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Index

How Drones Are the New Face of Warfare

Why in the News

- India's Operation Sindoor, launched in response to the Pahalgam terror attack in May 2025, marked a pivotal moment in the country's defence strategy.
- For the first time, India actively used drones in coordination with standoff weapons, redefining its approach to counter-terrorism and active combat.
- Globally, drone warfare is transforming, as seen in Ukraine's Operation Spider Web, Myanmar's rebel tactics, and the continued strategic deployment of drones in conflicts like the 2020 Nagorno-Karabakh war.

Background

- Drones, or Unmanned Aerial Vehicles (UAVs), have evolved from surveillance tools into decisive weapons on the battlefield.
- Earlier restricted to reconnaissance and tactical observation, they now carry out strikes, electronic warfare, and swarming missions.
- The 2020 Nagorno-Karabakh War was a turning point, demonstrating how loitering munitions (kamikaze drones) like the Israeli Harop could neutralise traditional air defence systems and armoured vehicles.
- Ukraine's ongoing conflict with Russia has taken drone warfare to an industrial scale. Ukraine, despite limited resources, has innovatively employed commercial drones, machine vision, and AI-driven terrain navigation to target high-value military assets.
- Meanwhile, Russia's use of Iranian Shahed drones in large numbers to overwhelm Ukrainian defences has shown how quantity can outweigh quality in this new era.
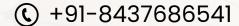
- This shift signifies that modern warfare is less about brute strength and more about tactical agility, innovation, and the integration of emerging technologies like artificial intelligence (AI), 3D printing, and autonomous control.

Features of Modern Drone Warfare
Blurring of Military and Commercial Technologies

- Modern drones range from high-end systems like Wing Loong II or TB-2 Bayraktar to commercially modified quadcopters equipped with explosive payloads.
- The dual-use nature of these technologies means civilian drones can easily be weaponised. This has created a strategic ambiguity on the battlefield.
- **For example,** during Ukraine's Operation Spider Web, commercial drones outfitted with explosives damaged four Russian air bases, targeting strategic bombers - an operation previously deemed feasible only for state militaries.

Force Multipliers in Asymmetric Conflicts

- Drones allow smaller, less equipped actors to level the playing field against technologically superior opponents.
- Myanmar's rebels have used 3D-printed drones to strike military bases.

These tactics are increasingly shaping low-cost, high-impact warfare models, which are extremely difficult to predict or counter.

Swarm and Saturation Tactics

- Russia's drone warfare campaign against Ukraine employs large swarms of Shahed drones.
- Their purpose is not just destruction but to overwhelm Ukrainian air defence systems and create openings for precision missile strikes.
- Similarly, China's CH-901 kamikaze drones are designed specifically for swarm tactics, posing a significant threat to India's defences along the Line of Actual Control (LAC).

Counter-Drone and EW Resilience

- Drones today are engineered to counter Electronic Warfare (EW) measures. Techniques like frequency hopping, AI-based jamming evasion, and pre-loaded topographical data help drones navigate contested zones.
- Ukraine's deployment of fibre-optic-tethered drones is a creative response to RF-jamming by Russian EW units.

Role in Strategic Deterrence

- Drones offer non-nuclear deterrence tools. In Operation Sindoor, India's use of standoff weapons and drones added a new layer of strategic ambiguity in cross-border retaliation.
- This helps create pressure without escalating to full conventional or nuclear war, especially in nuclear triads like South Asia.

Challenges
Countering Enemy Drones

- India's Integrated Air Command and Control System (IACCS).

systems like Akash, S-400, and MR-SAM have been effective in intercepting drones.

- However, high operational costs of air defence versus low-cost drone swarms raise sustainability concerns.
- For instance, deploying a multi-million-dollar interceptor missile to shoot down a $30,000 loitering drone creates a resource imbalance in prolonged engagements.

Inadequate Industrial Capacity

- India's anaemic defence procurement pipeline discourages private players from investing in drone production.
- The lack of consistent orders and uncertain demand cycles leads to low-volume production, which hampers the development of an agile and responsive drone ecosystem.
- In contrast, Ukraine's surge production using local workshops and 3D printers has ensured resilience despite heavy losses.

Strategic Threat from China and Pakistan

- China has developed a diverse drone fleet, including Soaring Dragon, BZK-005, and TB-001 for high-altitude surveillance and strikes.
- Coupled with affordable kamikaze drones, this enables swarm saturation attacks along the LAC.
- Pakistan has acquired drones like Bayraktar TB-2 and partnered with China to build armed UAVs.
- These could be deployed in cross-border strikes or terrorist attacks, making India's drone defence not just a military but a homeland security priority.

Non-State Actors and Internal Security

- Drones are increasingly being used by terrorist groups.
- Their low cost, easy availability, and minimal training requirements make them ideal for targeting civilian infrastructure, VVIP movements, and strategic assets.
- Internal security agencies need independent anti-drone mechanisms, especially around sensitive installations like nuclear plants, airports, and government buildings.

Ambiguity in Legal and Doctrinal Frameworks

- The rapid evolution of drone warfare has outpaced international law and military doctrines. For instance, whether a commercial drone carrying an IED constitutes an act of war remains debatable.
- This grey zone has been exploited by non-state actors and even state-sponsored proxies.
- India lacks a comprehensive doctrine on unmanned warfare, especially regarding rules of engagement, legal responsibility, and retaliatory thresholds.

Way Forward
Develop a National Drone Warfare Doctrine
India needs a doctrine on drone warfare encompassing rules for both deployment and engagement. This should include:

- Categorisation of drones by function (surveillance, combat, logistics).
- Command structures for cross-agency operations.

- Rules of engagement for internal security scenarios.
- Coordination between the MoD, MHA, and DRDO for technology sharing.

Scale Domestic Drone Production
A robust and diversified drone ecosystem requires:

- Stable and long-term procurement plans.
- Tax incentives, grants, and private-public partnerships.
- Promotion of start-ups through schemes like iDEX (Innovations for Defence Excellence).
- 3D printing and modular drone design for flexibility and rapid manufacturing.

Enhance Counter-Drone Infrastructure
Deploying a multi-layered counter-UAV network is crucial. It should combine:

- RF and acoustic sensors.
- Kinetic interceptors like Skywall or laser-based systems.
- Jamming and spoofing tools, especially for urban security forces.

