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ABSTRACT

New methods: Garnierite, a greenish nickel ore, on the bank of a river in Indonesia on April 16. AFP

How extracting and producing nickel can be made more sustainable

Nickel is an important metal used in several clean energy technologies, especially electric vehicles. The demand for it is expected to surpass six million tonnes a year by 2040. However, producing just one tonne of nickel can result in more than 20 tonnes of carbon dioxide emissions

Hirra Azmat

Manzoor, U., Mujica Roncery, L., Raabe, D. et al, 'Sustainable nickel enabled by hydrogen-based reduction', *Nature* 641, 365-373 (2025). doi.org/10.1038/s41586-025-08901-7

Nickel powers everything, from gadgets to green technologies. But getting it currently involves a far from green, in fact, a dirty process. However, a new study has revealed what its authors have said is a game-changing and sustainable method to extract nickel from low-grade ores using hydrogen plasma instead of carbon. It's a one-step process free of carbon dioxide that reportedly saves both energy and time.

Nickel is an important metal used in several clean energy technologies, especially Electric Vehicles (EVs), and the demand for it is expected to surpass six million tonnes a year by 2040. While EVs are seen as a cleaner alternative to traditional fossil fuel-powered vehicles, there are hidden environmental costs associated with their production, especially in the manufacturing of lithium-ion batteries.

A major component in these batteries is nickel and its extraction is highly carbon-intensive. Producing just one tonne of nickel can result in more than 20 tonnes of carbon dioxide emissions. So while EVs reduce emissions during operation, the process of sourcing materials like nickel simply shifts the pollution burden from the transportation sector to the mining and processing sector, among others.

The methodology

The study, published in *Nature* on April 30, was conducted by researchers at the Max Planck Institute for Sustainable Materials in Düsseldorf, Germany. In the study, the researchers bypassed the traditional multistep process to extract nickel – which includes calcination, smelting, reduction, and refining – and developed a single metallurgical step conducted in one furnace. "The proposed method has the potential to be up to about 18% more energy efficient while cutting direct carbon dioxide emissions by up to 84% compared with the current practice," the paper wrote.

Ubaid Manzoor, a researcher at the Max Planck Institute and lead author of the study, said, "Traditional nickel extraction is multi-step, energy-intensive and relies on carbon. Nickel oxide is heated with carbon, which removes the oxygen, producing pure nickel, along with carbon dioxide emissions." The researchers have proposed replacing carbon with hydrogen as the reducing agent and using electricity as the energy source, specifically through an electric arc furnace.

"In our method, we use hydrogen plasma. Hydrogen gas, when subjected to high-energy electrons in an electric arc, splits into high-energy ions, entering a plasma state – the extremely hot and reactive fourth state of matter. It is distinct from solids, liquids, and gases. This hydrogen plasma rapidly reduces the metal oxides. From a thermodynamic perspective, the process is not only cleaner but significantly faster," Mr. Manzoor said. He added that the method is kinetically superior – meaning the chemical reaction is more energetically favoured – thanks to the highly reactive and unstable nature of plasma.

"The end product of hydrogen reacting with oxygen is water, not carbon dioxide. Therefore, the entire process is carbon-free, using only electricity, hydrogen, and yielding water as a byproduct," he added.

Enabling sustainable production

The study focused on laterite ores, a type of soil-rich rocks that contain metals like nickel. They form in hot, tropical regions when rain and heat break down rocks over time, leaving behind metal-rich layers. They are abundant but tough to process. "While sulphide ores are found deeper underground and are easier to process, they're rapidly depleting. The new method used in the study works efficiently on laterites, making it key to future nickel production," Mr. Manzoor said.

India has substantial nickel laterite reserves, particularly in Odisha's Sukinda region. "These deposits, containing 0.4-0.9% nickel as nickeliferous limonite in chromite mine overburden, are often overlooked because traditional methods require higher-grade ores. But [the team's method] excels at extracting value from these lower-grade resources," Dierk Raabe, professor and director of the Max Planck Institute and co-author of the study, said. He added that the technology could play a major role as the demand for sustainably produced materials continues to grow.

