentives:** Providing subsidies, low-interest loans, and PPP models to boost smart grid investments.
    - **Eg: Revamped Distribution Sector Scheme (RDSS)** with ₹3 lakh crore allocation for grid modernization.
2. **Standardized regulatory framework:** Establishing a national policy for uniform implementation of smart grids across states.
    - **Eg:** NITI Aayog's **National Energy Policy** recommends uniform grid regulations.
3. **Capacity building and skill development:** Training programs for workforce development in smart grid technology.
    - **Eg:** Initiatives like **Skill India Mission** to train personnel in energy management systems.
4. **Strengthening cybersecurity:** Implementing robust cybersecurity protocols and regular audits to prevent cyber threats.
    - **Eg:** National Critical Information Infrastructure Protection Centre (NCIIPC) guidelines for power sector.
5. **Consumer awareness programs:** Nationwide campaigns to educate consumers on the benefits of smart grids and dynamic pricing models.
    - **Eg: Ujjwal DISCOM Assurance Yojana (UDAY)** includes consumer engagement initiatives.

Conclusion

Smart grids are pivotal for India's energy transition**, but their successful implementation requires a multi-pronged approach involving financial, regulatory, and technological interventions** to ensure a sustainable and resilient energy future.

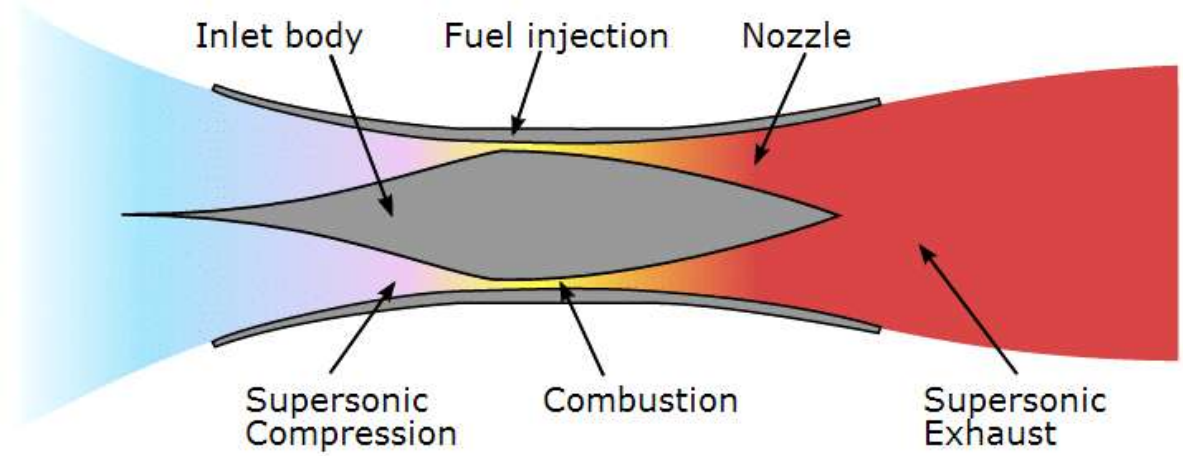
Q. What are scramjet engines, and how do they contribute to the development of hypersonic technology? Discuss their significance for India's defence capabilities. (10 M)

Introduction

Scramjet (Supersonic Combustion Ramjet) engines are an advanced propulsion technology that enables air-breathing hypersonic flight, crucial for enhancing **military strike capabilities** and **space exploration.** Their development is a significant step in India's pursuit of **self-reliance in cutting-edge defense technologies.**

Body

What Are Scramjet Engines?



The principle of operation of a scramjet engine

1. **Definition and working principle:** Scramjets are air-breathing engines that compress incoming air at supersonic speeds and achieve combustion without slowing down the airflow.
    - Eg: Unlike traditional ramjets, scramjets operate efficiently beyond **Mach 5**, making them ideal for **hypersonic applications.**
2. **No moving parts:** Scramjets operate without rotating components like compressors and turbines, relying solely on air compression via high-speed intake.
    - Eg: This design improves **reliability** and reduces **mechanical complexity** compared to conventional jet engines.
3. **Dependence on atmospheric oxygen:** Scramjets eliminate the need for onboard oxidizers, reducing weight and improving fuel efficiency.
    - Eg: This allows for a **higher payload-to-weight ratio** in military and aerospace applications.

4. **Challenges in ignition and flame stability:** Achieving sustained combustion in supersonic airflow requires precise control of fuel injection and flame stabilization techniques.
    - Eg: DRDO developed **innovative flame stabilization techniques** for continuous combustion at airspeeds exceeding **1.5 km/s.**
5. **Applications of scramjets:** Scramjets have potential applications in **hypersonic missiles, space launch systems, and rapid global transportation.**
    - Eg: The technology is integral to the development of India's **Hypersonic Technology Demonstrator Vehicle (HSTDV).**

Scramjet Engines and Their Role in Hypersonic Technology

1. **Achieving hypersonic speeds:** Scramjets enable sustained flight at speeds greater than **Mach 5,** significantly reducing travel time and increasing strike capabilities.
    - Eg: Hypersonic weapons using scramjets can travel at speeds exceeding **5,400 km/hr,** making them highly effective for **strategic deterrence.**
2. **Improved fuel efficiency:** The air-breathing nature of scramjets reduces the need for carrying oxidizers, allowing for extended operational ranges.
    - Eg: Indigenous development of **endothermic scramjet fuel** by DRDO offers better **ignition properties and cooling effects.**
3. **Enhanced maneuverability:** Hypersonic vehicles equipped with scramjets can perform **evasive maneuvers** at high speeds, making interception difficult.
    - Eg: Hypersonic cruise missiles with scramjets can evade existing **missile defence systems.**
4. **Thermal management solutions:** The extreme heat generated at hypersonic speeds is managed using advanced materials and cooling techniques.
    - Eg: Development of **thermal barrier coatings (TBCs)** by DRDO allows scramjet engines to withstand temperatures beyond the **melting point of steel.**
5. **Potential for reusability:** Scramjet-powered systems can be used multiple times, reducing costs for both defence and space applications.
    - Eg: Future Indian space missions aim to incorporate scramjet technology for **low-cost satellite deployment.**

Significance for India's Defence Capabilities

1. **Strategic deterrence enhancement:** Hypersonic missiles powered by scramjets provide India with **rapid response capabilities** against emerging threats.
    - Eg: Integration of hypersonic missiles with scramjets into **India's nuclear triad** enhances **second-strike capability.**
2. **Self-reliance in defense technology:** Developing indigenous scramjet technology aligns with **Atmanirbhar Bharat,** reducing dependency on foreign defense imports.
    - Eg: DRDO's success in developing scramjets positions India alongside nations like **the US, Russia, and China** in hypersonic capabilities.

3. **Asymmetric warfare advantage:** Hypersonic weapons can penetrate modern air defense systems, offering India a significant **tactical edge.**
    - Eg: Hypersonic cruise missiles can be a countermeasure to **China's growing military capabilities** in the Indian Ocean region.
4. **Boost to aerospace industry:** Successful development of scramjet technology can lead to spin-off benefits in **space exploration and commercial aviation.**
    - Eg: Collaboration between **DRDO and ISRO** could accelerate low-cost access to space using scramjet-powered vehicles.
5. **Deterrence against regional adversaries:** Hypersonic missiles can serve as a credible deterrent against **conventional and nuclear threats** from neighboring countries.
    - Eg: Hypersonic platforms could provide India with the capability to conduct **precision strikes deep inside enemy territory.**

Conclusion

Scramjet technology represents a paradigm shift in **India's defense and aerospace sectors,** enhancing strategic deterrence and self-reliance. Moving forward, increased investments in **R&D, collaborations with private industry,** and international partnerships will be crucial in achieving full operational capability.

Q. Critically analyze the feasibility of India developing its own Large Language Model (LLM) in the backdrop of global competition and economic constraints. What should be India's strategic focus in AI development? (15 M)

Introduction

India's ambition to develop an indigenous **Large Language Model (LLM)** is driven by the need for technological self-reliance and addressing unique socio-linguistic challenges. However, it faces several constraints in terms of infrastructure, investment, and competition from global tech giants.

Body

Feasibility of India developing its own LLM

1. **High financial investment:** Developing an LLM requires substantial capital for computing infrastructure and R&D.
    - **Eg:** The US-based Stargate Project has planned a **$500 billion investment**, while India's AI mission is allocated ₹13,370 crore (Source: MeitY, 2024).
2. **Hardware dependency:** India relies on foreign semiconductor firms for high-performance GPUs, with recent **US export restrictions** posing a challenge.
    - **Eg:** The **Biden administration's AI hardware export policy** limits GPU procurement for India (Source: US Department of Commerce, 2024).

3. **Data availability and quality:** India's diverse languages and dialects require extensive data curation, which is scattered and non-uniform.
    - **Eg:** India has **22 scheduled languages and over 19,500 dialects**, making data collection complex (Source: Census 2011).
4. **Talent and expertise gaps:** While India has a large IT workforce, specialized AI research and development expertise is still limited.
    - **Eg:** India ranks **8th globally** in AI skill availability, far behind China and the US (Source: Global AI Index, 2024).
5. **Scalability challenges:** LLMs demand vast computing resources and energy consumption, posing challenges for sustainability and scaling.
    - **Eg:** Training a model like GPT-4 requires **megawatts of power**, which may stress India's energy infrastructure.

Positive aspects supporting feasibility of India developing its own LLM

1. **Strong IT and AI ecosystem:** India has a robust tech industry with companies capable of contributing to AI model development.
    - **Eg:** Firms like **TCS, Infosys, and Wipro** are investing in AI capabilities and cloud computing infrastructure.
2. **Government initiatives:** Policy support and financial investment through schemes like the **IndiaAI Mission** provide a strong foundation.
    - **Eg: The government has earmarked ₹13,370 crore** to support AI data centers and infrastructure (Source: MeitY, 2024).
3. **Indigenous language diversity:** Developing an India-centric LLM can cater to regional needs, providing a competitive edge in the vernacular market.
    - **Eg:** Platforms like **Bhashini AI** are already working on digitizing Indian languages to bridge the linguistic gap.
4. **Growing startup ecosystem:** India has a thriving AI startup landscape that can collaborate on specialized applications.
    - **Eg:** Startups like **Karya AI and Sarvam AI** are leveraging AI to solve localized challenges.
5. **Cost-effective talent pool:** Despite gaps, India's AI workforce offers cost advantages compared to Western markets.
    - **Eg:** India's AI talent costs are **50% lower** than those in the US and Europe, making large-scale development economically viable.
6. **Geopolitical collaborations:** India's participation in multilateral tech partnerships provides access to resources and expertise.
    - **Eg:** Partnerships under the **Quad AI Initiative** can provide technological cooperation with countries like the US and Japan.

India's strategic focus in AI development

1. **Leveraging open-source models:** India should build upon existing LLMs like **DeepSeek** and fine-tune them for local applications to reduce development costs.

    - **Eg:** Customizing open-source models for healthcare and education in vernacular languages.
2. **Developing domain-specific AI models:** Focus should be on AI applications in critical sectors such as healthcare, agriculture, and governance.
    - **Eg:** AI-based solutions for smart farming under **Digital India Initiatives.**
3. **Public-private collaboration:** Encouraging joint efforts between the government, academia, and industry to scale AI innovation.
    - **Eg:** Collaboration between **IITs and AI companies** to build sector-specific AI tools.
4. **Infrastructure investment:** Strengthening domestic **semiconductor and cloud computing capabilities** to support large-scale AI training.
    - **Eg:** The government's **Semicon India Program** aims to boost chip manufacturing.
5. **Skill development programs:** Upskilling the workforce through AI-specific training initiatives to close the expertise gap.
    - **Eg:** The **FutureSkills PRIME initiative** targets AI upskilling for professionals.
6. **Ensuring ethical AI development:** Establishing a regulatory framework to ensure transparency, accountability, and data privacy in AI use.
    - **Eg:** The proposed **National AI Policy 2024** will regulate AI adoption across sectors.

Conclusion

India should pursue a **hybrid approach**, focusing on leveraging open-source AI models while developing indigenous solutions tailored to its unique socio-economic landscape. With strategic investment and collaboration, India can position itself as a global leader in AI for emerging economies.

Q. Discuss the significance of the Draft Legal Metrology (Indian Standard Time) Rules, 2025 in ensuring uniformity and precision in timekeeping across India and its impact on critical sectors. (10 M)

Introduction

Accurate and uniform timekeeping is crucial for national security, economic efficiency, and technological development. The **Draft Legal Metrology (Indian Standard Time) Rules, 2025**, aim to synchronize time across India with microsecond-level accuracy to enhance operational efficiency across various sectors.

Body

Significance of the draft rules in ensuring uniformity and precision in timekeeping

1. **National synchronization**: Ensuring all sectors follow a single time standard for seamless coordination and governance.
    - **Eg:** Adoption of **IST-based timestamps** in government records to prevent discrepancies in legal documentation.
2. **Technological precision**: Enhancing the accuracy of time-sensitive operations in telecommunications and financial transactions.
    - **Eg: 5G network rollout** requires synchronized time for latency-free operations and uninterrupted connectivity (Source: DoT, 2024).
3. **Regulatory compliance**: Mandating a legal framework for IST adherence across sectors, ensuring standardization and accountability.
    - **Eg:** Compliance audits conducted under the **Legal Metrology Act, 2009**, to monitor synchronization adherence.
4. **Cybersecurity enhancement**: Strengthening national cybersecurity by reducing reliance on foreign time sources and mitigating cyber threats.
    - **Eg:** Adoption of **Precision Time Protocol (PTP)** to counter cybersecurity vulnerabilities in critical infrastructure like power grids.
5. **Operational efficiency**: Synchronization improves operational efficiency across transportation, logistics, and emergency response systems.
    - **Eg:** Indian Railways implementing **real-time train tracking** to improve scheduling accuracy.
6. **Judicial and administrative efficiency**: Uniform time helps in maintaining precise legal records and avoiding disputes in courts and administrative processes.
    - **Eg:** Courts and police records will have a **common time stamp** to ensure accuracy in crime investigations.

Impact on critical sectors

1. **Banking and financial services**: Ensuring accurate timestamps for seamless financial transactions and fraud prevention.
    - **Eg: Stock market operations** (NSE, BSE) rely on accurate time synchronization for trading integrity.
2. **Telecommunications**: Providing precise time references to enable seamless data transfer and network efficiency.
    - **Eg:** Telecom operators mandated to follow **IST-based synchronization** to avoid call drop issues.
3. **Power grid management**: Enabling efficient power distribution and reducing grid failures by ensuring real-time synchronization.
    - **Eg: Power Grid Corporation of India** implementing synchronized monitoring to avoid cascading failures.
4. **Scientific and research applications**: Enhancing precision in astronomical studies and deep-space navigation.
    - **Eg: ISRO's Chandrayaan missions** require precise IST synchronization for trajectory calculations.