Efforts should be extended beyond the armed forces to include:

- CRPF, NSG, SPG, CISF, and state police forces.

Invest in AI and Autonomy
India must boost R&D in AI-powered autonomous drones. Focus areas include:

- Autonomous navigation in GPS-denied zones.
- Swarm intelligence algorithms.
- AI-based target acquisition and adaptive mission programming.

Build Redundancy and Modularity

India should develop resilient drone fleets that can adapt in the event of attrition. Drawing on Ukraine's lessons, modular designs that allow for quick part replacement and 3D-printed components will be critical in extended wars.

Regional and Global Collaborations

India should deepen collaboration with Israel, France, and the U.S. for joint R&D and co-production. At the same time, India can also assist other nations in Asia and Africa through its Drone Shakti mission, creating strategic depth.

Civilian Regulation and Public Awareness

Civilian drone use should be regulated without stifling innovation. India's Drone Rules 2021 need regular updates to address:

- Geo-fencing of critical areas.
- Mandatory drone registration.
- Ban on weaponisable modifications for civilian drones.

Public campaigns on drone misuse awareness, akin to cybersecurity drives, can help in community-led surveillance and response.

Conclusion

The drone revolution has radically altered the dynamics of modern warfare, shifting power from heavy machines to smart, autonomous, and low-cost systems. India's adoption of drones during Operation Sindoor is a strategic watershed, but also a reminder that the future battlefield is already here. With adversaries like China and Pakistan investing heavily in drone ecosystems and non-state actors weaponising off-the-shelf technologies, India must act swiftly to bridge the capability and production gap.

Main question

Discuss the opportunities and challenges that drone technology presents for India in both external defence and internal security contexts." **(250 words)**

Question 1: Which of the following statements best explains the strategic significance of drone warfare in modern conflicts?

A. Drone warfare reduces the need for traditional intelligence, surveillance, and reconnaissance (ISR) systems and makes manned aircraft obsolete.
B. The use of drones in conflict enhances state accountability due to precise targeting and the transparency of real-time footage.
C. Drone warfare creates a grey zone between conventional and nuclear thresholds, enabling states to carry out precision strikes without escalating into full-scale war.
Drones are primarily useful for naval warfare and have limited application in land-based conflicts due to terrain and jamming constraints.

Correct Answer: C
Explanation:

Modern drone warfare enables precision engagement of targets below the threshold of traditional military escalation, particularly evident in conflicts like Operation Sindoor, where drones were used alongside standoff weapons. This creates strategic ambiguity, allowing states to respond to threats without crossing into full-scale warfare or provoking nuclear retaliation. This grey-zone utility is especially critical in the India–Pakistan and India–China contexts.

Option A is incorrect: Drones complement, not replace, traditional ISR or manned aircraft.

Option B is incorrect: Drones can be used covertly, and accountability depends on the actor's intent.

Option D is incorrect: Drones are widely used in land warfare, including urban and mountainous terrains (e.g., Ukraine, Myanmar).

Digital Postal Index Number (DIGIPIN)

Why in the News
- In a major step towards enhancing India's digital infrastructure and precision mapping, the Government of India has launched DIGIPIN, a geo-coded digital address system.
- Developed by the Department of Posts in collaboration with IIT Hyderabad and the Sensing Centre (NRSC) under ISRO, DIGIPIN aims to transform how addresses are genNational Remoteerated, accessed, and used, especially in regions without formal address structures.

Background
- India's traditional address system relies on the PIN Code, a six-digit numerical code introduced by India Post in 1972.
- While PIN codes have enabled effective mail sorting and delivery, they are area-based and cover broad geographical regions, leading to inefficiencies in last-mile delivery, poor location accuracy, and exclusion of remote or informal settlements.
- With rapid urbanisation, e-commerce expansion, and the growing need for location-based public services, India has been facing serious limitations with its address identification system. More than 20% of Indian addresses are non-standard, informal, or lack digital mapping.
- This scenario created the need for a next-generation addressing solution - one that is precise, scalable, and interoperable.

Features of DIGIPIN
Geo-Coded and GNSS-Based
- DIGIPIN leverages Global Navigation Satellite System (GNSS) data to assign each physical location a precise digital address. Each code corresponds to a 4x4 square meter area, ensuring ultra-high spatial resolution.

10-Character Alphanumeric Code
- Every location is given a unique 10-character alphanumeric code, allowing for standardisation, easy referencing, and reduced errors in location communication.

Open Source and Interoperable
- DIGIPIN is built on open-source principles, meaning the code can be freely used and integrated into different platforms- logistics apps, emergency services, navigation software, and more. This encourages innovation and adoption.

Privacy by Design
- The system does not store personal data, which addresses concerns around surveillance and data security. The focus is on the location, not the individual.

Wide Area Coverage
- It works across all terrains - urban, rural, tribal, forest, desert, and oceanic areas- thus covering regions where traditional addresses don't exist or are unreliable.

Significance of DIGIPIN
Precision Mapping
- It offers a fundamental shift from area-based codes to point-based identification, enabling micro-level
- This is critical for urban planning, infrastructure development, and disaster management.

Enhancing E-Commerce and Logistics
- For platforms like Amazon, Flipkart, and India Post itself, DIGIPIN removes ambiguity from addresses, reduces delivery errors, optimises routing, and enhances the last-mile delivery ecosystem.

Improved Emergency Services
- Police, ambulance, and fire brigades can quickly locate and reach people in distress, especially in remote areas or congested urban spaces with informal settlements.

Inclusive Governance
- Welfare schemes often fail due to address ambiguity. DIGIPIN helps in precise service delivery, identification of beneficiaries, and geotagging of households in schemes like PMAY, Ujjwala, and Jal Jeevan Mission.

Disaster Response and Environmental Monitoring
- During natural calamities or forest fires, DIGIPIN codes can help in pinpointing exact locations, aiding rescue operations and satellite-based tracking.

Maritime and Forest Zone Integration
- By extending geocoding to forests, oceans, and tribal belts, DIGIPIN helps include previously unaddressed geographies in national databases and development programmes.