"Without such innovations, the sustainability revolution – whether in electrification, renewables, or green infrastructure – risks merely shifting the carbon dioxide and energy burdens from one sector to another. In other words, we might build a 'greener' world through EVs, solar panels, and high-performance magnets while still relying on carbon-intensive methods to mine and refine the critical metals ... that make all of it possible," he said.

The inescapable demand for nickel in multiple industries and its traditionally carbon-intensive production pose "a particular challenge for countries like India, where rapid industrial growth is essential for economic development. India must simultaneously meet ambitious climate goals and leverage market opportunities in the green economy," Mr. Raabe added.

He continued that the technology aligns well with India's dual goals – to accelerate industrialisation and infrastructure development while staying committed to the goal of achieving net-zero emissions by 2070. It also reduces the need to import high-grade ores and maximises the potential of domestic, underutilised mineral assets, he added.

Some challenges

Pratik Kumar, assistant professor in the Department of Civil Engineering at IIT-Jammu and who wasn't associated with the new study, said this research could be a very appropriate method for nickel extraction from an ore, especially when the world is thinking critically in the direction of carbon neutrality. The method produces high-purity ferronickel – an alloy with which stainless steel can be made – eliminating the need for extensive refining steps and making the overall process more sustainable on paper. "However, the scalability of the mentioned study to an industrial production would involve certain challenges, including a high initial investment in infrastructure and renewable energy and limitations in ore applicability. Also, further in-depth study on thermodynamic kinetics may be required along with a demand for continuous free oxygen species supply at the arc-melt interface," Mr. Kumar cautioned.

"Despite these hurdles, the study offers a promising, sustainable alternative to conventional nickel extraction methods."

Hirra Azmat is a Kashmir-based journalist who writes on science, health, and environment.

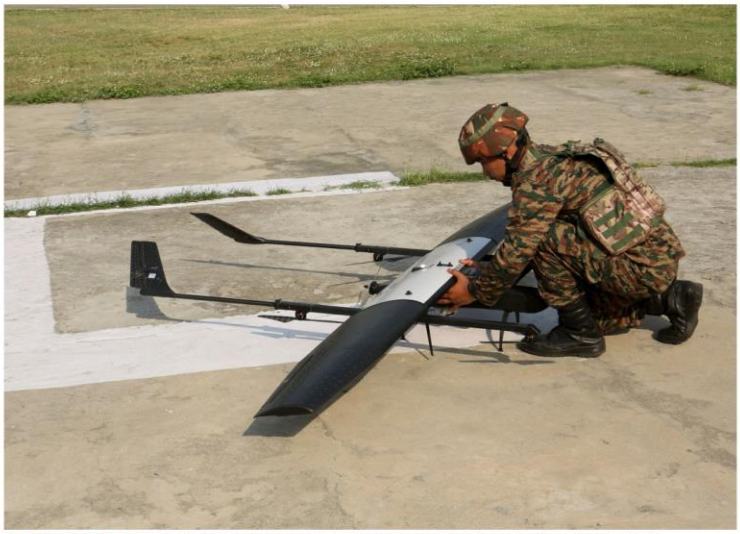
How drones are the new face of warfare

The ubiquitous drone is rapidly becoming the weapon of choice in active combat, serving as a force multiplier to achieve strategic objectives while blurring the distinctions between military-grade and commercial technologies

WORLD INSIGHT

Pushan Das

India's Operation Sindoor in the wake of the Pahalgam terror attack has marked a notable shift in the country's adoption of Unmanned Aerial Vehicles (UAVs) in combat. In combination with standoff weapons, India's use of UAVs in active combat represents a tactical shift in military doctrine – part of a global playbook. Ukraine's Operation Spider Web also marks a turning point in how low-cost, improvised unmanned systems can be employed with strategic impact.



New modes of combat: An Indian soldier pictured with a drone at the Akhnoor sector near the Line of Control (LoC) in Jammu on May 19. AFP

Global precedents

The ubiquitous drone is rapidly becoming the weapon of choice serving as a force multiplier to achieve strategic objectives while blurring the distinctions between military-grade and commercial technologies. Building resilience in drone warfare requires India to build modularity and redundancy in mass produced drones, and nurture a responsive defence production base.