5. **Public transport and logistics**: Improving scheduling accuracy and passenger convenience in road, rail, and air transportation.
    - **Eg:** Airports Authority of India (AAI) uses **IST-based scheduling** to manage air traffic efficiently.
6. **Digital governance**: Ensuring accurate timestamps in e-governance services for better public service delivery.
    - **Eg: Aadhaar authentication systems** depend on synchronized timestamps to prevent identity fraud.

Conclusion

The Draft Legal Metrology (Indian Standard Time) Rules, 2025, will enhance India's technological and economic landscape by ensuring **precision, uniformity, and security** across sectors. Their effective implementation will foster **global competitiveness and national resilience** in the digital era.

Q. Discuss the significance of India's decision to develop a domestic Large Language Model (LLM) under the India AI Mission. How can this initiative impact technological sovereignty and digital economy? (10 M)

Introduction:

India's decision to develop a domestic **Large Language Model (LLM)** under the **₹10,370 crore IndiaAI Mission** is a landmark step toward **technological self-reliance**. It aims to **reduce dependence on foreign AI**, enhance data sovereignty, and make AI inclusive for India's diverse languages.

Body

Significance of India's decision to develop a domestic LLM

1. **Data Sovereignty and Security:** Prevents sensitive national data from being processed by foreign AI models.
    - **Eg: EU AI Act (2024)** mandates strict data governance to protect national interests.
2. **Linguistic and Cultural Representation:** Addresses the needs of **22 official languages** and multiple dialects.
    - **Eg:** Existing LLMs **lack regional language capabilities**, limiting digital inclusion for rural users.
3. **Reduced Dependence on Foreign AI:** Minimizes risks associated with **monopoly of Western AI firms (OpenAI, Google, etc.)**.
    - **Eg: China's DeepSeek R1** launched a low-cost AI model to compete globally.
4. **Strategic Autonomy in Critical AI Tech:** Reduces external control over **defense, governance, and financial sectors**.

- **Eg: US restrictions on China's AI chip access (2023)** highlight risks of dependency.

5. **Lower Cost and Higher Accessibility:** Provides subsidized AI compute power to Indian startups and researchers.
    - **Eg: ₹115.85/hour GPU cost** post-subsidy, while **global rates exceed $3/hour**.

Impact on Technological Sovereignty

1. **Control Over AI Ethics and Regulations:** Aligns AI with **Indian constitutional values** and **judicial rulings on privacy**.
    - **Eg: Justice K.S. Puttaswamy Case (2017)** upheld the **Right to Privacy**, making data localization crucial.
2. **Indigenous AI Development Ecosystem:** Encourages **IITs, IIITs, and startups** to build AI solutions **suited for India**.
    - **Eg:** Government's partnership with **10 firms** to develop **18,693 GPUs** for AI.
3. **Support for India's Digital Infrastructure:** Enhances AI-driven governance under **Digital India** and **Aatmanirbhar Bharat**.
    - **Eg:** AI models aiding **real-time monitoring of government schemes**.
4. **Preventing Bias in AI Models:** Ensures AI aligns with India's **social, economic, and legal frameworks**.
    - **Eg:** Foreign AI models often exhibit **Western bias**, making them less effective for **Indian legal and policy contexts**.

Impact on Digital Economy

1. **Boost to AI Startups and Enterprises:** Reduces **entry barriers for AI innovation** by providing **subsidized compute power**.
    - **Eg: NASSCOM estimates AI will contribute $500 billion** to India's GDP by **2025**.
2. **Enhancing AI in Key Sectors:** Drives **agriculture, healthcare, education, and fintech** growth.
    - **Eg: AI-driven weather predictions** for farmers to improve crop yield.
3. **Job Creation and Skill Development:** Increases demand for **AI engineers, data scientists, and policy analysts**.
    - **Eg: AI for All Initiative (2021)** aims to train **1 million+ Indians** in AI skills.
4. **Global Competitiveness in AI:** Positions India as a **leading AI power** competing with **China and the US**.
    - **Eg: India aims to rival ChatGPT, DeepSeek R1, and Google Gemini** with its indigenous model.

Conclusion

India's **domestic LLM initiative** will shape its **AI sovereignty**, making **AI more affordable, accessible, and locally relevant**. With **strong policy support, indigenous innovation, and strategic investments**, India is set to become a **global AI powerhouse**, driving economic and technological growth.

Awareness in the fields of IT, Space, Computers, robotics, Nano-technology, bio-technology and issues relating to intellectual property rights.

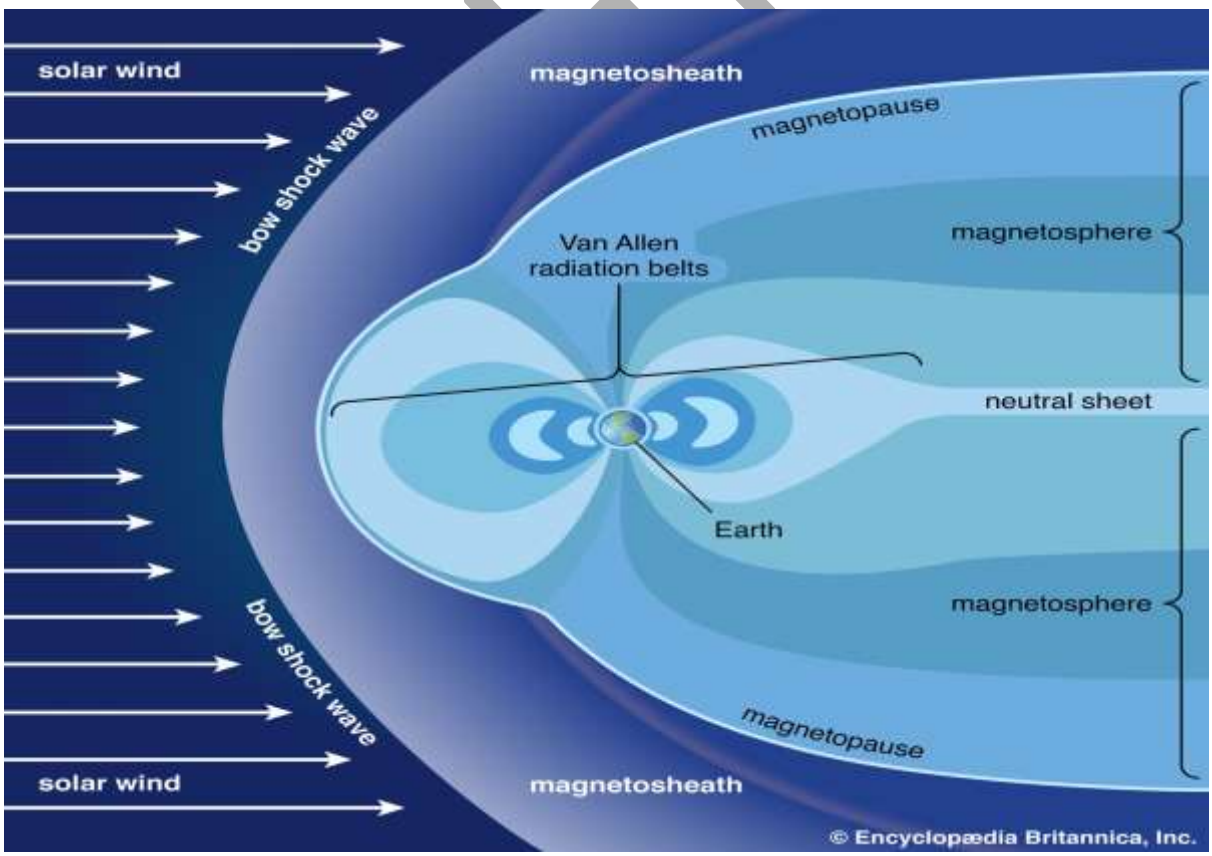
Q. What is the Van Allen Radiation Belt? Discuss its impact on satellite operations and manned space missions. (10 M)

Introduction

The Van Allen Radiation Belt, discovered in **1958 by James Van Allen**, is a region of charged particles trapped by Earth's magnetic field. It significantly influences space operations and requires mitigation strategies for satellite and human space missions.

Body

What is the Van Allen Radiation Belt?



1. **Structure and composition**: The belt comprises two main zones of high-energy particles trapped by Earth's magnetic field—the inner belt (protons) and outer belt (electrons).
    - Eg: The **inner belt** ranges from 1,000 to 12,000 km, while the **outer belt** extends from 13,000 to 60,000 km above Earth.
2. **Formation process**: It forms due to the interaction of solar wind particles and cosmic rays with Earth's magnetosphere.
    - Eg: The **Van Allen Probes (2012–2019)** studied how solar storms influence belt dynamics.
3. **Dynamic nature**: The intensity and structure of the belts vary during solar storms and geomagnetic activity.
    - Eg: During **Carrington-like solar events**, the belts can expand, affecting low-Earth orbit satellites.
4. **Role in space weather**: The belt serves as a natural laboratory for studying the interaction between Earth's magnetosphere and solar activity.
    - Eg: Data from the **NASA THEMIS mission (2020)** enhanced space weather forecasting.

Impact on satellite operations

1. **Damage to electronics**: High-energy particles cause degradation of microprocessors and circuitry.
    - Eg: The **Anik E2 satellite failure (1994)** was attributed to charged-particle damage from radiation.
2. **Reduced lifespan**: Persistent radiation exposure decreases satellite operational lifespan.
    - Eg: The **GOES weather satellites** are equipped with radiation-hardened systems to withstand prolonged exposure.
3. **Operational disruptions**: Radiation affects signal transmission, leading to communication blackouts and navigation errors.
    - Eg: **GPS accuracy decreases** during solar storms that energize the belts.
4. **Anomalous charging events**: Charging on spacecraft surfaces can result in sudden discharges, damaging systems.
    - Eg: **Intelsat 511 failure (1997)** was caused by surface charging in the belt region.
5. **Shielding challenges**: Designing radiation-resistant satellites increases mission costs and complexity.
    - Eg: **ESA's Galileo satellites** employ multi-layer shielding to endure belt crossings.

Impact on manned space missions

1. **Radiation exposure risks**: High-energy particles increase the risk of cancer, central nervous system damage, and acute radiation sickness.

- Eg: **Apollo missions** minimized exposure by limiting transit time through the belts to a few hours.

2. **Shielding requirements**: Adequate protection increases payload mass and complicates spacecraft design.
    - Eg: The **Artemis mission spacecraft** uses advanced shielding materials to protect astronauts.
3. **Impact on space station operations**: Spacecraft in higher orbits like the ISS require enhanced radiation management.
    - Eg: The **ISS shielding layers** protect astronauts from high-energy particle exposure.
4. **Implications for long-duration missions**: Prolonged exposure is a major challenge for missions to Mars or beyond.
    - Eg: NASA is developing **innovative radiation-proof materials**, such as hydrogen-rich polymers, for deep space travel.
5. **Trajectory optimization**: Space missions require precise planning to limit time spent in the belts.
    - Eg: The **Orion spacecraft's trajectory** during Artemis I avoided prolonged exposure to the belts.

Conclusion

The Van Allen Radiation Belt represents a critical challenge for advancing satellite technology and manned space exploration. **Continued innovation in shielding materials, real-time space weather forecasting, and adaptive spacecraft design** will ensure the success and safety of future space endeavours.

Q. What is dark matter, and how does it influence the behaviour of galaxies? Discuss the scientific significance of studying dark matter and analyze the challenges in its detection and research. (15 M)

Introduction

Dark matter is an invisible and non-luminous form of matter that constitutes about **27% of the universe's total mass-energy content**. Its existence is inferred from its **gravitational effects** on visible matter, radiation, and the large-scale structure of the universe.

Body

Influence of dark matter on the behaviour of galaxies

1. **Galactic rotation curves**: Stars at the edges of galaxies rotate at nearly the same velocity as those near the center, defying Newtonian predictions.
    - Eg: **Vera Rubin's research** on spiral galaxies in the **1970s** revealed the "missing mass" problem, providing evidence for **dark matter**.

2. **Gravitational lensing**: Dark matter bends the light from distant celestial objects, confirming its gravitational influence.
    - Eg: Observations from the **Hubble Space Telescope (2021)** detected **dark matter halos** around galaxy clusters like **Abell 1689**.
3. **Formation of cosmic structures**: Dark matter acts as a gravitational scaffold for galaxies and galaxy clusters to form.
    - Eg: The **Planck Mission (2018)** demonstrated how dark matter influences the **large-scale cosmic web**.
4. **Prevention of galactic disintegration**: Dark matter prevents galaxies from flying apart due to rotational forces.
    - Eg: Studies of the **Andromeda Galaxy (M31)** showed that without dark matter, stars in the outer regions would escape its gravitational pull.
5. **Cosmic microwave background (CMB) evidence**: Irregularities in the CMB patterns reflect dark matter's role in the early universe.
    - Eg: The **WMAP and Planck missions** confirmed how dark matter influenced the **density fluctuations** in the early universe.

Scientific significance of studying dark matter

1. **Understanding cosmic evolution**: Dark matter plays a key role in galaxy formation and clustering, helping explain the structure of the universe.
    - Eg: The **Sloan Digital Sky Survey (SDSS)** confirmed dark matter's contribution to the **distribution of galaxies**.
2. **Advancing fundamental physics**: Dark matter could validate the existence of new particles like **WIMPs (Weakly Interacting Massive Particles)** or axions.
    - Eg: The **Large Hadron Collider (LHC)** experiments are testing theories beyond the **Standard Model of Physics**.
3. **Improving cosmological models**: Dark matter is integral to the **Lambda-CDM model**, which explains the evolution of the universe.
    - Eg: The **Euclid Mission (2023)** by the European Space Agency aims to refine our understanding of **dark matter and dark energy**.
4. **Driving technological innovation**: The quest to detect dark matter has led to the development of highly sensitive detectors.
    - Eg: The **XENONnT experiment (2021)** advanced particle detection technologies for dark matter research.
5. **Revolutionizing our understanding of gravity**: Studying dark matter may lead to breakthroughs in theories of gravity and quantum mechanics.
    - Eg: Ongoing research into dark matter interactions could help bridge **quantum mechanics and general relativity**.

Challenges in detection and research

1. **Non-interacting nature**: Dark matter does not interact with electromagnetic forces, making it undetectable by traditional methods.

- Eg: The **XENON1T experiment (2020)** reported inconclusive results despite being one of the most sensitive dark matter detectors.