Challenges
Despite its futuristic promise, DIGIPIN faces several roadblocks:
- Digital Literacy and Access
- Large sections of the population, especially in rural India, lack digital literacy or access to smartphones or GPS devices, limiting the reach of the system.

Adoption and Awareness
- Success hinges on mass adoption by citizens, government bodies, logistics players, and emergency services.
- A low adoption rate could reduce the system to a niche tool.

Integration with Legacy Systems
- India's existing systems, like PIN codes, Aadhaar addresses, land records, and electoral rolls, are not designed for GNSS-level granularity. Integration could be time-consuming and resource-intensive.

Privacy Concerns
- Although the system is privacy-conscious by design, any centralised digital infrastructure may draw scrutiny regarding location surveillance, especially if linked to other digital ID systems.

Infrastructure and Maintenance
- Maintaining the digital infrastructure across diverse geographies, ensuring real-time updates, and fixing bugs will require consistent technical investment and trained personnel.

Legal and Regulatory Framework
- There is currently no clear legal status or mandate for digital addresses. Without legislative backing, DIGIPIN may face resistance or a lack of uniform application across sectors

Way Forward
Legislative Backing and Standardisation
- The Government must formalise DIGIPIN through an Addressing Standards Act, laying out rights, responsibilities, privacy safeguards, and integration mechanisms.

National Awareness Campaign
- A wide-scale IEC (Information, Education, and Communication) campaign is required to familiarise citizens, postal workers, and local bodies with the use and benefits of DIGIPIN.

Integration with Public Services
- Government schemes like DBT, land records digitisation, Swamitva, PMGSY, and electoral rolls should integrate DIGIPIN for better targeting, verification, and delivery.

Private Sector Partnerships
- Collaboration with e-commerce firms, delivery startups, and telecom companies can fast-track adoption. Providing API access and incentives for adoption could prove effective.

Capacity Building and Training
- Postal workers, Gram Panchayats, municipal officials, and ASHA workers must be trained to use and explain DIGIPIN, especially in areas with low literacy or internet penetration.

Offline Accessibility Solutions
- DIGIPIN services must work in offline or low-bandwidth areas through SMS-based systems or QR codes to ensure universal utility.

Monitoring and Feedback Mechanism
- Establish a National Addressing Council to periodically review performance, fix bottlenecks, and ensure citizen feedback is incorporated.

Conclusion
DIGIPIN is a landmark initiative in India's journey towards precision governance and digital inclusion. By replacing vague and inconsistent address formats with geo-tagged digital identifiers, it holds the potential to revolutionise delivery, governance, and emergency response systems. However, success depends on public adoption, legal reinforcement, and ecosystem-wide integration. If implemented well, DIGIPIN can help map the unmapped India - empowering citizens, supporting digital commerce, and enhancing state capacity in a truly transformative way.

Main question
Question: Critically evaluate the potential of DIGIPIN in transforming public service delivery, logistics, and digital governance in India. Also, discuss the challenges in its implementation and suggest a way forward. **(250 words)**

Q. About DIGIPIN, recently launched by the Government of India, consider the following statements:
1. DIGIPIN codes are assigned using satellite-based Global Navigation Satellite System (GNSS) data and are accurate up to an area of 4 square kilometres.
2. It is a proprietary system developed solely by the Department of Posts without involvement from any research or space institutions.
3. DIGIPIN codes are interoperable, privacy-focused, and can function even in regions without traditional addresses.
4. Once assigned, a DIGIPIN is linked to the Aadhaar address database for welfare delivery and identification purposes.

Which of the above statements is/are correct?
A. 1 and 2 only
B. 3 only
C. 3 and 4 only
D. 1, 2, and 4 only

Answer: B. 3 only
Explanation:
- **Statement 1 Incorrect:** DIGIPIN codes correspond to 4×4 meter squares, not 4 square kilometres. The precision is much higher.
- **Statement 2 Incorrect:** It was developed by the Department of Posts in collaboration with IIT Hyderabad and NRSC under ISRO, not independently.
- **Statement 3 Correct:** DIGIPIN is open-source, interoperable, privacy-conscious, and works in areas with no formal addressing system.
- **Statement 4 Incorrect:** DIGIPIN does not link to Aadhaar or store any personal data- it is designed to be location-specific, not identity-specific.
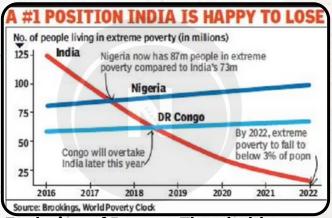
India's Poverty Decline

Why in the News?

The World Bank's recent report (June 2025) has made a striking revelation: extreme poverty in India has declined from 27.1% in 2011–12 to just 5.3% in 2022–23, based on revised poverty thresholds. This development represents one of the most significant reductions in poverty globally over the last decade. Importantly, these trends are being re-assessed using Purchasing Power Parity (PPP)-adjusted international poverty lines, offering a more realistic measure of the cost of living.

Background: Understanding the World Bank's Poverty Lines

- The World Bank uses international poverty lines to compare poverty across countries by adjusting for inflation and the relative cost of living.
- These thresholds are updated periodically using PPP conversion factors, allowing for consistent comparisons across space and time.

Source: Brookings, World Poverty Clock

Evolution of Poverty Thresholds:

- 2011 PPP: $1.90/day – for tracking global extreme poverty.
- 2017 PPP:
- $2.15/day – revised for lower-income nations.

June 2025 Update:

- Low-income countries: $3.00/day
- Lower middle-income countries (LMICs): $4.20/day (up from $3.65
- Upper middle-income countries: $8.40/day (up from $6.85)
- India, currently categorised as a lower-middle-income country, is now assessed at the $4.20/day benchmark.
- The update provides a more realistic lens for examining the scale and scope of poverty reduction, especially in emerging economies like India.

Features: Key Highlights of India's Poverty Reduction
Rural-Urban Trends

- Rural Poverty: Declined from 69% to 32.5%
- Urban Poverty: Declined from 43.5% to 17.2%
- Rural-Urban Gap: Narrowed from 25 to 15 percentage points
- This indicates that rural areas, though still lagging, have seen faster improvements- partly due to expanded rural employment, welfare coverage, and infrastructure.