The Nagorno-Karabakh War in 2020 provided one of the first demonstrations of how drones can change the nature of aerial warfare with new capabilities. Azerbaijan's success hinged on the use of loitering munitions or Kamikaze drones, like the Israeli-made Harop drones, in destroying air defences.

Additionally, the war in Ukraine has emerged as a real-world laboratory for drone technology, with rapid innovation and counter innovation cycles defining modern warfare. However, Ukraine's most obvious innovation was the country's ability to produce and deploy a wide variety of drones. In Myanmar also, rebel groups are deploying 3D-printed drones against a better-equipped military, levelling the playing field.

As India continues to reform and modernise its military, learning and applying the right lessons from recent conflicts, including Operation Sindoor, is key. Among New Delhi's adversaries, China already has a large and diverse fleet of unmanned systems, which could provide it with an edge in a potential war along the Line of Actual Control (LAC). Pakistan too has bolstered its unmanned weapons capabilities through collaborations with China and Türkiye.

Drone resilience

Drones are vulnerable to many countermeasures such as electronic warfare, guns and air defences. The impact of drones, therefore, depends on its ability to evade or overwhelm defences against them.

Countermeasures against drones in the form of air defences come with limitations and vulnerabilities and can be defeated through a range of technologies and tactics, making innovation and counter-innovation a critical part of drone warfare. India's counter-drone systems include multilayered sensors and weapon systems, as well as indigenously developed soft- and hard-kill counter-UAV systems. Both played a crucial role in thwarting Pakistan's drone and missile attacks in the recent flareup of hostilities.

To evade such systems, drones can, with advanced navigation, be made to adjust flights. Similarly, Artificial Intelligence (AI) and frequency hopping can be used to overcome jamming and spoofing autonomously. For instance, Ukraine has incorporated machine vision algorithms and pre-loaded terrain data to navigate complex routes in order to avoid air defences. By operating at low altitudes, drones can exploit gaps in radar coverage and reduce the likelihood of detection.

Some drones are also designed with electronic warfare features, allowing them to jam or spoof enemy radar and communication systems. These capabilities enhance their survivability and effectiveness in contested environments. Ukrainian developers came up with a simpler solution – tethering a drone to a fibre-optic cable for guidance.

Alternatively, employing a large number of drones and decoys to fly in mass can overwhelm and confuse air defence and surveillance systems. Russia's drone campaign, for instance, makes use of Shahed drones to saturate Ukrainian air defences. It causes dilemmas on the rate of attrition of limited air defence assets, and creates openings for precision strikes.

India's air defence systems tied together under the Integrated Air Command and Control System (IACCS) performed well against numerous Pakistani drones and missile attacks. Boosting procurement and domestic production of munition stocks for its air defence systems (S-400, MR-SAM, Akash, etc) will be key to building magazine depth in any protracted conflict. With regard to the offence debate, given the low survivability rate of current drones, India will need to invest in building volume in its drone and loitering munitions toolkit.

The military-commercial crossover

Ukraine's Operation Spider Web demonstrated that low-cost UAV's combined with accessible technologies and innovative employment strategies can have strategic impact deep into enemy lines. The operation targeted four air bases inflicting damage to Russia's long-range bomber fleet.

The fact that almost any drone can be used and modified to become an offensive weapon, coupled with the widespread use and accessibility of drones, has blurred the distinctions between military-grade and commercial drone systems. Moreover, the indiscriminate use of the term "drones" obscures distinctions in capabilities, intended uses and public perception.

While advanced military-grade drones offer greater capabilities, they also come with higher costs and logistical challenges. Easily available commercial systems, open-source software, and modular engineering have lowered the entry barrier for the adoption of drone technologies. There is a trade-off between adding capabilities to drones and an increase in cost, size, and complexity. For example, drones such as China's Wing Loong, Iran's Shahed, or Turkey's TB-2 incorporate low-cost and dual-use technologies.