2. **Dependence on indirect evidence**: Research relies on indirect gravitational effects rather than direct observations.
    - Eg: The **Bullet Cluster study (2006)** provided evidence for dark matter through the separation of **visible matter and gravitational effects**.
3. **Technological limitations**: Current detectors lack the precision to conclusively detect dark matter particles.
    - Eg: The **LUX-ZEPLIN detector (2023)** improved detection capabilities but still has not confirmed dark matter particles.
4. **Theoretical challenges**: Competing theories like **Modified Newtonian Dynamics (MOND)** challenge the existence of dark matter.
    - Eg: MOND proposes alternative explanations for galaxy rotation curves, creating scientific debate.
5. **Global collaboration and funding issues**: Dark matter research requires substantial funding and international cooperation, which are often inconsistent.
    - Eg: India's **INO Project (2023)**, aimed at detecting dark matter, has faced delays due to funding and policy hurdles.

Conclusion

Dark matter is central to understanding the universe's hidden mysteries and advancing modern astrophysics. **Innovative technologies**, global collaboration, and sustained research efforts are essential to unravel this profound cosmic enigma.

Q. "Fuel cell technology is considered a game-changer for clean mobility, but its commercialization in India remains limited". Analyze the reasons and propose a roadmap for its integration. (15 M)

Introduction

Fuel cell technology is a transformative solution for clean mobility, capable of addressing environmental challenges and aligning with India's **National Hydrogen Mission (2021)** to achieve **net-zero by 2070**. Its potential lies in its high efficiency and scalability across multiple sectors.

Body

Fuel cell technology is a game-changer for clean mobility

1. **Zero greenhouse gas emissions**: Fuel cells emit only water vapor, significantly reducing air pollution.
    - **Eg**: **Toyota Mirai** and **Hyundai Nexo** demonstrate zero-emission transport globally.

2. **High energy efficiency**: Efficiency levels of **60-70%** make fuel cells more energy-efficient than traditional internal combustion engines (~25-30%).
    - **Eg**: Used in **hydrogen buses in South Korea**, reducing fuel consumption compared to diesel buses.
3. **Versatility across sectors**: Applicable in heavy-duty transport, marine vessels, and even aviation.
    - **Eg**: **Airbus** is developing **hydrogen-powered planes** for commercial use by **2035**.
4. **Energy storage and grid stability**: Hydrogen storage allows for the integration of renewable energy sources, providing stability to grids.
    - **Eg**: **Japan** uses fuel cells to store surplus energy from **solar and wind farms**.
5. **Long range and rapid refuelling**: Fuel cell vehicles (FCVs) offer longer driving ranges (up to **500-800 km**) and faster refueling (under 5 minutes) than battery EVs.
    - **Eg**: **California's hydrogen refueling network** supports efficient FCV operations.

Commercialization of fuel cell technology in India remains limited

1. **High production costs**: Electrolysis of water, the preferred method for green hydrogen production, is expensive, with hydrogen costing **₹300-400/kg**.
    - **Eg**: **Platinum catalysts** in fuel cells significantly increase costs; India lacks large-scale indigenous production.
2. **Lack of infrastructure**: Minimal hydrogen refuelling stations, storage facilities, and dedicated pipelines hinder adoption.
    - **Eg**: As of **2023**, India has only **two hydrogen refuelling stations**, compared to **over 150 in Japan**.
3. **Dependence on fossil fuel-based hydrogen**: Over **90% of hydrogen** in India is grey hydrogen, which emits CO_2 during production.
    - **Source**: **International Energy Agency (IEA) Hydrogen Report (2023)**.
4. **Policy and regulatory gaps**: Absence of targeted incentives, unclear safety guidelines, and lack of long-term roadmap for hydrogen adoption.
    - **Eg**: Unlike **EU's Hydrogen Strategy (2020)**, India's policies lack detailed timelines for green hydrogen integration.
5. **Public safety and awareness concerns**: Hydrogen's flammability raises public apprehensions, and safety protocols are underdeveloped.
    - **Eg**: Safety issues during trials in **South Korea** have delayed broader adoption of hydrogen technologies.

Roadmap for integrating fuel cell technology in India

1. **Develop green hydrogen production hubs**: Promote green hydrogen production using renewable energy, reducing reliance on grey hydrogen.
    - **Eg**: Announced **green hydrogen hubs** in **Rajasthan** and **Gujarat** in the **2024 Union Budget**.

2. **Build hydrogen infrastructure**: Establish pipelines, storage units, and a nationwide hydrogen refueling network.
    - **Eg**: **MNRE targets 50 hydrogen corridors by 2030**, connecting major highways and industrial clusters.
3. **Provide fiscal incentives**: Reduce costs through subsidies and tax rebates for fuel cell vehicles, hydrogen production, and R&D.
    - **Eg**: Introduce a scheme modeled on **FAME-II**, offering subsidies for green hydrogen and fuel cells.
4. **Promote domestic manufacturing**: Develop indigenous capacity for fuel cell and hydrogen storage technologies to reduce import dependency.
    - **Eg**: Leverage the **Production-Linked Incentive (PLI) scheme** for green energy technology.
5. **Enhance public-private partnerships (PPPs):** Encourage collaborations between government and industry to fund and scale projects.
    - **Eg**: **Indian Oil's collaboration with Hyundai Motors (2022)** to develop hydrogen infrastructure.

Conclusion

Fuel cell technology represents a crucial pillar for India's clean energy transition. With targeted policies, robust infrastructure, and global collaboration, India can lead the global hydrogen economy while achieving its **sustainable development goals (SDGs)** and **net-zero ambitions**.

Q. "Renewable energy, while environmentally friendly, has significant lifecycle environmental cost". Examine this statement with respect to solar panel production and disposal. (10 M)

Introduction

While renewable energy sources like solar power are environmentally friendly in their usage phase, the lifecycle—from production to disposal—reveals significant environmental costs, raising concerns about long-term sustainability.

Body

Renewable energy-environmentally friendly but with significant lifecycle environmental cost

1. **High material demand**: Solar panel production requires mining rare earth elements like silicon, silver, and cadmium, which leads to habitat destruction and groundwater depletion.
    - **Eg**: Mining in **China's Inner Mongolia** for polysilicon production has caused severe environmental degradation, including hazardous silicon tetrachloride waste.

2. **Energy-intensive manufacturing**: Solar panel production involves significant energy input, often powered by fossil fuels, creating a carbon footprint.
    - **Eg**: **Fraunhofer Institute (2023)** found that polysilicon production in coal-dominated regions offsets emissions only after **2-3 years** of usage.
3. **Chemical usage in production**: Use of hazardous chemicals like cadmium telluride and lead poses risks of soil and water contamination during manufacturing.
    - **Eg**: Improper disposal from solar panel manufacturing units in **Vietnam** has contaminated local water sources, affecting agriculture.
4. **Short lifespan of panels**: Panels typically last **20-25 years**, after which they contribute to electronic waste (e-waste).
    - **Eg**: India is projected to generate over **200,000 tonnes of solar waste by 2030** (source: **IRENA, 2022**).
5. **Global supply chain emissions**: Transportation of raw materials and finished panels across continents adds to the lifecycle carbon footprint.
    - **Eg**: Importing panels from **China to India** increases emissions, undermining environmental goals.

Solar panel production and disposal

1. **Environmental cost of material extraction**: Mining quartz and rare earth materials for solar cells depletes natural resources and damages ecosystems.
    - **Eg**: Quartz mining in **Australia** has caused **groundwater depletion** and soil erosion in mining regions.
2. **Disposal challenges**: End-of-life solar panels release toxic materials like cadmium and selenium if not disposed of properly.
    - **Eg**: Informal solar panel disposal units in **India (2021)** released harmful cadmium into rivers, affecting aquatic life.
3. **Recycling inefficiencies**: Recycling of solar panels is complex, costly, and underdeveloped, leading to their accumulation in landfills.
    - **Eg**: Only **10% of solar panels globally** are recycled due to high costs and lack of efficient technology (source: **IEA, 2022**).
4. **Energy losses during production**: High energy input during manufacturing offsets some of the emissions saved during operation.
    - **Eg**: A study by **Stanford University (2023)** highlighted **30% energy inefficiency** in silicon panel production processes.
5. **Emerging waste crisis**: Many developing countries lack robust waste management infrastructure to handle imported and domestic solar waste.
    - **Eg**: African nations face rising solar waste due to imports of low-quality panels from developed countries.

What can be done

1. **Invest in advanced recycling technologies**: Develop cost-effective methods to recover silicon, silver, and other rare materials from discarded panels.

    - **Eg**: The **PV Cycle Program (EU)** recycles over **90% of materials** from end-of-life solar panels.
2. **Adopt green manufacturing practices**: Use renewable energy and non-toxic alternatives in solar panel production to reduce environmental costs.
    - **Eg**: **Kyocera Corporation (Japan)** runs solar panel manufacturing facilities powered entirely by renewable energy.
3. **Mandate extended producer responsibility (EPR)**: Manufacturers should be made accountable for collecting and recycling discarded panels.
    - **Eg**: **India's Draft E-Waste Rules (2023)** propose integrating solar waste under EPR frameworks.
4. **Develop policy frameworks for solar waste**: Enforce robust policies to regulate disposal and recycling of solar panels.
    - **Eg**: **EU Waste Electrical and Electronic Equipment Directive** mandates recycling of solar panels by producers.
5. **Encourage public-private partnerships (PPP)**: Collaborate with private companies to establish recycling plants and promote innovation in waste management.
    - **Eg**: **Adani Solar** and **MNRE** are planning solar waste management systems for India.

Conclusion

While **renewable energy like solar power is essential for a sustainable future, addressing its lifecycle environmental costs through robust policies, advanced technologies**, and global collaboration will ensure its long-term viability and environmental integrity.

Q. "AI in healthcare is transforming the way professionals work, but its responsible use remains a challenge". Comment. (10 M)

Introduction

Artificial Intelligence (AI) is transforming healthcare by enhancing **efficiency, precision, and accessibility**, but its integration also poses significant challenges such as **data privacy**, **accuracy**, and **equity**, requiring responsible and regulated adoption.

Body

Transformative potential of AI in healthcare

1. **Enhanced diagnostics**: AI improves accuracy in early disease detection and personalized treatments.
    - **Eg:** Google's **DeepMind AI** achieved 94% accuracy in detecting breast cancer, surpassing radiologists (2023).
2. **Administrative automation**: AI reduces the burden of repetitive tasks, such as medical documentation and patient records.

    - **Eg: AI transcription tools** implemented in AIIMS for faster medical record-keeping (2024).
3. **Knowledge dissemination**: AI simplifies complex medical literature and accelerates professional education for doctors and trainees.
    - **Eg:** ChatGPT is widely used by doctors for **creating medical presentations** (Somita Pal, 2025).
4. **Improved patient interaction**: AI-based tools provide customized responses and patient education, enhancing treatment compliance.
    - **Eg: AI chatbots** like Ada Health improve patient awareness and engagement.
5. **Resource optimization**: AI supports healthcare delivery in remote and underserved areas.
    - **Eg: AI-driven telemedicine** platforms like Practo bridge healthcare access gaps in rural India.

Challenges in the responsible use of AI

1. **Accuracy and biases**: AI may deliver flawed or biased outputs if trained on inadequate or non-diverse datasets.
    - **Eg: Lancet (2022)** reported AI biases in skin cancer diagnostics due to limited training data diversity.
2. **Data privacy concerns**: AI tools handling sensitive patient data face risks of breaches and misuse.
    - **Eg:** Concerns emerged about data misuse in the **Cambridge Analytica scandal**.
3. **Ethical dilemmas**: Over-reliance on AI could replace human judgment, especially in critical healthcare decisions.
    - **Eg:** WHO's 2023 report warned against **AI autonomy** in surgical procedures without oversight.
4. **Regulatory gaps**: Lack of global and national legal frameworks for AI integration in healthcare exacerbates risks.
    - **Eg:** India lacks a comprehensive **AI governance policy** specific to healthcare.
5. **Digital divide**: AI adoption is uneven, with rural healthcare providers lacking infrastructure and access.
    - **Eg: NITI Aayog (2022)** noted a 74% specialist shortage in rural areas, limiting AI benefits.

Conclusion

To harness AI's transformative potential in healthcare, India must focus on **robust regulatory frameworks**, **ethical AI use**, and **data privacy safeguards**. Additionally, investments in **capacity-building programs** and **rural infrastructure** can ensure equitable access to AI tools. By integrating AI responsibly, healthcare can become more **efficient, inclusive, and patient-centric**, paving the way for a **sustainable and innovative healthcare system**.

Conservation, environmental pollution and degradation, environmental impact assessment.

Q. Discuss the concept of ecological carrying capacity and its relevance in managing India's growing urbanization and resource consumption. (10 M)

Introduction

Ecological carrying capacity refers to the maximum population size that an environment can sustain indefinitely without degrading natural resources. In the context of India's rapid urbanization, maintaining this balance is critical to sustainable development.

Body

Concept of ecological carrying capacity

1. **Definition and significance:** It determines the sustainable limit of resource consumption and waste generation to prevent ecological collapse.
    - **Eg:** The concept is central to the **United Nations Sustainable Development Goals (SDGs), especially Goal 11 (Sustainable Cities and Communities).**
2. **Factors influencing carrying capacity:** Population growth, technological advancement, resource extraction, and waste management impact ecological sustainability.
    - **Eg:** The **2019 NITI Aayog report** on water stress highlights over-extraction leading to declining groundwater levels.

Relevance in managing India's growing urbanization

1. **Urban sprawl management:** Excessive urban expansion strains natural resources, leading to unsustainable growth patterns.
    - **Eg:** Unplanned growth in **Delhi NCR** has resulted in high air and water pollution levels.
2. **Infrastructure planning:** Sustainable urban planning based on carrying capacity ensures efficient resource utilization and reduced environmental degradation.
    - **Eg:** The **Atal Mission for Rejuvenation and Urban Transformation (AMRUT)** focuses on improving urban infrastructure in a sustainable manner.
3. **Waste management and pollution control:** Overburdening of urban ecosystems leads to waste accumulation and pollution beyond sustainable limits.
    - **Eg: Mumbai generates 7,000 tonnes of waste daily**, exceeding its waste management capacity (CPCB report, 2021).
4. **Water resource sustainability:** Rapid urbanization leads to excessive groundwater extraction and water scarcity.
    - **Eg:** Chennai faced an acute **'Day Zero' water crisis in 2019**, highlighting the unsustainable water consumption pattern.

Relevance in managing resource consumption

1. **Sustainable resource allocation:** Ensuring resource efficiency through sustainable policies and consumption patterns.
    - **Eg:** The **National Resource Efficiency Policy (2019)** aims to optimize resource use across sectors.
2. **Renewable energy transition:** Managing ecological capacity through a shift from fossil fuels to sustainable energy sources.
    - **Eg:** India's target to achieve **500 GW of renewable energy** by 2030 under the Paris Agreement.
3. **Carrying capacity-based industrial policies:** Promoting eco-sensitive industrialization to balance resource consumption with ecological health.
    - **Eg:** The **Coastal Regulation Zone (CRZ) guidelines** regulate industries in fragile coastal areas.
4. **Behavioral change initiatives:** Encouraging responsible consumption patterns through awareness and policy interventions.
    - **Eg:** The **Swachh Bharat Mission** has promoted sustainable waste disposal and cleanliness practices.