Inequality Trends

- Consumption Gini fell from 28.8 to 25.5 – indicating improved consumption equality.
- Income Gini rose from 52 to 62, pointing to rising income concentration, especially among the top deciles.
- This reflects a paradox where consumption is more equitable (possibly due to subsidies and redistribution), but incomes are becoming more skewed, raising concerns about long-term economic equality.

Employment Dynamics
- Post-2021–22, employment growth has exceeded the working-age population growth.
- Urban Unemployment Rate: Dropped to 6.6%, the lowest since 2017–18.
- However, youth unemployment remains high at 13.3%, and among graduates, it's a worrying 29%.

This duality suggests India is creating jobs, but not necessarily the kind of skilled youth aspire an issue tied to education-employment mismatch.

Multidimensional Poverty Reduction
- Dropped from 53.8% (2005–06) to 15.5% (2022–23)
- **Covers:**

Health (nutrition, child mortality)
Education (years of schooling, school attendance)
Living Standards (sanitation, cooking fuel, housing, assets)
India's performance under the Multidimensional Poverty Index (MPI) demonstrates holistic progress, not just in income terms, but in well-being and dignity.

Challenges
Despite the impressive poverty reduction, several structural and emerging challenges

remain:
Rising Income Inequality
The growing gap between the rich and poor in terms of income (despite improved consumption equality) could:
Erode social cohesion
Fuel discontent

Undermine long-term sustainable growth
Youth and Educated Unemployment
- High unemployment among educated youth suggests systemic flaws in skilling and higher education.

- It risks the demographic dividend turning into a liability if not addressed urgently.

Regional Imbalances
- Northern and Eastern states still host a majority of the poor.
- The southern and western states have significantly lower poverty rates.
- This creates federal policy dilemmas around resource allocation and political equity.

Underemployment and Informal Work
- Much of the employment growth is in informal, low-paying jobs.
- The lack of formalisation reduces social security, labour rights, and economic mobility.

Urban Slums and Hidden Poverty
- Official urban poverty figures might underestimate deprivation in urban slums, where basic services, safety, and infrastructure are lacking.

Climate and Food Price Risks
- Rising food prices, extreme heat, droughts, and floods (as seen in 2024–25) threaten rural incomes and food security, especially for marginal communities.

Data Gaps and Methodology
- India hasn't released official poverty estimates post-2011–12.
- Much of the current analysis depends on modelled or estimated datasets, raising concerns about accuracy, granularity, and transparency.

Way Forward

To sustain and deepen poverty reduction, India must focus on inclusive, regionally balanced, and future-proof strategies. Invest in Job-Centric Growth

- Prioritise labour-intensive sectors (textiles, MSMEs, tourism)
- Encourage manufacturing clusters and startups beyond metros
- Promote green jobs aligned with climate goals

Skill India 2.0

- Strengthen the link between education and employability
- Create state-level skill strategies, targeting dropout youth and semi-urban populations
- Expand apprenticeship-based vocational models

Regional Equity

- Design targeted poverty alleviation strategies for high-burden states (UP, Bihar, MP)
- Increase devolution of funds and performance-based incentives under central schemes.

Modernise Social Safety Nets

- Expand Direct Benefit Transfers (DBT) with better Aadhaar-seeding and grievance redressal
- Create a portable welfare stack for migrant workers
- Universalise health and nutritional safety for children, pregnant women, and the elderly

Climate-Resilient Rural Development

- Scale up climate-smart agriculture
- Ensure crop insurance, irrigation access, and market linkages
- Green NREGA: integrate afforestation, water conservation, and renewable energy tasks

Release and Update Poverty Data

- India must resume regular Household Consumption Expenditure Surveys (HCES)
- Publicly release granular poverty and inequality data to enable evidence-based policymaking
- Empower Women and Marginalised Groups

Enhance female labour force participation through:

- Safe transport
- Flexible work
- Digital skilling
- Focus on ST, SC, and minority communities for affirmative development

Conclusion

India's poverty reduction journey over the last decade is nothing short of historic. From over a quarter of the population living in extreme poverty in 2011 to less than 6% by 2022–23, the nation has taken significant strides in inclusive growth. However, the goal of eliminating poverty in all forms requires vigilance, innovation, and equity-centred policymaking.

Main question

Critically examine the factors that contributed to poverty reduction in India and suggest strategies to ensure inclusive and sustainable development." **(150words)**

Q. According to the World Bank's 2025 revision of international poverty lines and recent estimates, which of the following statements is/are correct regarding poverty trends in India?

1. India's extreme poverty declined to 5.3% in 2022–23 when measured at the $2.15/day poverty line.

2. The updated poverty line for Lower Middle-Income Countries is now $4.20 per person per day.
3. Income inequality in India has improved between 2011–12 and 2022–23.
4. Uttar Pradesh, Maharashtra, Bihar, West Bengal, and Madhya Pradesh account for over half of India's poor population.

Select the correct answer using the code below:
A. 1 and 3 only
B. 2 and 4 only
C. 1, 2 and 4 only
D. 1, 2, 3 and 4

Correct Answer: C. 1, 2 and 4 only
Explanation:
- **Statement 1 is incorrect:** At $2.15/day, poverty fell to 2.3%, not 5.3%. The 5.3% figure applies to the $3/day threshold.
- **Statement 2 is correct:** In June 2025, the poverty line for Lower Middle-Income Countries was revised to $4.20/day.
- **Statement 3 is incorrect:** Income inequality worsened, with the Gini index rising from 52 to 62.
- **Statement 4 is correct:** These five states now represent about 54% of India's poor.

Tamhini Wildlife Sanctuary

Why in the News?

- The Tamhini Wildlife Sanctuary in Maharashtra recently gained national attention after the state Forest Department partnered with Microsoft and the Centre for Youth Development and Activities (CYDA), Pune.
- This unique collaboration aims to address socio-ecological challenges in the sanctuary through the application of digital technologies and inclusive community engagement.
- The initiative signifies a critical shift toward technology-enabled biodiversity conservation, integrating local livelihoods and environmental sustainability in one of the most ecologically sensitive regions of India.

Background

Tamhini Wildlife Sanctuary is located in the Western Ghats - a UNESCO World Heritage Site and one of the eight "hottest hotspots" of biodiversity globally. Notified in 1986, the sanctuary is situated near Pune, Maharashtra, and covers approximately 49.62 sq. km. It was carved out from:

- 12 compartments of reserved forests from the Paund and Sinhgad ranges in the Pune Forest Division, and
- 8 compartments from the Mangaon range in the Roha Division of Thane.
- Tamhini serves not just as a sanctuary for flora and fauna but also as an ecological buffer and watershed zone for the region.
- It supports dense forest cover, diverse wildlife, and important hydrological functions, making it critical for both biodiversity and human well-being.

Features of Tamhini Wildlife Sanctuary
Geographic and Ecological Setting

- Located in the northern Western Ghats, the sanctuary lies between the Mulshi and Kundalika valleys, which are rich in monsoon-fed streams, misty plateaus, and dense vegetation.
- It connects other key conservation landscapes like Bhima-Shivneri corridors and is close to Mulshi Lake and Tamhini Ghat, a tourist hotspot.

Vegetation and Forest Types

- The sanctuary features evergreen, semi-evergreen, and moist deciduous forests.
- Key tree species include:
  - Teak
  - Bamboo
  - Ain (Terminalia tomentosa)
  - Shisham
  - Mango and Jamun

These forests provide both ecological stability and economic resources to adjacent communities.

Faunal Diversity
Tamhini is a haven for a variety of mammals, birds, reptiles, and insects:

- **Mammals:** Indian giant squirrel, Indian pangolin, barking deer, Indian civet, wild boar.

- **Avifauna: It is especially rich in birdlife, including:**
  - Malabar Whistling Thrush
  - Crested Serpent Eagle
  - Grey Junglefowl
  - Golden Oriole
  - Indian Pitta

The area is also frequented by herpetofauna such as Indian rock pythons, frog species, and rare butterflies, making it a rich ecological repository.

Community Presence

Several tribal and rural communities live in the periphery, relying on the forest for:

- Non-Timber Forest Products (NTFPs)
- Small-scale farming
- Ecotourism
- Firewood collection

Their activities are both vital for survival and potentially damaging if not regulated sustainably.

Recent Tech Collaboration

The recent partnership with Microsoft and CYDA aims to:

- Digitally map ecological and socio-economic data
- Monitor species movement and habitat fragmentation
- Integrate youth and local knowledge systems in conservation
- Develop mobile apps and dashboards for real-time reporting

Challenges Facing Tamhini Wildlife Sanctuary
Despite its rich ecological and cultural value, Tamhini faces several ongoing threats:
Habitat Fragmentation

- Linear infrastructure like roads, power lines, and tourism facilities has sliced through animal corridors.
- The expansion of the Mulshi dam backwaters has disrupted water flow and submerged forest patches.

Unregulated Tourism

- Tamhini Ghat is a popular destination during the monsoon. However, unregulated visitors, vehicular pollution, and littering harm the ecosystem.
- Noise and light pollution disturb sensitive bird and mammal species.

Human-Wildlife Conflict

- With wildlife venturing into fields for food, cases of crop damage and occasional attacks on livestock are reported.
- This leads to retaliatory actions by locals and reduced tolerance for conservation.

Lack of Data-Driven Management

- The sanctuary lacks a comprehensive ecological database to guide forest officers.
- Wildlife tracking is still largely manual and sporadic, limiting effective anti-poaching or rescue efforts.

Climate Variability

- Changing rainfall patterns and increasing heat waves affect the health of moist forests and endemic species.
- Ephemeral streams vital for wildlife during summer are drying earlier, reducing water security.

Socioeconomic Pressures

- Youth migration, unemployment, and lack of alternative income sources force many locals to rely heavily on forest resources.
- The absence of structured eco-development programs leads to unsustainable harvesting of forest goods.

Way Forward

Tamhini Wildlife Sanctuary's future depends on integrated conservation strategies that balance biodiversity needs with community aspirations and technological innovation.

Community-Centric Conservation

- Expand Joint Forest Management Committees (JFMCs) with representation from women and youth.
- Promote sustainable livelihoods like eco-guiding, handicrafts, NTFP value-addition, and organic agriculture.

Technology and Data Integration

- Use AI and remote sensing to monitor deforestation, illegal encroachment, and species movement.
- Create mobile-based citizen science platforms to involve tourists and villagers in biodiversity monitoring.

Regulating Tourism

- Implement a carrying capacity model and eco-tourism guidelines.
- Promote off-season tourism and guided nature trails to reduce environmental impact.

Landscape-Level Planning

- Integrate Tamhini with nearby corridors like Bhima, Varandha–Koyna to ensure long-range animal movement.
- Prioritise wildlife overpasses and underpasses for safe crossings.

Climate-Resilient Restoration

- Use native species to reforest degraded patches.
- Protect natural springs and watersheds that serve both wildlife and villages.

Education and Youth Engagement

- Strengthen partnerships with schools, NGOs, and companies like Microsoft for tech-enabled conservation education.
- Organise wildlife camps, digital storytelling projects, and skill training for eco-entrepreneurship.

Conclusion

Tamhini Wildlife Sanctuary exemplifies both the richness and fragility of India's ecological landscapes. Its recent partnership with Microsoft and CYDA represents a new chapter in digitally empowered, people-participative conservation. To ensure that Tamhini continues to thrive, efforts must be made to align environmental protection with livelihood generation, science with tradition, and policy with participation. Only then can Tamhini truly become a model for sustainable forest management in the 21st century.

Main question

Q.. "Tamhini Wildlife Sanctuary in Maharashtra reflects the growing synergy between technology, conservation, and community involvement. Critically evaluate the role of recent public-private partnerships in promoting sustainable forest management in ecologically sensitive zones."   **(150 words)**

Q. Consider the following statements about Tamhini Wildlife Sanctuary:

1. It is located in the Eastern Ghats and is famous for dry deciduous forests.
2. It has recently partnered with private entities to address conservation using AI and mapping tools.
3. The sanctuary was carved from compartments belonging solely to the Thane Forest Division.