Conclusion

Integrating ecological carrying capacity into urban planning and resource policies is crucial for ensuring a balance between development and environmental sustainability, securing a livable future for upcoming generations.

Q. "The Arctic is a bellwether for global climate change, with its transformations carrying cascading impacts worldwide". Discuss. (15 M)

Introduction

The Arctic, warming at **twice the global average**, serves as an early warning system for climate change, influencing weather patterns, sea-level rise, and global ecosystems. Its rapid transformations have far-reaching consequences for both the environment and human societies.

Body

Why the Arctic is a bellwether for global climate change

1. **Accelerated warming**: Arctic amplification results in higher warming rates, leading to drastic changes in ice cover and permafrost thawing.
    - **Eg:** The **IPCC AR6 report (2023)** states that Arctic temperatures have risen by **3°C since pre-industrial times**, affecting global climate stability.
2. **Permafrost thawing**: Releases large quantities of **methane and CO2**, accelerating global warming and triggering feedback loops.
    - **Eg:** According to **NOAA (2023)**, Arctic permafrost stores **1,500 gigatons** of carbon, which, if released, could significantly raise global temperatures.

3. **Sea ice loss and albedo effect**: Reduction in Arctic ice lowers Earth's reflectivity, causing further heat absorption and warming.
    - **Eg:** The **NSIDC (2024)** reported a **13% decrease per decade** in Arctic sea ice extent, intensifying the global energy imbalance.
4. **Changing oceanic currents**: Melting Arctic ice alters the **Atlantic Meridional Overturning Circulation (AMOC)**, impacting global climate systems.
    - **Eg:** Studies from **NASA (2023)** indicate disruptions in the Gulf Stream, contributing to extreme weather events in Europe and North America.
5. **Disruption of polar vortex**: Warming Arctic conditions weaken the polar vortex, leading to extreme cold events in mid-latitudes.
    - **Eg:** The **US winter storm (2021)** was linked to Arctic warming-induced disruptions in atmospheric circulation patterns.

Cascading global impacts of Arctic transformations

1. **Rising sea levels**: Melting Greenland ice sheets contribute significantly to rising sea levels, threatening coastal communities worldwide.
    - **Eg:** According to **IPCC (2023)**, Greenland's ice sheet loss accounts for **20% of global sea-level rise** since 2000.
2. **Extreme weather events**: Arctic changes intensify hurricanes, droughts, and floods globally due to shifts in jet streams and atmospheric rivers.
    - **Eg:** The **Pakistan floods (2022)** were linked to Arctic-induced shifts in the monsoon patterns.
3. **Loss of biodiversity**: Changing Arctic ecosystems disrupt global migratory patterns and food chains, impacting marine and terrestrial biodiversity.
    - **Eg:** The **WWF Arctic Programme (2023)** highlighted disruptions in polar bear and fish populations affecting global marine industries.
4. **Geopolitical and economic consequences**: Melting ice opens new shipping routes, leading to competition for Arctic resources and strategic interests.
    - **Eg:** The **Arctic Council (2024)** reported increased military and economic activities in the region by global powers like the USA and Russia.
5. **Threat to indigenous communities**: Traditional livelihoods of Arctic indigenous populations are at risk due to loss of hunting and fishing grounds.
    - **Eg:** Reports by **UNEP (2023)** show rising displacement of Inuit communities due to vanishing ice and changing climate patterns.

Way forward to mitigate Arctic climate change impacts

1. **Strengthening global climate policies**: Enforcing stringent carbon reduction commitments under agreements like the **Paris Accord** to curb Arctic warming.
    - **Eg:** The **COP28 summit (2023)** emphasized achieving **net-zero emissions by 2050** to protect polar ecosystems.
2. **Enhanced Arctic monitoring and research**: Utilizing satellite technologies and climate models for better understanding and response strategies.

- **Eg:** The **EU Copernicus Program** provides real-time Arctic data to track climate changes.

3. **Promoting renewable energy**: Transitioning from fossil fuels to sustainable energy sources to minimize Arctic emissions.
    - **Eg:** The **International Renewable Energy Agency (IRENA)** targets a **50% renewable share** by 2040.
4. **Adaptation measures for vulnerable communities**: Providing financial and technological support to mitigate socio-economic disruptions.
    - **Eg:** The **UN Green Climate Fund (2023)** supports indigenous Arctic communities in adapting to climate impacts.
5. **Conservation of Arctic biodiversity**: Strengthening international cooperation for the protection of Arctic flora and fauna.
    - **Eg:** The **Arctic Biodiversity Congress (2024)** proposed measures for sustainable fishing and habitat protection.

Conclusion

The Arctic's transformations are a **global concern** that necessitates **urgent, collective action** to mitigate cascading environmental, economic, and social impacts. Proactive measures focusing on **climate adaptation, emission reductions, and sustainable development** are crucial to safeguarding the planet's future.

Q. Discuss the role of industrial safety frameworks in mitigating disasters in high-risk sectors such as chemicals and petrochemicals. Highlight the challenges and suggest ways to improve India's approach to industrial safety. (15 M)

Introduction

Industrial safety frameworks are critical in mitigating disasters in high-risk sectors like chemicals and petrochemicals. They ensure a **proactive approach to risk identification and disaster prevention**, safeguarding lives, property, and the environment.

Body

Role of industrial safety frameworks in mitigating disasters

1. **Regulatory oversight and compliance**: Frameworks like the **Chemical Accidents Rules, 1996**, mandate safety audits, hazard identification, and emergency response planning.
    - **Eg:** Post the **Vizag gas leak (2020)**, authorities mandated stricter compliance for MAH units.
2. **Process safety management**: These frameworks focus on eliminating operational hazards through systems like hazard operability (HAZOP) studies.
    - **Eg:** Adoption of **HAZOP techniques** in ONGC's petrochemical units has reduced major accidents.

3. **Emergency response mechanisms**: Frameworks emphasize mock drills and disaster response teams to mitigate the impact of disasters.
    - **Eg: CIPET Chennai's mock drill (2025)**, coordinated with Kothari Petrochemicals, demonstrated effective onsite crisis management.
4. **Incident reporting and risk analysis**: Frameworks ensure post-incident analyses and safety enhancements through reporting mechanisms.
    - **Eg:** Post-incident assessments after the **Jaipur IOC depot fire (2009)** led to updated fire safety norms for oil and chemical industries.
5. **Technological integration**: The use of AI and IoT under safety frameworks enables real-time monitoring of chemical processes and leakages.
    - **Eg:** The **Hazira Industrial Zone** uses IoT-based monitoring systems to detect early signs of gas leaks.
6. **Community risk reduction**: Frameworks encourage industries to educate surrounding communities about risks and safety measures.
    - **Eg: Tirupur Industrial Belt** initiated community awareness programs for chemical safety after minor incidents.
7. **Environmental safeguards**: Guidelines for hazardous waste management, spill prevention, and pollution control reduce ecological harm.
    - **Eg:** Adoption of **zero-liquid discharge (ZLD)** systems in industries in Gujarat industrial corridors has minimized water pollution.

Challenges in implementation

1. **Weak enforcement mechanisms**: Regulatory bodies often lack the resources to monitor compliance comprehensively.
    - **Eg: Bhilai Steel Plant accident (2018)** revealed lapses in enforcement despite existing norms.
2. **Aging infrastructure**: Many industrial units in India still use outdated equipment, heightening risks.
    - **Eg:** The **Bhopal gas tragedy (1984)** remains a reminder of outdated and neglected safety systems.
3. **Limited workforce training**: Insufficient training in safety protocols leads to human errors in handling hazardous materials.
    - **Eg:** The **NIDM report (2022)** highlighted a shortage of trained safety personnel in MAH units.
4. **Overlapping jurisdiction**: Coordination between different regulatory bodies, such as the NDMA and state disaster authorities, is often ineffective.
    - **Eg:** Disjointed responses during the **Sterlite Copper protests (2018)** revealed gaps in regulatory cooperation.
5. **Lack of real-time monitoring systems**: Many industrial zones lack advanced technology for early detection of hazards.
    - **Eg:** Reports by the **CPCB (2023)** highlighted the absence of IoT sensors in over 50% of MAH units.

Suggestions to improve India's approach

1. **Updating legal frameworks**: Revise the **Factories Act, 1948**, and align it with global safety standards to address modern industrial risks.
    - **Eg:** Adoption of recommendations from the **NDMA guidelines (2022)** can significantly enhance safety standards.
2. **Specialized safety training**: Regular, sector-specific safety training for workers, managers, and disaster response teams.
    - **Eg:** The **Action Plan under Viksit Bharat@2047** aims to train personnel in 2393 MAH units across India.
3. **Integrated safety monitoring systems**: Deploy AI, IoT, and GIS-based tools for real-time safety monitoring and disaster prediction.
    - **Eg: IoT-based gas detectors** have reduced incidents in industrial hubs like **Dahej SEZ**.
4. **Stronger enforcement mechanisms**: Strengthen regulatory inspections with trained manpower and periodic third-party audits.
    - **Eg:** Japan's model of **external safety audits** is a global best practice India can adopt.
5. **Public-private partnerships (PPP)**: Foster collaboration between industries and the government for safety innovations and funding.
    - **Eg:** PPPs in **Tamil Nadu's Petrochemical Industrial Zone** have enhanced spill management and hazardous waste disposal systems.
6. **Community-based disaster management**: Involve local communities in planning and drills to enhance resilience against disasters.
    - **Eg:** Community disaster preparedness programs in **Visakhapatnam's industrial belt** have minimized risks.

Conclusion

A robust industrial safety framework is pivotal for achieving **sustainable industrial growth** and protecting both people and the environment. By integrating **modern technology**, strengthening enforcement, and promoting **community collaboration**, India can set global benchmarks in industrial safety.

Q. Discuss the implications of shifting climate responsibilities onto developing nations due to weak commitments from developed countries. How can developing nations balance climate action with their developmental needs? (10 M)

Introduction

The **principle of Common but Differentiated Responsibilities (CBDR)** under the **UNFCCC** acknowledges that developed nations, having historically contributed the most to global emissions, must take the lead in climate action. However, **weak commitments and**

withdrawal from climate agreements have shifted the burden onto developing nations, affecting their **economic growth, energy security, and social equity**.

Body

Implications of shifting climate responsibilities onto developing nations

1. **Increased economic burden**: Developing nations must divert limited resources toward climate mitigation, impacting poverty alleviation and infrastructure development.
    - **Eg:** India's renewable energy transition requires **$10 trillion by 2070** (CEA, 2023), but **climate finance commitments remain unfulfilled**.
2. **Energy security challenges**: Pressuring developing countries to **reduce fossil fuel dependence prematurely** can hinder industrialization and energy access.
    - **Eg: Africa's electrification rate is just 43%** (IEA, 2023), yet global funding for fossil fuel projects is being restricted.
3. **Reduction in climate finance and technology transfer**: Developed nations have failed to meet their **$100 billion per year climate finance commitment**, limiting green technology access for developing countries.
    - **Eg:** At **COP29 (2024, Baku)**, only **$300 billion was committed**, far below the required levels.
4. **Loss of carbon space and just transition concerns**: Developing nations have limited historical emissions but are being **forced to decarbonize rapidly**, limiting industrial competitiveness.
    - **Eg:** The **U.S. has emitted over 25% of historical global emissions**, while India contributes just **4%** (World Bank, 2024).
5. **Food security and adaptation gaps**: Climate change impacts like extreme weather and erratic rainfall affect agricultural productivity, increasing vulnerability.
    - **Eg: India lost 5 million hectares of crops in 2023** due to extreme climate events (IMD, 2024).

Strategies for balancing climate action with developmental needs

1. **Strengthening climate finance mechanisms**: Developing nations must push for legally binding **climate finance commitments** and transparent disbursal mechanisms.
    - **Eg:** India has advocated for a **Loss and Damage Fund** at **COP28 (Dubai, 2023)** to compensate vulnerable nations.
2. **Leveraging domestic green finance**: Scaling up **sovereign green bonds, blended finance, and public-private partnerships** to fund renewable transitions.
    - **Eg:** India issued **₹16,000 crore in green bonds** in 2023 to finance clean energy projects.
3. **Phased energy transition with flexibility**: Developing economies must adopt **a mix of renewables, clean coal, and natural gas** to balance growth with sustainability.

- **Eg:** India's **Energy Transition Roadmap (2023)** allows coal use till **2040**, while increasing **renewables to 50% by 2030**.

4. **Technology transfer and local innovation**: Strengthening **domestic R&D and international cooperation** for clean technologies like hydrogen and carbon capture.
    - **Eg:** India and the U.S. launched the **U.S.-India Strategic Clean Energy Partnership (2023)** to enhance green technology transfer.
5. **Resilience-focused adaptation policies**: Investing in **climate-resilient agriculture, water conservation, and disaster mitigation** to protect vulnerable communities.
    - **Eg:** The **National Adaptation Fund for Climate Change (NAFCC, ₹3,500 crore)** supports climate adaptation in India's rural regions.

Conclusion

Developing nations **cannot bear the climate burden alone**, and **equitable global cooperation** is essential. A **just transition, backed by strong climate finance, technology access, and policy flexibility**, is crucial to achieving **sustainable and inclusive growth** while meeting climate commitments.

Disaster and disaster management.

Q. Analyze the socio-economic and environmental challenges posed by disaster-induced displacement in India. Suggest policy interventions for climate-resilient rehabilitation. (15 M)

Introduction

Disaster-induced displacement in India, driven by climate change and natural hazards, disrupts livelihoods, exacerbates vulnerabilities, and strains resources, demanding urgent policy responses.

Body

Socio-economic challenges

1. **Loss of livelihoods:** Displaced communities lose access to stable income sources, leading to economic insecurity.
    - **Eg: Cyclone Amphan (2020)** displaced thousands of coastal fishermen in **West Bengal**.
2. **Housing and infrastructure deficits:** Inadequate shelter and lack of essential services create long-term dependency on relief measures.
    - **Eg:** Post-**2018 Kerala floods**, rehabilitation struggles due to housing shortages.
3. **Health vulnerabilities:** Poor living conditions and lack of healthcare access increase disease burden among displaced populations.

- **Eg: NIDM report (2023)** highlighted rising waterborne diseases in flood-prone areas.

4. **Education disruption:** Displacement often leads to dropouts, affecting children's long-term development and future employment opportunities.
    - **Eg:** Post-**Uttarakhand floods (2013)**, thousands of students dropped out due to school destruction.
5. **Social integration issues:** Cultural dislocation and loss of social networks hinder effective community reintegration.
    - **Eg:** Tribal displacement in **Odisha** post-**cyclone Fani (2019)** faced challenges in integrating with host communities.