4. Indian pangolins, civets, and Indian pittas are found in the sanctuary.

Which of the above statements are correct?
A. 2 and 4 only
B. 1, 3, and 4 only
C. 2 and 3 only
D. 1 and 2 only
Correct Answer: A. 2 and 4 only

Explanation:
- **Statement 1 is incorrect:** Tamhini is in the Western Ghats, not the Eastern Ghats.
- **Statement 2 is correct:** It is in the news for partnering with Microsoft and CYDA for AI/mapping-based conservation.
- **Statement 3 is incorrect:** It includes compartments from both Pune and Thane divisions, not just Thane.
- **Statement 4 is correct:** These species are native to the sanctuary.

Arsia Mons

Why in the News?

NASA's 2001 Mars Odyssey orbiter recently captured a stunning image of Arsia Mons rising through a thick blanket of early morning Martian clouds. The image offers unprecedented visual clarity of the largest volcano in the Tharsis region of Mars and highlights the complex relationship between Martian topography and atmospheric dynamics.
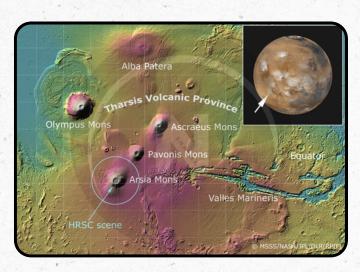

Background

- Arsia Mons is a giant shield volcano located on Mars, forming part of the Tharsis Montes - a trio of colossal volcanic mountains on the Red Planet.
- Named after the Latin word Arsia, meaning "burnt" or "scorched," it was first observed through telescopic data and later studied in detail by space missions like Mariner 9, Viking Orbiters, and Mars Odyssey.
- With dimensions dwarfing Earth's volcanoes, Arsia Mons provides valuable insights into Martian geologic history, tectonic activity, and planetary evolution.

Features of Arsia Mons
Volcano Type

- Shield Volcano: Formed by low-viscosity basaltic lava flows that spread over large areas, leading to a broad, dome-like structure.

Size and Scale

- Height: Over 18 km (11 miles) above the Martian surface (more than twice the height of Mount Everest).
- Base Diameter: More than 300 km (190 miles).
- Caldera: Summit depression roughly 110 km (68 miles) wide.

Geological Composition

- Dominated by fluid basaltic lava, consistent with shield volcanoes on Earth like Mauna Loa.
- Lava channels, flow ridges, and vents visible on its flanks indicate a complex volcanic history.

Eruptive History

- Likely active for over 3 billion years.
- The most recent eruptions may have occurred as recently as 2 million years ago - relatively recent in planetary terms.

Atmospheric Interaction

- A recent image captured the volcano piercing through early Martian clouds, which are composed of water-ice crystals, providing insights into Martian atmospheric circulation.

Challenges
Climate Implications

- How have Arsia Mons' eruptions impacted the Martian climate and atmosphere composition over geological timescales?

Life and Habitability

- Ancient lava tubes and thermal energy may have provided a habitable environment for microbial life, a key target for astrobiological research.

Remote Mapping Difficulties

- The Martian atmosphere, though thin, presents challenges in capturing clear images due to dust storms and low light angles.

Landing Hazards

- The steep flanks, rugged terrain, and potential lava tube collapses make landing and exploring this region technologically demanding.

Way Forward
Robotic Exploration

- Future missions should target lava tubes on Arsia Mons to study geothermal activity and search for biosignatures.

Orbital Surveillance

- Continued imaging by satellites like Mars Odyssey, MAVEN, and the Mars Reconnaissance Orbiter will help monitor any changes in the surface or atmospheric interaction.

Planetary Comparison

- Comparing Arsia Mons with Earth's shield volcanoes can reveal planetary similarities and divergences in volcanism.

Human Exploration

- Arsia Mons may serve as a potential base site in the future due to its elevation (reducing atmospheric pressure challenges) and possible underground lava tubes for shelter.

Earth Analogue Research

Terrestrial studies in Hawaii and Iceland offer analogues for understanding Martian volcanic structures and can guide robotic mission planning.

Conclusion

Arsia Mons, one of the largest volcanoes in the solar system, is more than just a Martian landmark - it is a window into the planet's geologic and atmospheric history. As NASA's Mars Odyssey reveals new perspectives, this ancient volcano may yet yield answers about Mars' past, its habitability, and the broader story of planetary evolution across the solar system.

Main Question

Q.. "Discuss the scientific significance of Arsia Mons in understanding Martian geology and the potential for past habitability on Mars. How can recent advancements in planetary imaging, such as those from NASA's Mars Odyssey, aid future exploration missions?"
(Answer in 150 words)

Q. About Arsia Mons, consider the following statements:

1. It is the tallest known mountain in the entire solar system.
2. Arsia Mons is a stratovolcano located in the eastern hemisphere of Mars.
3. The caldera at the summit of Arsia Mons is over 100 km wide.
4. Recent images by NASA's 2001 Mars Odyssey show Arsia Mons rising above early morning cloud cover.

Which of the above statements are correct?

A. 1, 2 and 3 only
B. 3 and 4 only
C. 1 and 4 only
D. 2, 3 and 4 only

Correct Answer: B. 3 and 4 only

Explanation:

- **Statement 1 Incorrect:** Olympus Mons (not Arsia Mons) is the tallest mountain in the solar system.
- **Statement 2 Incorrect:** Arsia Mons is a shield volcano, not a stratovolcano.
- **Statement 3 Correct:** Its caldera is ~110 km wide.
- **Statement 4 Correct:** NASA's Mars Odyssey recently captured Arsia Mons above cloud cover, making headlines.

Thitu Island Incident: Renewed Flashpoint in South China Sea Dispute

Why in the News?

A Chinese vessel recently ran aground near Thitu Island (Pag-asa Island), which is administered by the Philippines, amid severe weather and shallow waters. The incident prompted a high alert response from Filipino troops stationed on the island, citing potential maritime security threats in the disputed South China Sea (SCS).

This episode comes amid growing tensions between China and the Philippines, particularly over freedom of navigation, sovereignty claims, and military posturing in the resource-rich and strategically vital region.

Background
About Thitu Island (Pag-asa Island)

- Location: South China Sea, part of the Spratly Islands archipelago.
- Alternative Name: Known as Pag-asa Island in the Philippines.

Significance:

- Second-largest naturally occurring island in the Spratlys.
- The largest island occupied by the Philippines in the archipelago.
- Administration: Under Philippine control since 1971.