Environmental challenges

1. **Ecological degradation:** Displaced populations exert pressure on fragile ecosystems, leading to deforestation and resource depletion.
    - **Eg:** Encroachments in **Sundarbans** due to recurrent cyclones have worsened mangrove loss.
2. **Waste management issues:** Unplanned settlements contribute to pollution and health hazards in resettlement areas.
    - **Eg:** Waste accumulation post-**Chennai floods (2015)** worsened sanitation crises.
3. **Water resource stress:** Over-extraction and contamination of water sources occur in temporary settlements.
    - **Eg: NITI Aayog (2021)** reported acute groundwater depletion in refugee camps post-**2020 Assam floods**.
4. **Climate vulnerability:** Temporary settlements are often in hazard-prone areas, exacerbating future disaster risks.
    - **Eg:** Frequent flash floods in **Himalayan settlements** post-**2013 Kedarnath disaster**.

Policy interventions for climate-resilient rehabilitation

1. **Sustainable housing solutions:** Climate-resilient housing using local materials and eco-friendly designs.
    - **Eg:** Kerala's **'Rebuild Kerala' initiative** after **2018 floods** promotes eco-friendly housing.
2. **Livelihood diversification:** Skill development programs and alternative employment opportunities to reduce vulnerability.
    - **Eg: NDMA guidelines** advocate livelihood restoration programs post-disasters.
3. **Health and nutrition support:** Mobile healthcare units and targeted nutritional programs for displaced populations.
    - **Eg:** The **Ayushman Bharat scheme** expanded health coverage post-**cyclone Fani (2019)**.

4. **Community participation:** Involving local communities in planning and implementation of rehabilitation projects.
    - **Eg: Sendai Framework (2015)** emphasizes community-driven risk reduction measures.
5. **Legal and policy framework:** Strengthening legal mechanisms to recognize displaced populations' rights.
    - **Eg:** Draft **National Policy on Internal Displacement (2019)** focuses on long-term rehabilitation measures.
6. **Infrastructure resilience:** Building disaster-resistant infrastructure in high-risk zones.
    - **Eg:** Bihar's **'Jal-Jeevan-Hariyali' mission** integrates flood-resilient infrastructure.
7. **Environmental restoration:** Reforestation and ecosystem-based approaches in resettlement planning.
    - **Eg:** Odisha's post-**cyclone restoration** of coastal ecosystems to combat erosion.

Conclusion

A holistic, community-driven, and climate-resilient approach, integrating sustainable policies and robust implementation mechanisms, is crucial to safeguard displaced populations and ensure long-term resilience.

Linkages between development and spread of extremism.

Q. Analyze the role of development in addressing left-wing extremism (LWE) in India. Can development alone eradicate the root causes of extremism? (10 M)

Introduction

Left-Wing Extremism (LWE) affects **38 districts in India** and stems from socio-economic inequalities, governance deficits, and alienation of marginalized communities. Development plays a crucial role in addressing the root causes, but its success depends on complementing it with governance and security reforms.

Body

Role of Development in Addressing LWE

1. **Economic opportunities and livelihood generation**: Development projects create jobs and reduce poverty, limiting Maoist recruitment.
    - **Eg: PMGSY improved road connectivity in LWE-affected** areas like **Sukma (Chhattisgarh)**, enhancing access to markets and livelihoods.
2. **Social empowerment through education and health**: Investments in education and healthcare improve living standards and address grievances stemming from neglect.

- **Eg: Eklavya Model Residential Schools (EMRS)** provided quality education to tribal youth, reducing their vulnerability to extremism.

3. **Strengthening state presence**: Development initiatives bring governance and public services to remote areas, countering the Maoist narrative of neglect.
    - **Eg:** Under the **Aspirational Districts Programme**, **Dantewada (Chhattisgarh)** improved governance and service delivery.
4. **Land reforms and tribal rights**: Recognizing tribal land and forest rights reduces exploitation and fosters trust in the state.
    - **Eg: The Forest Rights Act (2006) granted land** titles to tribal communities in Odisha and Jharkhand.

Why Development Alone is Not Enough

1. **Lack of inclusive governance**: Development without political empowerment cannot address alienation or build trust in state institutions.
    - **Eg: The absence of tribal leaders in governance perpetuates** mistrust in LWE regions.
2. **Need for security measures**: Development requires complementary security frameworks to restore law and order in insurgency-prone areas.
    - **Eg: The SAMADHAN strategy integrates development** and security to combat LWE effectively.
3. **Addressing ideological indoctrination**: Maoist propaganda sustains recruitment and support, which development alone cannot counter.
    - **Eg: Rehabilitation programs in Jharkhand** for surrendered Maoists have helped reduce recidivism.
4. **Administrative inefficiency and corruption**: Mismanagement and diversion of development funds weaken the impact of welfare schemes.
    - **Eg: Reports of corruption in PDS distribution** in LWE regions fuel grievances among tribal communities.

What Can Be Done

1. **Strengthen governance and political inclusion**: Empower tribal communities through representation and governance reforms.
    - **Eg: Effective implementation of the PESA Act** has strengthened self-governance in tribal areas.
2. **Integrate development with security measures**: Expand the **SAMADHAN strategy** to include localized security frameworks alongside targeted development programs.
    - **Eg: Andhra Pradesh's Greyhounds force** combines security and local development initiatives.
3. **Counter Maoist propaganda**: Launch de-radicalization programs and community-driven awareness campaigns to counter extremist narratives.
    - **Eg: Tribal leaders and NGOs have played** key roles in awareness campaigns in Chhattisgarh.

4. **Promote skill development and entrepreneurship**: Introduce tailored skill programs to engage tribal youth in productive activities.
    - **Eg: Skill India Mission** has trained youth in LWE-affected states like Jharkhand and Odisha.

Conclusion

Development is a vital tool in combating LWE, but it must be integrated with **inclusive governance, security measures, and ideological de-radicalization**. A comprehensive approach, aligned with **SDG 16 (Peace, Justice, and Strong Institutions)**, is essential to achieve long-term peace and development in insurgency-affected regions.

Q. Evaluate the role of guerrilla warfare tactics in sustaining Left-wing extremism (LWE) in India and suggest measures to counter them effectively. (10 M)

Introduction

Guerrilla warfare, with its **hit-and-run tactics, ambushes, and use of terrain**, has allowed Left-Wing Extremists (LWE) to evade superior state forces and sustain their movement. It thrives in India due to challenging geographies and socio-economic grievances in tribal areas.

Body

Role of guerrilla warfare tactics in sustaining LWE

1. **Exploitation of terrain**: Dense forests and hilly regions offer strategic cover and mobility for Maoists.
    - **Eg:** The **Dandakaranya region**, covering Chhattisgarh, Odisha, and Maharashtra, serves as a Maoist stronghold due to its impenetrable forests and poor road infrastructure.
2. **Decentralized command structure**: Independent operational cells provide flexibility and continuity.
    - **Eg:** The **People's Liberation Guerrilla Army (PLGA)** is divided into zonal and sub-zonal units, allowing uninterrupted operations even when leaders are captured or killed.
3. **Ambushes and IEDs**: Guerrilla tactics focus on ambushing security forces and using improvised explosive devices (IEDs).
    - **Eg:** In the **Sukma ambush (2017)**, Maoists used human shields and forested terrain to kill 25 CRPF personnel, demonstrating their tactical sophistication.
4. **Psychological warfare**: Attacks on high-profile targets and infrastructure create fear among security forces and local administrators.
    - **Eg:** In **Dantewada (2023)**, Maoists ambushed a convoy, killing 10 security personnel and damaging road construction vehicles, disrupting local development projects.

5. **Community support**: Maoists embed themselves within tribal communities, leveraging grievances like displacement and land alienation.
    - **Eg:** In Chhattisgarh, Maoists exploit the **displacement due to mining projects in Bastar** to recruit locals into their ranks.

Measures to counter guerrilla warfare tactics effectively

1. **Advanced surveillance and intelligence**: Deploy drones, satellite imagery, and human intelligence networks to track Maoist movements.
    - **Eg:** In **Gadchiroli (2022)**, drones helped identify Maoist camps in dense forests, leading to successful anti-Maoist operations.
2. **Specialized counter-insurgency forces**: Training and deploying region-specific forces for jungle warfare.
    - **Eg: Greyhounds in Andhra Pradesh and Telangana**, trained in guerrilla tactics, drastically reduced Maoist influence, forcing them to retreat to neighboring states.
3. **Development-driven strategies**: Address underlying grievances through welfare schemes focused on education, employment, and infrastructure.
    - **Eg:** The **Aspirational Districts Program** has significantly improved education and healthcare metrics in LWE-affected districts like Sukma and Dantewada.
4. **Empowering local governance**: Strengthen Panchayati Raj Institutions (PRIs) to address grassroots issues and counter Maoist narratives.
    - **Eg:** In Odisha's Malkangiri district, improved PRI participation through **Mission Shakti initiatives** reduced Maoist influence by empowering tribal women.
5. **Psychological and digital warfare**: Use social media and local platforms to counter Maoist propaganda and promote government schemes.
    - **Eg: Chhattisgarh's community radio programs**, such as "Radio Bastar," create awareness about government initiatives and encourage youth to abandon extremism.

Conclusion

A sustainable solution to LWE requires **intelligence-driven security operations** combined with **socio-economic reforms** to address root grievances. Balancing security measures with inclusive development can help dismantle the guerrilla warfare machinery and restore peace in the affected regions.

Q. "Insurgency in India's North-East cannot be resolved without addressing the region's ethnic diversity and cultural autonomy". Comment (15 M)

Introduction

The North-East, with its **200+ ethnic groups** and rich cultural diversity, remains vulnerable to insurgency due to historical neglect, ethnic marginalization, and autonomy-related issues. Addressing these requires balancing **ethnic diversity**, **cultural autonomy**, and **socio-economic inclusion**.

Body

Reasons for insurgency in the North-East

1. **Ethnic marginalization**: Perceived neglect and lack of representation in decision-making drive alienation.
    - **Eg:** The **NSCN (IM)** demands a "Greater Nagalim" to unify Naga-inhabited areas spanning across Nagaland, Manipur, Assam, and Arunachal Pradesh, citing ethnic marginalization.
2. **Migration-led demographic shifts**: Unchecked cross-border migration has disrupted ethnic balances, fueling identity-based tensions.
    - **Eg:** In **Assam**, the fear of losing native Assamese identity due to large-scale migration from Bangladesh triggered the **Assam Agitation (1979-85)**, leading to the contentious **Assam Accord (1985)**.
3. **Inadequate autonomy provisions**: The Sixth Schedule's limited autonomy often fails to address local governance aspirations.
    - **Eg:** The **Karbi Anglong unrest** in Assam persists despite being under the Sixth Schedule, with repeated demands for a separate state.
4. **Resource-based conflicts**: Competition over control of land and forests escalates ethnic tensions.
    - **Eg:** The **Naga-Kuki clashes in Manipur (1990s)** arose due to competing claims over land and territorial boundaries.
5. **Cultural neglect**: Failure to protect tribal languages, traditions, and rituals exacerbates grievances.
    - **Eg:** The **Meitei-ST status demand** in Manipur stems from fears of cultural and economic marginalization by other ethnic groups.

Insurgency cannot be resolved without addressing ethnic diversity and cultural autonomy

1. **Strengthening Sixth Schedule provisions**: Expanding autonomy frameworks tailored to specific ethnic needs can empower local governance.
    - **Eg:** The **Bodoland Territorial Region Accord (2020)** granted enhanced autonomy to Bodo groups, reducing violent insurgency in Assam.
2. **Recognition of ethnic identities**: Legal safeguards under **Article 29** and constitutional protection of minority rights must be enforced.
    - **Eg:** The **Mizoram Peace Accord (1986)** successfully preserved the identity of Mizos while addressing insurgency.

3. **Facilitating inter-ethnic reconciliation**: Ethnic groups must resolve boundary disputes and cultural tensions through dialogue.
    - **Eg:** The **Bru-Reang Agreement (2020)**, which resolved a 23-year-long conflict, rehabilitated over 30,000 displaced Brus in Tripura while respecting Mizo identity.
4. **Preservation of tribal land rights**: Protecting tribal land ownership under the **Forest Rights Act, 2006** ensures socio-economic equity.
    - **Eg:** In Arunachal Pradesh, tribal opposition to land allotment for industrial projects has highlighted the need for FRA enforcement.
5. **Inclusive governance**: Political and economic empowerment through community participation can foster trust.
    - **Eg:** The **North Eastern Council (NEC)**, since its inception in 1971, has played a significant role in funding region-specific projects to empower marginalized communities.

What more can be done?

1. **Regional development councils**: Setting up region-specific councils with legislative backing for grievance redressal.
    - **Eg:** A proposed **North-East Regional Development Authority** can address state disputes while focusing on cohesive development planning.
2. **Cross-border cooperation**: Strengthening ties with neighbors to curb arms supply and insurgent safe havens.
    - **Eg:** Joint military operations like **Operation Sunrise (2019)** with Myanmar dismantled militant camps along the Indo-Myanmar border.
3. **Timely implementation of peace accords**: Building trust through transparent and time-bound delivery.
    - **Eg:** The delay in implementing the **Naga Peace Accord (2015)** continues to escalate tensions and mistrust among Naga factions.
4. **Economic integration via Act East Policy**: Expanding regional trade and connectivity to boost local economies.
    - **Eg:** Projects like the **Kaladan Multi-Modal Transit Transport Project** enhance connectivity between Mizoram and Myanmar, fostering economic opportunities.
5. **Empowering youth through education and employment**: Addressing radicalization and alienation by creating opportunities.
    - **Eg:** The **Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY)** has trained over **50,000 youths** in the North-East, providing them with alternative livelihoods.

Conclusion

A lasting resolution to insurgency in the North-East requires a **bottom-up approach**, balancing ethnic and cultural aspirations with inclusive development. Collaborative

governance and targeted regional initiatives can pave the way for peace and prosperity in this geopolitically sensitive region.

Role of external state and non-state actors in creating challenges to internal security.

Q. "Internal security challenges in India are no longer confined to borders but are increasingly influenced by external and transnational factors".Discuss. (15 M)

Introduction

India's internal security has evolved to encompass not just domestic issues but also external and transnational factors like cross-border terrorism, cyber threats, and illegal migration. These challenges demand a **multi-dimensional security framework** integrating domestic and international responses.

Body

External and transnational factors influencing internal security

1. **Cross-border terrorism**: India faces terrorism sponsored by external states and non-state actors, aimed at destabilizing its border areas and beyond.
    - **Eg:** The **Pulwama attack (2019)** by **Pakistan-based Jaish-e-Mohammed** highlights cross-border terrorism targeting Jammu & Kashmir.
2. **Illegal migration and demographic shifts**: Influx of illegal immigrants creates resource pressures, demographic changes, and communal tensions, particularly in sensitive regions.
    - **Eg:** The arrival of **Rohingya refugees** in **Assam and West Bengal** has led to significant socio-political unrest (MHA, 2023).
3. **Narco-terrorism**: Smuggling of drugs from the **Golden Crescent** and **Golden Triangle** funds extremist groups and undermines internal stability.
    - **Eg:** The seizure of **3,000 kg heroin at Mundra Port (2021)** underscores the growing role of transnational drug cartels in India.
4. **Cyber threats and misinformation**: External actors use cyberattacks to disrupt critical infrastructure, spread misinformation, and manipulate public opinion.
    - **Eg:** The **Mumbai power grid cyberattack (2020)**, attributed to Chinese hackers, disrupted essential services, showcasing the vulnerability of critical infrastructure.
5. **Radicalization via social media**: External extremist groups exploit social media platforms to recruit youth and propagate divisive ideologies.
    - **Eg: ISIS-inspired modules** in India, fueled by online propaganda, have been uncovered in several states (NIA, 2021).
6. **Human trafficking and organized crime**: Transnational trafficking networks exploit porous borders, targeting vulnerable populations and weakening internal law enforcement.

- **Eg:** Trafficking routes from **Bangladesh and Nepal** into India are major sources of illegal migration and exploitation (UNODC, 2023).

7. **Climate-induced migration**: Environmental degradation and climate change in neighboring countries, like Bangladesh, lead to migration and resource conflicts in India.
    - **Eg:** Rising **sea levels in the Sundarbans** have displaced communities, increasing migration into **West Bengal** (IPCC, 2023).

Measures to address external and transnational threats

1. **Modernizing border management**: Deploying smart border solutions, including **CIBMS (Comprehensive Integrated Border Management System)**, drones, and thermal imaging, to prevent infiltration and smuggling.
    - **Eg: Smart fencing along the India-Bangladesh border** has significantly reduced illegal migration and trafficking.
2. **Enhancing intelligence-sharing networks**: Collaborating with international allies for real-time intelligence on terrorism, trafficking, and cyber threats.
    - **Eg:** The **Quad Cybersecurity Initiative (2022)** enhances India's preparedness against transnational cyberattacks.
3. **Strengthening counter-radicalization programs**: Implementing de-radicalization and community engagement initiatives targeting vulnerable groups.
    - **Eg: De-radicalization programs in Jammu & Kashmir**, under the **MHA**, have rehabilitated youth exposed to extremist propaganda.
4. **Combating narco-terrorism**: Strengthening ties with neighbours and global organizations like the **UNODC** to dismantle drug trafficking networks.
    - **Eg:** The **India-UNODC MoU (2023)** focuses on combating drug smuggling from the **Golden Crescent**.
5. **Cybersecurity resilience**: Building advanced defences through the **National Cyber Security Strategy**, monitoring misinformation, and securing critical infrastructure.
    - **Eg:** The **CERT-In** team has mitigated major attacks on Indian financial and defence sectors in the past decade.
6. **Leveraging multilateral platforms**: Using forums like **SAARC**, **ASEAN**, and **UNODC** to tackle transnational organized crime and terrorism.
    - **Eg:** The **SAARC Terrorism Offences Monitoring Desk** helps track cross-border terror activities.
7. **Integrated resource and climate strategies**: Collaborating with neighbouring countries to address resource conflicts and climate-induced migration.
    - **Eg:** India's joint initiatives with Bangladesh under the **Bonn Challenge** address environmental migration from the Sundarbans.

Conclusion

India's internal security is deeply influenced by external and transnational factors, requiring a **comprehensive approach combining border modernization, intelligence collaboration, and technological interventions**. Addressing these challenges not only strengthens internal

stability but also enhances India's global standing in combating security threats, aligning with **SDG 16 (Peace, Justice, and Strong Institutions)**.

Q. "India's internal security threats are increasingly interconnected with global geopolitical developments". Discuss. (15 M)

Introduction

In an increasingly interconnected world, India's internal security landscape is profoundly shaped by **global geopolitical shifts, ranging from cross-border terrorism to cyber warfare and economic dependencies**. Addressing these challenges requires a nuanced understanding of their transnational nature and strategic policy interventions.

Body

Interconnection between India's Internal Security and Global Geopolitics

1. **Cross-border terrorism and insurgency:** India's security is affected by state-sponsored terrorism and insurgencies influenced by geopolitical rivalries.
    - **Eg:** The 2016 **Uri attack** linked to Pakistan-based groups like Jaish-e-Mohammed, escalating tensions.
2. **Cybersecurity threats from foreign actors:** Hostile nations and non-state actors exploit cyber vulnerabilities to target India's critical infrastructure.
    - **Eg:** The **2020 China-linked cyberattack** on Indian power grids during the Ladakh border crisis (Source: Recorded Future).
3. **Radicalization through global networks:** Extremist ideologies spread through digital platforms with external influence, posing a domestic security risk.
    - **Eg:** The **ISIS-inspired modules** uncovered by the NIA in Kerala in 2022.
4. **Economic dependencies and vulnerabilities:** Trade dependencies, especially in strategic sectors like energy and defence, impact India's security autonomy.
    - **Eg:** India's **reliance on Chinese imports** for pharmaceutical raw materials amid geopolitical tensions.
5. **Maritime security in the Indo-Pacific:** Regional power struggles impact India's maritime trade routes and strategic interests.
    - **Eg:** China's activities in the **Indian Ocean Region (IOR)**, including the development of ports in neighbouring countries.
6. **Illegal migration and demographic shifts:** Influx of migrants from conflict zones in neighbouring countries poses internal security challenges.
    - **Eg:** The **Rohingya refugee influx** in north-eastern India raising security concerns.
7. **Drug trafficking and organized crime:** Transnational crime syndicates exploit India's geographic position to smuggle narcotics and arms.
    - **Eg:** The seizure of **2,500 kg heroin** from an Iranian vessel off Gujarat in 2023 (Source: NCB).

8. **Hybrid warfare and misinformation campaigns:** Adversarial states use social media and disinformation to destabilize India's internal environment.
    - **Eg:** Pakistan-based misinformation campaigns during the **2019 Pulwama attack crisis**.

Strategies to Strengthen India's Internal Security

1. **Enhanced border security measures:** Deployment of advanced surveillance systems and smart fencing to secure porous borders.
    - **Eg:** Implementation of **Comprehensive Integrated Border Management System (CIBMS)** along the western border.
2. **Strengthening cyber defence infrastructure:** Establishing AI-driven threat detection mechanisms and stringent cyber regulations.
    - **Eg:** Formation of **Defence Cyber Agency (DCA)** for military cyber operations.
3. **Community-based deradicalization programs:** Engaging local communities to counter extremist ideologies through awareness campaigns.
    - **Eg:** The **'Operation Chakravyuh'** by intelligence agencies to identify radicalized individuals.
4. **Strengthening maritime surveillance:** Enhancing naval capabilities and fostering regional cooperation through strategic alliances.
    - **Eg:** Collaboration under the **QUAD framework** for maritime security.
5. **Boosting economic self-reliance:** Reducing dependence on foreign imports through policies like Aatmanirbhar Bharat.
    - **Eg:** Development of **indigenous semiconductor manufacturing hubs** with government incentives.
6. **Coordinated intelligence sharing:** Strengthening institutional coordination between security agencies to counter evolving threats.
    - **Eg:** The **Multi-Agency Centre (MAC)** facilitating real-time intelligence sharing.

Conclusion

India's internal security challenges require a **multi-dimensional approach** involving **technological advancements, intelligence collaboration, and strategic international partnerships** to effectively address evolving geopolitical threats.

Challenges to internal security through communication networks, role of media and social networking sites in internal security challenges, basics of cyber security; money-laundering and its prevention.

Q. Explain the concept of Critical Information Infrastructure (CII) and its importance in ensuring national security. Highlight the threats posed to CII in India. (10 M)

Introduction

Critical Information Infrastructure (CII) comprises systems and assets vital to a nation's economy, governance, and security. Protecting CII ensures the uninterrupted functioning of critical sectors, making it central to national security.

Body

Concept of Critical Information Infrastructure

1. **Definition and legal basis**: CII refers to systems whose disruption can severely affect national security, public health, and the economy.
    - **Eg**: Defined under **Section 70 of the IT Act, 2000**, with protection overseen by the **National Critical Information Infrastructure Protection Centre (NCIIPC)**.
2. **Examples of CII sectors**: Telecommunications, financial systems, power grids, transportation, healthcare, and defense networks are classified as CII in India.
    - **Eg**: **Aadhaar**, **RBI servers**, and the **Indian Energy Exchange** are critical CII components.
3. **Global standards**: Internationally, frameworks like the **US Cybersecurity and Infrastructure Security Agency (CISA)** and **EU NIS Directive** offer models for CII protection.

Importance of CII in ensuring national security

1. **Economic stability**: Securing financial systems prevents disruptions in trade, banking, and digital payment ecosystems.
    - **Eg**: A cyberattack on the **RBI's payment systems** could paralyze India's **UPI network** and impact economic transactions.
2. **Defense readiness**: CII underpins defense communications and real-time decision-making during conflicts.
    - **Eg**: The **Network for Spectrum (NFS)** ensures secure communication for Indian armed forces.
3. **Public service continuity**: Safeguarding essential services like electricity, healthcare, and transportation ensures societal stability.

    - **Eg**: Cyberattacks on India's **power grids in 2020**, reportedly linked to China, targeted electricity supply during border tensions.
4. **Preventing data breaches**: Protecting citizen data from breaches ensures public trust in governance and services.
    - **Eg**: The **Aadhaar database** faced multiple cyberattack attempts but remains critical for welfare delivery.
5. **Global interdependence**: As India integrates with global digital systems, robust CII protection is essential to maintaining international trust and competitiveness.

Threats posed to CII in India

1. **State-sponsored cyberattacks**: Hostile nations use cyberattacks to disrupt critical infrastructure.
    - **Eg**: The **Red Echo cyberattack (2021)**, attributed to China, targeted Indian power grids during Ladakh tensions.
2. **Ransomware attacks**: Criminals exploit vulnerabilities in CII for financial extortion.
    - **Eg**: The **Ransomware attack on AIIMS (2022)** disrupted healthcare services and exposed patient data.
3. **Insider threats**: Employees or contractors with privileged access pose significant risks.
    - **Eg**: **Data breaches in public sector banks (2023)** were linked to insider negligence.
4. **Dependency on foreign technology**: Reliance on imported hardware and software increases vulnerabilities to espionage.
    - **Eg**: Concerns over **Chinese-origin 5G equipment** compromising India's telecom networks.
5. **Legacy systems**: Outdated infrastructure in key sectors lacks robust cybersecurity protocols.
    - **Eg**: Vulnerable SCADA systems in India's **water and energy sectors**.
6. **Global malware campaigns**: Malware like WannaCry exploits vulnerabilities in outdated systems.
    - **Eg**: WannaCry ransomware affected **critical healthcare and banking systems globally** in 2017, including in India.

Conclusion

The protection of CII is paramount for India's security and economic stability in an increasingly digital world. Leveraging **indigenous technologies**, **AI-driven threat monitoring**, and **global partnerships** can bolster India's resilience against growing threats. Proactive measures will ensure the robustness of CII and secure India's critical assets.

Q. "Money laundering undermines economic stability and national security". Discuss the processes involved in money laundering and evaluate the legislative and institutional measures taken by India to combat it. (15 M)

Introduction

Money laundering disrupts the economic fabric of nations, facilitating organized crime and terrorism, which directly challenges **national security** and weakens **financial systems**.

Body

Money laundering undermines economic stability and national security

1. **Threat to financial systems**: Laundering corrupts legitimate financial institutions and reduces foreign investor confidence.
    - Eg: **IL&FS crisis** (2018) exposed irregularities linked to fund diversions, impacting the financial sector.
2. **Funding for terrorism**: Laundered money is often routed to terror outfits, amplifying threats to national security.
    - Eg: **Hawala networks** in India have been used to fund terrorist groups like Lashkar-e-Taiba.
3. **Economic inequality**: Undeclared wealth leads to unequal resource distribution and promotes a parallel economy.
    - Eg: The **Paradise Papers (2017)** revealed offshore accounts that evaded Indian tax laws, impacting equitable wealth distribution.
4. **Loss of revenue**: Tax evasion through laundering reduces government resources, affecting public services.
    - Eg: According to a **2022 CBI report**, India loses approximately ₹1 lakh crore annually due to tax fraud linked to laundering.

Processes involved in money laundering

1. **Placement**: Injecting illegal money into the financial system through cash-intensive businesses, casinos, or trade.
    - Eg: **Delhi Gold Smuggling Case (2020)**, where illicit cash was introduced into the system through gold imports.
2. **Layering**: Complex financial transactions are used to obscure the origin of funds, such as creating shell companies or fake invoices.
    - Eg: The **Punjab National Bank scam (2018)** involved multiple fake letters of undertaking to launder funds abroad.
3. **Integration**: Laundered money is reinvested into legitimate sectors like real estate, luxury assets, or stock markets.
    - Eg: The **Mumbai real estate market** (2021) witnessed a significant crackdown on properties bought using laundered money.

Legislative and institutional measures taken by India to combat money laundering

1. **Prevention of Money Laundering Act (PMLA), 2002**: Provides mechanisms for confiscating properties and punishing offenders.
    - Eg: **2022 amendments** allowed attachment of assets linked to crypto laundering cases like the **WazirX probe**.
2. **Financial Intelligence Unit (FIU-IND)**: Tracks suspicious financial transactions to assist enforcement agencies.
    - Eg: FIU flagged ₹12,000 crore in suspicious banking transactions in 2023 (**MoF report**).

3. **Fugitive Economic Offenders Act (FEOA), 2018**: Enables seizure of properties of offenders fleeing the country.
    - Eg: Properties worth over ₹18,000 crore of **Vijay Mallya, Nirav Modi**, and **Mehul Choksi** confiscated under FEOA.
4. **Role of Enforcement Directorate (ED)**: Investigates money laundering and enforces PMLA provisions.
    - Eg: In **2023**, the ED attached properties worth ₹21,000 crore in laundering cases across sectors, including real estate and financial fraud.
5. **Global compliance with FATF**: India adopted FATF recommendations for strengthening its anti-money laundering framework.
    - Eg: In **2023**, FATF lauded India for increased scrutiny on shell companies.
6. **Use of advanced technology**: AI and blockchain are used to monitor suspicious transactions in real time.
    - Eg: **RBI's pilot blockchain system** (2024) helps track illicit fund movements in banking networks.
7. **Committee recommendations**: The **Malhotra Committee on Financial Reforms (1997)** emphasized tighter regulation of cash-intensive sectors to prevent laundering.
    - Eg: Steps to improve reporting standards in sectors like real estate and gold trade were adopted in **2022**.

Conclusion

A **multi-faceted approach**, combining stringent enforcement, global cooperation, and innovative technology, is essential to combat money laundering, safeguard financial stability, and secure India's national interests.