Inhabitants:

- Civilian settlers since the 1990s.
- Home to a fishing village, a school, a municipal government, and a Philippine military garrison.

Infrastructure:

- Rancudo Airfield
- Lighthouse for navigation
- A harbour that supports local and military logistics

Proximity to China:

- Only 24–27 km from China's Subi Reef, where military installations, including a runway and radars, are located.
- The Spratly Islands Dispute

Claimants:

- China, Taiwan, and Vietnam claim the entire archipelago.
- Malaysia and the Philippines claim portions of it.

Strategic Importance:

Key sea lanes (1/3 of global shipping passes through the SCS).

- Rich in hydrocarbons, fisheries, and potential undersea mineral resources.
- Military vantage points due to the reef-to-island conversion.

UNCLOS & 2016 Ruling:

- The Permanent Court of Arbitration (PCA) ruled in 2016 against China's "Nine-Dash Line" claim.

However, China rejected the ruling and continued militarisation.

Challenges
Maritime Tensions and Incursions

- Regular presence of Chinese militia and coast guard ships around Thitu Island.
- Harassment of Filipino fishermen and supply missions by China's maritime forces.
- Increased risk of accidental clashes due to close naval encounters.

Geopolitical Confrontation

- The island is a flashpoint between the U.S.-backed Philippines and assertive Chinese claims.
- The presence of foreign naval ships, including U.S. freedom of navigation operations (FONOPs), increases great-power competition.

Violation of International Law

- Despite the 2016 PCA ruling, China continues artificial island-building, militarisation, and rejection of international arbitration.

Environmental Degradation

- Coral reefs are being damaged due to reclamation activities and illegal fishing practices.
- Local biodiversity, essential for the livelihood of islanders, is threatened.

Vulnerability to Natural Disasters

- The island is exposed to typhoons, rising sea levels, and cyclonic winds.
- Inadequate disaster preparedness and poor evacuation logistics remain concerns.

Infrastructure Constraints

- Civilian facilities are rudimentary and depend heavily on supply ships.
- Harsh marine conditions and Chinese interference often delay or block resupply missions.

Way Forward
Strengthening Legal and Diplomatic Posture

- The Philippines should continue to reaffirm sovereignty using UNCLOS and PCA rulings as the legal foundation.
- Enhance cooperation through ASEAN, the Quad, and global platforms like the UN and IORA.

Boosting Island Resilience

- Invest in sustainable infrastructure: renewable energy, desalination, and disaster shelters.
- Expand civilian settlement programs and eco-tourism potential under regulated norms.

Defensive Modernisation

- Strengthen surveillance via radar, coastal monitoring, and drone systems.
- Upgrade Rancudo Airfield for better defence preparedness and emergency response.

Maritime Domain Awareness (MDA)

- Collaborate with nations like the U.S., Japan, and Australia on intelligence sharing and naval training.
- Use satellite and AI-enabled monitoring for real-time tracking of foreign ships.

Confidence-Building Measures (CBMs)

- Initiate Code of Conduct (CoC) negotiations under ASEAN-China frameworks.
- Establish hotlines and naval protocol agreements to prevent clashes and accidental escalation.

Community Empowerment

- Provide education, healthcare, and livelihood support for islanders.

- Promote sustainable fishing practices, marine conservation zones, and participatory governance.

Environmental Safeguarding

- Enforce rules against reef damage, cyanide fishing, and overexploitation.
- Partner with international bodies on marine biodiversity protection.

Conclusion

The recent grounding of a Chinese vessel near Thitu Island underscores the fragility and volatility of the South China Sea disputes. As a symbol of sovereignty and resilience, Thitu Island represents the Philippines' frontline in asserting maritime rights and protecting its people.

While military readiness is essential, a holistic strategy encompassing diplomacy, development, environmental care, and legal assertion is vital for long-term peace and sustainable presence in this strategically contested region.

MAIN QUESTION

Thitu Island has emerged as a flashpoint in the South China Sea dispute. Discuss the strategic importance of the island for the Philippines and analyse the multifaceted challenges involved in maintaining sovereignty over such contested territories.

Q. About Thitu Island (Pag-asa Island) in the South China Sea, consider the following statements:

1. Thitu Island is the largest naturally formed island in the Spratly group.
2. It lies more than 100 km from any Chinese military facility.
3. The 2016 ruling of the Permanent Court of Arbitration supported China's Nine-Dash Line claim.
4. The island hosts both military and civilian infrastructure under Philippine administration.

Which of the above statements is/are correct?

A. 1 and 2 only
B. 4 only
C. 1, 3, and 4 only
D. 1 and 4 only

Answer: B. 4 only
Explanation:

- **Statement 1 is incorrect:** Thitu is the second-largest naturally formed island, not the largest.
- **Statement 2 is incorrect:** Thitu lies just 24–27 km from China's Subi Reef, not over 100 km.
- **Statement 3 is incorrect:** The 2016 PCA ruling rejected China's Nine-Dash Line claim.
- **Statement 4 is correct:** Thitu Island has both civilian and military infrastructure administered by the Philippines.

India's first gene-edited sheep

Why in the News?

- India has achieved a breakthrough in livestock biotechnology with the successful development of the country's first gene-edited sheep by researchers at the **Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST)**, Kashmir.
- This sheep, a Kashmir Merino, has undergone CRISPR-Cas9 gene editing to disable the myostatin gene, leading to a significant 30% increase in muscle mass.
- The success marks a full-lifecycle application of gene-editing, from lab to live birth, and signals India's growing capabilities in advanced genomic research in agriculture.

BACKGROUND
Gene Editing in Livestock
Gene editing is a revolutionary biotechnology that allows for precise alterations in an organism's DNA to improve desirable traits. CRISPR-Cas9, one of the most popular gene-editing tools, enables scientists to cut and modify specific genes efficiently and cost-effectively. While gene editing has been applied in crops, its use in livestock has been limited in India due to ethical, regulatory, and infrastructural constraints.

However, globally, countries like China, the U.S., and Brazil have advanced research in gene-edited pigs, cattle, and sheep to improve meat yield, disease resistance, and wool production. India's entry into this domain marks a turning point.