Q. "Media and social networking sites are increasingly used as instruments of information warfare".Examine the implications for internal security in India and suggest measures to counter this emerging threat. (15 M)

Introduction

Media and social networking platforms have become tools for **disinformation, propaganda, and psychological manipulation**, threatening **internal security and social cohesion** in democratic nations like India.

Body

Media and social networking sites as instruments of information warfare

1. **Misinformation and fake news**: Disinformation campaigns spread false narratives, creating confusion and distrust.
    - Eg: **Deepfake videos** used during the **2020 US elections** influenced public opinion.

2. **Psychological operations (PsyOps)**: Platforms are weaponized for **mass manipulation** and shaping narratives.
    - Eg: **China's influence operations** through fake accounts targeting Indian audiences on Twitter (source: 2021 MoD report).
3. **Election manipulation**: Bot-generated fake news influences electoral outcomes, undermining democracy.
    - Eg: Alleged manipulation through **bots in India's 2019 elections**, flagged by Election Commission observers.
4. **Radicalization and recruitment**: Terror groups exploit platforms to indoctrinate and mobilize individuals.
    - Eg: **ISIS recruiting youth in Kerala** through Telegram and encrypted messaging apps (NIA report, 2020).
5. **Cyber espionage**: Malicious actors use fake profiles and phishing to steal sensitive data.
    - Eg: **Chinese malware detected in India's power grid (2020)** (source: NTRO).

Implications for internal security in India

1. **Communal tensions and polarization**: Disinformation targeting religious and ethnic groups triggers violence.
    - Eg: Social media rumours fuelled the **2020 Delhi riots**, escalating communal tensions (Delhi Police report).
2. **Threat to democratic integrity**: Fake news and targeted propaganda disrupt electoral processes and public trust.
    - Eg: Allegations of **foreign influence in the 2019 Indian elections** through social media platforms.
3. **Economic disruption**: Misinformation causes panic and disrupts markets, impacting public confidence.
    - Eg: **Rumors of bank insolvencies during COVID-19** led to large-scale panic withdrawals (source: NCRB).
4. **Support for organized crime**: Criminal networks use social media for planning and coordination.
    - Eg: **Dark web platforms used in drug trafficking cases** detected by DRI in 2021.
5. **Mob violence**: Fake news about crimes such as kidnapping leads to mob attacks and killings.
    - Eg: **WhatsApp rumors in 2018** caused over **20 mob lynching incidents** across India (NCRB report).

Measures to counter this emerging threat

1. **Stronger regulatory frameworks**: Amend the **IT Act, 2000** to hold platforms accountable for hosting fake news and harmful content.

    - Eg: The **IT Rules 2021** introduced obligations for platforms to trace origins of flagged messages.
2. **Real-time fact-checking mechanisms**: Institutionalize public and private fact-checking initiatives to counter misinformation.
    - Eg: Expansion of **PIB Fact Check Unit** and partnerships with **Alt News**.
3. **Cybersecurity enhancement**: Adopt the **National Cyber Security Strategy 2021** to strengthen critical digital infrastructure.
    - Eg: Recommendations by the **Lt. Gen. Rajesh Pant Committee** include building cyber forensics capabilities.
4. **Public awareness campaigns**: Educate citizens about recognizing and reporting fake news to build digital literacy.
    - Eg: **Google's '#StaySafeOnline' campaign** educates users about online threats.
5. **International collaboration**: Partner with global initiatives to combat transnational cyber threats and propaganda.
    - Eg: India's participation in the **Global Internet Forum to Counter Terrorism (GIFCT)** to address extremist content.

Conclusion

Media and social networking sites, while empowering, can be misused for malicious purposes. A **multi-stakeholder approach**, combining **technology, governance, and citizen awareness**, is vital to protect India's internal security and ensure a safe digital ecosystem.

Security challenges and their management in border areas - linkages of organized crime with terrorism.

Q. How has the abrogation of Article 370 impacted the security scenario and counterterrorism efforts in Jammu and Kashmir? (10 M)

Introduction

The abrogation of **Article 370 on August 5, 2019**, sought to fully integrate Jammu and Kashmir into India's constitutional framework, with significant effects on security and counterterrorism measures in the region.

Body

Impact on the security scenario

1. **Decline in terror incidents**: The number of terror incidents has significantly reduced due to proactive measures by security forces.

- **Eg**: **Terror incidents dropped by 70% b**etween 2019 and 2022, as per official data.

2. **Reduction in local recruitment**: Targeted deradicalization programs have led to fewer youths joining terror groups.
    - **Eg**: **Recruitment dropped from 219 in 2018 to 89 in 2021**, as reported by J&K police.
3. **Improved border security**: Enhanced infrastructure, including modernized fencing and surveillance, has reduced infiltration.
    - **Eg**: **Ceasefire violations fell by 35%** in 2022 after a renewed border agreement between India and Pakistan.
4. **Civilian safety**: With reduced militant activity, civilian casualties in terror incidents have declined.
    - **Eg**: **Civilian deaths dropped from 191 (2016-2018)** to **110 (2019-2021)**, according to the Ministry of Home Affairs.

Impact on counterterrorism efforts

1. **Unified governance and laws**: Direct applicability of central laws has enhanced legal action against terrorism.
    - **Eg**: The **Unlawful Activities Prevention Act (UAPA)** was used to convict **1,000+ suspects** between 2019-2022.
2. **Weakened separatist networks**: Crackdowns on separatist leaders and funding sources have curtailed anti-India propaganda.
    - **Eg**: **NIA investigations in 2020** led to the **seizure of ₹223 crore** linked to terror financing through hawala networks.
3. **Improved intelligence coordination**: The formation of new intelligence agencies has streamlined counterterrorism operations.
    - **Eg**: The **State Investigation Agency (SIA)**, formed in 2021, cracked multiple terror-related cases in its first year.
4. **Development-led counterterrorism**: Increased development spending and employment opportunities have reduced discontent.
    - **Eg**: The **Back to Village (B2V) program** generated **employment for 20,000 youths** by 2022.

Challenges

1. **Cross-border terrorism**: Pakistan-backed groups like **Lashkar-e-Taiba** and **Jaish-e-Mohammed** continue to operate, posing a threat.
    - **Eg**: The **Nagrota encounter (2020)** exposed infiltration by Jaish-e-Mohammed operatives despite tighter border controls.
2. **Radicalization via digital platforms**: Extremist propaganda on encrypted platforms continues to attract vulnerable youth.
    - **Eg**: **Al-Qaeda-affiliated groups** increased recruitment via Telegram and WhatsApp post-abrogation.

3. **Public alienation**: Perceived disenfranchisement post-abrogation has fueled discontent among some sections of the population.
    - **Eg**: Protests over the **delimitation commission's recommendations (2022)** highlighted local grievances.
4. **Restoration of political process**: Delayed assembly elections have hindered inclusive governance.

Conclusion

The abrogation of Article 370 has significantly reduced terrorism and enhanced counterterrorism measures in J&K. However, **addressing cross-border threats, countering radicalization, and restoring political processes** are vital for lasting peace and stability in the region. A focus on **development and inclusivity** will ensure the transformation of J&K into a peaceful and prosperous region.

Q. "Terrorism is not confined to physical violence but includes economic destabilization and psychological warfare". Discuss. (15 M)

Introduction

Terrorism in its modern form transcends physical violence, targeting **economic systems** and leveraging **psychological tactics** to destabilize nations and undermine societal confidence.

Body

Terrorism beyond physical violence

Economic destabilization

1. **Disruption of infrastructure**: Attacks on power grids, transportation, and communication systems disrupt economies.
    - **Eg**: The **2015 Ukraine power grid attack** disrupted electricity for millions, affecting economic activity.
2. **Terror financing through illicit means**: Terrorist groups use money laundering, drug trafficking, and cryptocurrency for funding.
    - **Eg**: **ISIS generated $500 million annually** from illegal oil trade during its peak.
3. **Impact on investments and trade**: Persistent attacks deter foreign investments and disrupt trade.
    - **Eg**: **Pakistan lost $123 billion** in economic growth due to terrorism between 2002-2016 (Pakistan Economic Survey).
4. **Tourism and livelihood disruptions**: Targeting public spaces deters tourists and affects local economies.
    - **Eg**: The **2019 Sri Lanka Easter bombings** led to a **70% drop in tourist arrivals**, severely impacting GDP.

Psychological warfare

1. **Instilling fear and panic**: Attacks in public spaces amplify fear, affecting societal resilience and decision-making.
    - **Eg**: The **9/11 attacks** instilled global fear and altered perceptions of safety.
2. **Radicalization via digital platforms**: Social media is exploited to recruit youth and spread extremist ideologies.
    - **Eg**: **ISIS recruited thousands** globally using social media campaigns.
3. **Exacerbating communal tensions**: Terrorists exploit societal divisions to polarize communities.
    - **Eg**: The **Pulwama attack (2019)** intensified communal narratives in India.
4. **Misinformation and propaganda**: Fake news and digital manipulation erode trust in institutions and society.
    - **Eg**: The **2019 Christchurch shooting**, live-streamed online, amplified psychological impact and communal tensions.

Steps to counter the threat

1. **Strengthen financial oversight**: Enforce stringent anti-money laundering (AML) and counter-terror financing (CFT) mechanisms.
    - **Eg**: FATF grey-listed Pakistan, compelling reforms in its terror financing mechanisms.
2. **Protect critical infrastructure**: Enhance cybersecurity and protect vital economic systems from attacks.
    - **Eg**: India's **National Cyber Security Strategy** focuses on safeguarding digital ecosystems.
3. **Counter extremist propaganda**: Develop counter-narratives to neutralize recruitment and misinformation.
    - **Eg**: India's **Cyber Swachhta Kendra** combats fake news and radical content.
4. **Community and international engagement**: Foster communal harmony and global collaboration to dismantle terror networks.
    - **Eg**: The **UN Global Counter-Terrorism Strategy (2006)** promotes coordinated global actions.
5. **Education and awareness**: Promote digital literacy and social cohesion to reduce susceptibility to radicalization.
    - **Eg**: **Manipur's community-driven anti-insurgency programs** successfully engage locals in preventing extremist activities.
6. **Technological regulations**: Enforce stringent content moderation on digital platforms to curb online extremism.
    - **Eg**: India's **IT Rules (2021)** mandate platforms to remove harmful content promptly.

Conclusion

Terrorism today is a complex threat targeting **economies, societies, and minds**. A **comprehensive strategy** combining robust security frameworks, financial vigilance, and societal resilience is vital to counter its multifaceted dimensions effectively

Q. "The evolving nexus between organized crime and terrorism is undermining India's border security". Discuss this linkage with contemporary examples and its implications for national security. (10 M)

Introduction

The **nexus between organized crime and terrorism** is a growing challenge, leveraging illegal activities such as drug trafficking and arms smuggling to finance terror operations, directly threatening India's border security.

Body

The evolving nexus between organized crime and terrorism

1. **Financial linkage**: Organized crime funds terrorism through illegal trade and extortion.
    - Eg: The **narcotics trade in Punjab** is often linked to financing terrorist activities.
2. **Shared networks**: Criminal syndicates provide logistical support to terror groups, including arms and fake documents.
    - Eg: Smuggling networks in **North-East India** aid insurgent groups like ULFA.
3. **Use of border vulnerabilities**: Porous borders are exploited for human trafficking, drug smuggling, and infiltration.
    - Eg: Increased **drone activity across the Punjab border** for drugs and weapons in 2023.
4. **Money laundering and hawala**: Terror groups use organized crime to launder money through informal channels.
    - Eg: The **Terror Funding and Fake Currency (TFFC)** operations uncovered hawala networks linked to terror financing.
5. **Weapon proliferation**: Illegal arms trade is a critical enabler of terrorism, especially in conflict zones.
    - Eg: Recovery of arms smuggled via **India-Myanmar border** by militant groups in Manipur.

Implications for national security

1. **Undermining border integrity**: Smuggling of drugs, arms, and fake currency weakens border security and governance.
    - Eg: **Seizures along the Indo-Bangladesh border** indicate increased trafficking activities.
2. **Threat to internal stability**: Linkages between organized crime and terrorism fuel insurgencies and communal tensions.

    - Eg: **Drug cartels in Punjab** exacerbate youth addiction and fund extremist elements.
3. **Economic destabilization**: Fake currency circulation disrupts financial systems, affecting economic stability.
    - Eg: **RBI reports on counterfeit notes in 2023** highlight increased detection of fake Rs. 500 notes.
4. **Increase in hybrid threats**: Technological advancements like drones amplify transnational threats.
    - Eg: Drone-based arms and narcotics drops reported in **Jammu and Punjab**.
5. **Strain on law enforcement**: Combating multi-layered threats diverts resources, impacting other security priorities.
    - Eg: National Investigation Agency's (NIA) focus on terror funding cases reduces attention to other critical areas.

What can be done

1. **Integrated border management**: Enhance coordination among border forces and use advanced technology like drones and sensors.
    - Eg: Implementation of the **Comprehensive Integrated Border Management System (CIBMS)** along sensitive borders.
2. **Strengthening legal frameworks**: Amend laws to tackle transnational crimes and terror financing more effectively.
    - Eg: Strengthening **Unlawful Activities (Prevention) Act (UAPA)** to address emerging threats.
3. **Intelligence sharing and cooperation**: Regional and international partnerships must focus on intelligence sharing to counter organized crime.
    - Eg: Cooperation with **Interpol** on trafficking networks and terror links.
4. **Community engagement in border areas**: Develop local economies and involve communities to reduce dependence on illegal activities.
    - Eg: Programs like **Vibrant Villages Programme (2023)** along the India-China border.
5. **Specialized agencies and task forces**: Create dedicated units to counter organized crime and terror funding.
    - Eg: Formation of the **Multi-Agency Centre (MAC)** for coordinated intelligence gathering.

Conclusion

Addressing the nexus between organized crime and terrorism demands **a multi-pronged strategy combining advanced technology, robust legal frameworks, and international cooperation**. Strengthening community engagement and focusing on socio-economic development in border areas will ensure a sustainable solution to this evolving threat.

Q. "Effective border management requires a multi-dimensional approach encompassing defence, diplomacy, and development". Comment (15 M)

Introduction

Border management is a **dynamic process**, requiring an integrated approach that blends **defence, diplomacy, and development** to counter evolving threats and ensure national security.

Body

Role of defence in border management

1. **Strengthening infrastructure and forces**: Deployment of advanced technology, fencing, and trained personnel enhances border security.
    - Eg: **CIBMS** implemented along India-Pakistan and India-Bangladesh borders using smart fences.
2. **Joint operations and coordination**: Improved coordination between forces like **BSF, ITBP, and Indian Army** tackles cross-border infiltration and terrorism.
    - Eg: The success of **surgical strikes (2016)** highlighted operational synergy.
3. **Cybersecurity integration**: Cyber defence is crucial to protect sensitive data and critical infrastructure from cross-border cyberattacks.
    - Eg: Establishment of the **Defence Cyber Agency (2018)** to counter cyber threats from adversaries.
4. **Use of advanced surveillance technology**: Drones, night-vision cameras, and satellite imaging help monitor sensitive areas effectively.
    - Eg**: Deployment of Heron drones** in Ladakh during the India-China standoff (2020).

Importance of diplomacy in border management

1. **Bilateral agreements**: Diplomacy resolves disputes, reduces tensions, and ensures peaceful co-existence.
    - Eg: **Indus Waters Treaty (1960)** governs shared water resources with Pakistan.
2. **Confidence-building measures (CBMs)**: CBMs like hotline mechanisms and flag meetings foster trust between neighbouring nations.
    - Eg: Regular flag meetings between **India and China** post **Doklam standoff (2017)**.
3. **Leveraging multilateral platforms**: Regional forums like **SAARC and BIMSTEC** aid in tackling transnational issues like trafficking.
    - Eg: India's active role in **BIMSTEC's Disaster Management and Security Cooperation (2022)**.

4. **Border-specific cooperation mechanisms**: Agreements tailored to specific borders address unique challenges.
    - Eg: **India-Bangladesh Land Boundary Agreement (2015)** resolved decades-old disputes and improved relations.

Development as a cornerstone of border management

1. **Infrastructure development**: Road, rail, and air connectivity improve both defence readiness and civilian access in border areas.
    - Eg: Completion of the **Atal Tunnel (2020)** reduced travel time to Ladakh's border regions.
2. **Empowering local communities**: Providing education, healthcare, and employment reduces alienation and gains public support for security measures.
    - Eg: **Vibrant Villages Programme (2023)** prioritizes socio-economic development in border regions.
3. **Economic integration**: Border trade through regulated haats or markets fosters trust and reduces illegal activities.
    - Eg: Operationalization of **India-Bangladesh border haats** improved local economies.
4. **Telecom and digital inclusion**: Providing internet access enhances governance, connects isolated regions, and reduces insurgency risks.
    - Eg: **BharatNet project** improved digital connectivity in border villages of Arunachal Pradesh.

Challenges and gaps in implementation

1. **Porous borders**: Geographical and climatic conditions make fencing ineffective in some areas.
    - Eg: Persistent infiltration along the **Indo-Bangladesh border** despite the fencing project.
2. **Coordination issues**: Overlapping jurisdictions of border forces and local law enforcement lead to inefficiencies.
    - Eg: **Pathankot airbase attack (2016)** exposed gaps in inter-agency coordination.
3. **Funding and resource constraints**: Insufficient allocation for technology and infrastructure hampers comprehensive security.
    - Eg: The **Parliamentary Standing Committee on Defence (2022)** highlighted underutilization of border management funds.
4. **Increased hybrid threats**: Emerging challenges like cyber infiltration, drones, and smuggling complicate traditional security measures.
    - Eg: Rising drone activity along the **Punjab border** for drug and arms smuggling.

Conclusion

Modernizing border infrastructure, integrating **cutting-edge technology**, and empowering border communities through **targeted development initiatives** are vital for comprehensive management. **Institutional synergy** and proactive diplomacy, supported by a **National Border Management Policy**, are essential to create secure and resilient borders in the face of evolving challenges.

Q. "Urban terrorism is an evolving threat to India's internal security architecture". Analyze the factors contributing to it and suggest countermeasures. (10 M)

Introduction

The **rapid urbanization and technological advancements in India have transformed cities into potential targets for terrorism**, exploiting vulnerabilities in infrastructure, public spaces, and digital networks.

Body

Urban Terrorism as an Evolving Threat

1. **Exploitation of urban complexity:** Dense populations, diverse socio-economic profiles, and extensive transportation networks offer cover and operational advantages to terrorists.
    - **Eg:** The 2008 **Mumbai attacks**, where attackers utilized urban transport hubs and hotels to maximize impact.
2. **Expansion of sleeper cells:** Urban areas provide ideal conditions for radical elements to remain dormant and strike at opportune moments.
    - **Eg:** The 2014 **Burdwan blast**, which exposed an urban-based terror module linked to foreign networks.
3. **Targeting urban symbols of power:** Cities house political, financial, and technological institutions, making them lucrative targets for terrorism.
    - **Eg:** The 2001 **Parliament attack**, which aimed at destabilizing national governance.

Factors Contributing to Urban Terrorism

1. **Unregulated urban expansion:** Rapid growth of unplanned settlements and slums creates security blind spots and logistical challenges.
    - **Eg:** Terror suspects found hiding in **Delhi's unauthorized colonies**, as per intelligence reports.
2. **Digital radicalization and recruitment:** Social media platforms facilitate the spread of extremist propaganda, aiding recruitment in urban areas.
    - **Eg:** Multiple arrests of youth radicalized via **Telegram and WhatsApp channels** by global terror outfits.

3. **Availability of advanced logistics:** Easy access to transportation, financial services, and rental spaces enables terrorists to plan attacks discreetly.
    - **Eg:** The use of ride-hailing apps and e-commerce platforms in the **2018 Hyderabad terror plot**.
4. **Gaps in urban policing:** The overstretched law enforcement agencies struggle with the scale and complexity of city-based threats.
    - **Eg:** The lack of adequate **counter-terror training for local police forces**, as observed in major metro cities.
5. **Influence of global terrorist networks:** Urban nodes are increasingly linked to transnational terror groups, leveraging porous international connections.
    - **Eg:** The arrest of urban operatives linked to **Al-Qaeda's Indian Subcontinent (AQIS)** unit in 2021.

Suggested Countermeasures

1. **Smart surveillance systems:** Deploying AI-based facial recognition and predictive analytics to monitor potential threats.
    - **Eg:** The use of **integrated CCTV networks** in cities like Mumbai and Bengaluru for early threat detection.
2. **Urban counter-terrorism task forces:** Dedicated units focusing on intelligence gathering, risk assessment, and rapid response.
    - **Eg:** The establishment of **NSG hubs** in major urban centers for immediate action.
3. **Strengthening legal frameworks:** Updating urban-specific security policies to counter evolving terror tactics effectively.
    - **Eg:** The 2019 amendments to the **Unlawful Activities (Prevention) Act (UAPA)** for individual designation.
4. **Community engagement initiatives:** Sensitizing citizens through awareness programs and involving them in vigilance efforts.
    - **Eg:** The **Hyderabad Police's 'Know Your Neighbour' initiative**, enhancing community participation in security.
5. **Securing critical urban infrastructure:** Conducting vulnerability assessments and improving resilience mechanisms in transport, energy, and communication networks.
    - **Eg:** The deployment of **Rapid Action Force (RAF)** units to protect metro systems during high-threat alerts.

Conclusion

A comprehensive urban security strategy, combining **technological innovation, community cooperation, and policy reforms**, is essential to effectively counter the evolving threat of urban terrorism in India.

Various Security forces and agencies and their mandate.

Q. "Paramilitary forces are the backbone of India's internal security, yet they face significant structural and operational challenges". Discuss. (15 M)

Introduction

Paramilitary forces form the **backbone of India's internal security architecture**, addressing challenges like insurgency, terrorism, and border protection. However, they face persistent structural and operational issues that need immediate attention to ensure national stability and preparedness.

Body

Paramilitary forces are the backbone of India's internal security

International Border	Guarded by
Indo - Pakistan Border	Border Security Force (BSF)
Indo - Bangladesh	Border Security Force (BSF)
Indo - China Border	Indo - Tibetan Border Police (ITBP)
Indo - Nepal Border	Sashastra Seema Bal (SSB)
Indo - Bhutan Border	Sashastra Seema Bal (SSB)
Indo - Myanmar Border	Assam Rifles (AR)

1. **Counter-terrorism and insurgency operations**: Paramilitary forces are instrumental in neutralizing terrorist activities and insurgencies, particularly in conflict-prone regions.
    - Eg: **Assam Rifles** has been pivotal in reducing insurgent activities in the North-East, such as combating the National Socialist Council of Nagaland (NSCN) factions.
2. **Border management and surveillance**: Forces like the BSF and ITBP ensure national border security and prevent infiltration.
    - Eg: **BSF's vigilance along the India-Pakistan border** has prevented drug smuggling and infiltration, particularly in Punjab in 2022.

3. **Assistance during natural disasters**: Paramilitary forces provide critical support during disasters, rescuing civilians and delivering essential supplies.
    - Eg: **NDRF**, under CISF personnel, carried out rescue operations during the 2022 Assam floods, evacuating over 25,000 people.
4. **Ensuring election security**: Paramilitary forces maintain law and order, enabling free and fair elections in sensitive regions.
    - Eg: **CRPF's deployment in 2023 Tripura elections** ensured peaceful polling in left-wing extremism-affected areas.
5. **Restoration of law and order**: Units like RAF respond rapidly to communal unrest and riots.
    - Eg: **RAF's intervention during the Delhi riots in 2020** helped restore peace and prevent escalation of violence.

Significant structural and operational challenges

1. **Overlapping jurisdictions**: Role conflicts between paramilitary forces and state agencies create inefficiencies.
    - Eg: **BSF and Punjab Police's conflicting jurisdiction** on counter-infiltration operations in border areas led to delays in the 2022 Fazilka drug seizure case.
2. **Modernization deficits**: Outdated weapons and surveillance systems reduce operational efficiency.
    - Eg: The **2022 CAG report on BSF** highlighted inadequate procurement of night-vision devices, leaving 40% of border areas poorly monitored.
3. **Workforce stress and mental health**: Prolonged deployments and lack of support systems have led to high attrition rates and suicides.
    - Eg: According to **NCRB (2023)**, over 120 paramilitary personnel died by suicide, citing work stress and limited leave as contributing factors.
4. **Inadequate training**: Limited exposure to modern counter-insurgency methods and cyberwarfare techniques impacts readiness.
    - Eg: **The Shekatkar Committee (2016)** emphasized the need for specialized training programs for paramilitary forces in high-tech warfare.
5. **Poor infrastructure**: Substandard living conditions and lack of basic amenities affect morale and preparedness.
    - Eg: A **Parliamentary Committee report (2021)** highlighted the poor condition of ITBP border posts, with inadequate heating in Ladakh's sub-zero temperatures.
6. **Coordination challenges**: Poor communication between paramilitary forces and local police reduces operational efficiency.
    - Eg: Lack of coordination during the **2019 Pulwama attack investigation** delayed critical responses and intelligence-sharing.

What needs to be done

1. **Prioritize modernization**: Invest in advanced equipment like drones, surveillance systems, and automated weaponry.
    - Eg: The **Defence Acquisition Procedure (2020)** recommends fast-tracked procurement for critical operations.
2. **Enhanced training**: Provide forces with cyberwarfare and counter-terrorism training through partnerships with global security institutions.
    - Eg: Collaborative training programs with **Israel's counter-terrorism forces** can enhance expertise.
3. **Strengthen welfare measures**: Implement stress management programs, increase leave availability, and provide psychological support.
    - Eg: The **CAPF Plan 2023** includes proposals for mental health helplines and mandatory counseling sessions.
4. **Improve infrastructure**: Upgrade facilities in border outposts and camps to meet modern operational standards.
    - Eg: The **India-China Border Infrastructure Development Plan (2022)** upgraded ITBP camps along the Line of Actual Control (LAC).
5. **Enhance coordination mechanisms**: Establish clear communication protocols between paramilitary and state forces to avoid delays.
    - Eg: The **Second Administrative Reforms Commission (2008)** emphasized joint operational planning and resource-sharing frameworks.
6. **Role clarity and restructuring**: Clearly delineate jurisdictions of paramilitary forces to avoid conflicts with state and central agencies.
    - Eg: Implementation of **Shekatkar Committee recommendations (2016)** for rationalizing roles across forces.

Conclusion

Paramilitary forces are indispensable for India's internal security, but addressing their challenges through modernization, welfare reforms, and strategic coordination is essential. A reformed and well-equipped paramilitary force will ensure a more secure and resilient India.

Q. Analyze the role of India's specialized agencies, such as CERT-In and NTRO, in mitigating threats emerging from communication networks. (10 M)

Introduction

The **expanding communication networks** have increased India's vulnerability to **cyber threats** such as espionage, ransomware, and data breaches. Agencies like **CERT-In** and **NTRO** play a critical role in safeguarding the nation's digital infrastructure and ensuring cyber resilience.

Body

Role of CERT-In in mitigating threats

1. **Incident response and advisories**: CERT-In acts as the nodal agency for handling **cyber incidents**, providing real-time solutions to mitigate their impact.
    - Eg: Issued urgent guidelines during the **WannaCry ransomware attack (2017)** to control its spread in India.
2. **Vulnerability assessments**: Conducts **security audits** and regular vulnerability testing for key sectors such as telecom, energy, and banking.
    - Eg: Issued alerts on **Microsoft Exchange Server vulnerabilities (2021)** to prevent widespread exploitation.
3. **Threat intelligence and alerts**: Disseminates **threat intelligence** and real-time alerts to stakeholders, enabling preventive actions.
    - Eg: Published **COVID-19 phishing alerts (2020)** to safeguard against fraudulent schemes targeting healthcare data.
4. **Public awareness campaigns**: Promotes **cyber hygiene** through initiatives aimed at educating individuals and organizations about secure practices.
    - Eg: Launched the **Cyber Swachhta Kendra** to combat malware and secure devices.
5. **Global collaboration**: Collaborates with international organizations like **APCERT** and **FIRST** to combat transnational cyber threats.
    - Eg: Participated in the **APCERT Cyber Drill 2022**, enhancing India's readiness against global cyberattacks.

Role of NTRO in mitigating threats

1. **Cyber threat intelligence**: Provides **technical intelligence** to preempt cyberattacks by adversarial entities, focusing on strategic areas like defense and energy.
    - Eg: Detected and countered **Chinese malware targeting Indian power grids (2020)**.
2. **Securing critical communication networks**: Protects **classified communication systems** and sensitive government networks from breaches.
    - Eg: Played a vital role in securing **DRDO's communication channels** during critical projects.
3. **Offensive cyber operations**: Engages in **proactive cyber defense**, identifying and neutralizing malicious actors targeting national security.
    - Eg: Neutralized cyber-espionage attempts in India's defense and telecom sectors (2022).
4. **Counter-terrorism intelligence**: Tracks **terrorist communication networks**, including the darknet, to disrupt their activities.
    - Eg: Assisted in identifying and dismantling terrorist operations during **Pulwama investigations (2019)**.
5. **Capacity building and R&D**: Develops indigenous **cybersecurity tools** and conducts training programs to bolster India's cyber defense ecosystem.
    - Eg: Trained armed forces personnel on **cyber warfare preparedness** and secure network protocols.

Conclusion

India's **cybersecurity ecosystem** relies heavily on specialized agencies like CERT-In and NTRO for proactive threat mitigation. To counter evolving challenges, their capacity must be enhanced through **policy support, resource allocation, and global collaborations**, ensuring robust protection of the nation's communication networks.