About Kashmir Merino Sheep

- Origin & Development: Kashmir Merino is a domesticated breed created by crossbreeding exotic Merino rams with local sheep in Jammu and Kashmir.
- Climate Adaptation: Bred to thrive in cold and high-altitude Himalayan regions, they are resilient to low oxygen and extreme temperatures.
- Wool Quality: Known for fine, soft, and dense wool, which is highly valued in the handicrafts and textile industry.
- Livestock Economy: These sheep play a critical role in the local agrarian economy, providing both wool and mutton, thus ensuring livelihood for hundreds of families.

FEATURES OF THE GENE-EDITED SHEEP
Targeted Gene – Myostatin

- What it does: Myostatin naturally limits muscle growth in mammals.
- Editing impact: Disabling this gene using CRISPR-Cas9 removed the brake on muscle development, leading to ~30% more muscle mass, increasing meat yield without adverse effects.

Full-Cycle Genetic Innovation

- Embryo Development: The gene-edited embryo was developed in vitro (in the lab).

- **Surrogacy & Birth:** Successfully transferred to and carried by a surrogate ewe, demonstrating the viability of advanced reproductive technologies in India.

Potential Use Cases

- **Meat Production:** Improved yield can boost farmers' income and address protein demands.
- **Wool Quality Enhancement:** Gene editing may be adapted for improving fibre strength, fineness, and dyeability.
- **Disease Resistance:** Future gene targets could help resist parasitic and bacterial infections, reducing veterinary costs.
- **Pharmaceutical Proteins:** Sheep could be used to produce transgenic proteins for medical use.

India's Biotech Milestone

- **First of its kind:** Marks India's debut in gene-edited livestock, joining the ranks of advanced agri-biotech nations.
- **Public Sector Leadership:** The development by SKUAST highlights the capacity of Indian state universities to lead in cutting-edge research.

CHALLENGES
Regulatory Uncertainty

- India lacks clear-cut laws for gene-edited animals. The regulatory framework under GEAC (Genetic Engineering Appraisal Committee) is primarily focused on genetically modified crops, not livestock.

Ethical & Animal Welfare Concerns

- The use of embryos and gene manipulation raises bioethics debates.

- Activist concerns about unintended side effects, animal suffering, and commercial exploitation may arise.

Public Acceptance

- Perceptions of GM organisms in India are mixed.
- Consumers and farmers may resist gene-edited meat due to a lack of awareness or misconceptions.

Technical Barriers

- Reproductive technologies like embryo transfer, in vitro fertilisation (IVF), and cloning are not widely available in rural India.
- Maintaining gene-edited lines in harsh field conditions poses logistical challenges.

Export & Trade Limitations

- Many global markets are cautious about accepting genetically edited meat or wool, which could affect India's agricultural exports if not clearly labelled or regulated.

Way forward
Develop a Robust Regulatory Framework

- Draft clear policy guidelines for gene-edited animals, separating them from GMOs that involve transgenic foreign DNA.
- Adopt a case-by-case risk assessment approach, in line with the U.S. FDA and Japan's regulatory models.

Public Education and Farmer Engagement

- Launch awareness programs to educate farmers and consumers about gene editing, its benefits, and safety.
- Encourage pilot adoption in state-run sheep farms before scaling to private breeders.

Promote Ethical Research Practices
- Create bioethics committees in agricultural universities.
- Maintain strict animal welfare protocols and encourage transparent reporting of results and side effects.

Invest in Infrastructure and Training
- Expand animal biotechnology labs and IVF clinics in rural research centres.
- Train veterinarians and animal breeders in gene-editing tools and embryo transfer techniques.

Link with National Missions
- Align this innovation with the National Livestock Mission (NLM) and Startup India for Agri-Tech.
- Promote entrepreneurship in gene-editing startups for sheep, goats, and cattle.

Global Collaboration
- Partner with institutions in the EU, U.S., and Australia to benchmark protocols, ethics, and outcomes.
- Share gene-editing tools and techniques via South-South Cooperation with other developing nations.

CONCLUSION
The development of India's first gene-edited sheep using CRISPR-Cas9 technology is a landmark scientific achievement that holds promise for transforming animal husbandry. It symbolises the potential of Indian agricultural research to shift from traditional practices to precision biotechnology. However, for this breakthrough to translate into real-world benefits for farmers and consumers, India must urgently build a robust policy, regulatory, and ethical ecosystem.

With the right support, gene-edited livestock can ensure food security, higher rural incomes, and global competitiveness in the biotechnological age.

What is the application of somatic cell nuclear transfer technology?
Options:
(a) Production of bio larvicides
(b) Manufacture of biodegradable plastics
(c) Reproductive cloning of animals
(d) Production of organisms free of diseases

Answer (c)
Explanation: Somatic cell nuclear transfer (SCNT) is a technique where the nucleus of a somatic (body) cell is transferred into an enucleated egg cell, allowing the egg to develop into a genetically identical clone of the donor cell. The most famous example of this is the cloning of Dolly the sheep.
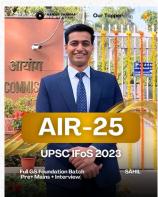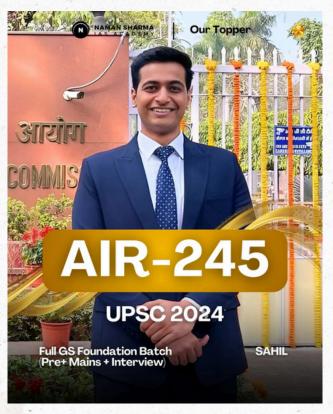
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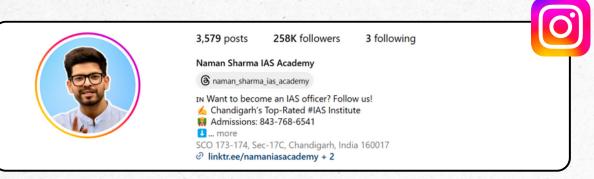AIR-35, PCS 2021
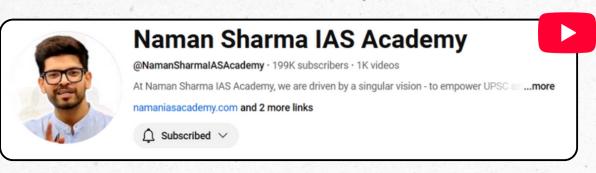
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