Innovation in technology has not been the only novelty in drone use, for manufacturing has also changed. 3D printing is rapidly becoming a key multiplier. For instance, in conflict zones such as Ukraine (Titan Falcon) and Myanmar (The Liberator MK1 and MK2) 3D printers provide alternate sources to mitigate manufacturing shortages. The adaptive employment of off-the-shelf drone technologies by non-state actors is providing states with valuable lessons in asymmetric and low cost aerial capabilities. For example, the U.S. and the U.K. are exploring commercial 3D printing ventures to mass produce drones at scale in order to manufacture bespoke components of weapons systems, thereby bypassing complex, expensive and often slow moving logistics supply chains.

India needs to prepare for the inevitability of easily weaponised commercial drones being used by terrorist organisations and non-state actors against its strategic and civil infrastructure. Counter-drone systems and tactics cannot be the purview of the military alone and should also be prioritised by internal security agencies.

Implications for India

The widespread adoption of drones in warfare signifies a shift in military strategy and operations. By deploying standoff weapons along with drones during Operation Sindoor, India has introduced a layer of strategic ambiguity – one that expands its toolkit vis-a-vis Pakistan in the space between conventional and nuclear. Meanwhile, China's export of drones, among other platforms, to Pakistan adds a layer of complexity to India's security challenge.

China's own drone capabilities are rapidly advancing as significant investments have been made in building up a diverse fleet of drones, including long-range systems like the Soaring Dragon, BZK-005, TB-001, and Wing Loong II alongside affordable kamikaze drones, like the CH-901, designed to overwhelm enemy defences through swarm tactics. This poses a significant and evolving military threat to India along the LAC.

For India, drones complement other weapons and can partially offset capability gaps as part of an asymmetric defence strategy vis-à-vis China. However, India needs to view the wars in Ukraine, Nagorno-Karabakh, and Myanmar as cautionary tales for the need to mass produce an affordable mix of drones.

Of the many lessons from the ongoing war in Ukraine, one stands out – the importance of a defence industrial base that can keep pace with the high-intensity of modern conflict. To fully realise India's drone potential, the Ministry of Defence (MoD) needs to support the defence industrial base to be able to scale production and create surge capacity. The ability to reconstitute and quickly replace drones, loitering munitions after losses, and surface-to-air missiles will make India more resilient.

India's anaemic procurement of systems has generally discouraged industry from ramping up its production capacity.

Addressing underlying structural issues that lead to uncertain demand is key in order to incentivise industry to ramp up production capacity and innovation in defence.

Pushan Das is a strategic affairs analyst who writes on defence and foreign policy.

THE GIST

- The war in Ukraine has emerged as a real-world laboratory for drone technology, with rapid innovation and counter innovation cycles defining modern warfare.
- For India, drones complement other weapons and can partially offset capability gaps as part of an asymmetric defence strategy vis-à-vis China.
- Of the many lessons from the ongoing war in Ukraine, one stands out — the importance of a defence industrial base that can keep pace with the high-intensity of modern conflict.

Empowering women in agriculture for food security

May-Elin Stener

is the Ambassador of Norway to India

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is the Representative and Country Director of the United Nations World Food Programme in India

The United Nations General Assembly has declared 2026 as the International Year of the Woman Farmer, garnering the support of over 100 co-sponsors. The resolution celebrates the essential role of women in global agriculture while raising awareness of their challenges, which include property rights and market access.

This article highlights insights from a symposia on women in agriculture organised by the Royal Norwegian Embassy and the United Nations World Food Programme (WFP) in India (with participation and guidance from the Government of India). It distils the discussions over six months, with 200 participants from diverse fields and backgrounds coming together to address the challenges women in agriculture face.

Some of the observations here also stem from a collaborative project called ENACT, or Enhancing Climate Adaptation of Vulnerable Communities through Nature-based Solutions and Gender Transformative Approaches, in Assam, implemented by the WFP in partnership with the Government of Assam, in Nagaon. The project aims to empower smallholder farmers, particularly women, to access climate-related information and make informed decisions to enhance their resilience. The project is financed by the Government of Norway under its strategy to promote self-sufficiency in food production and strengthen women's rights and their role in food production.

Ownership, control and access

Nearly half the global food supply is made possible by the contributions of women, who are responsible for 60% to 80% of food production in developing countries and account for 39% of the agricultural labour in South Asia. These figures highlight the vital role of women in agriculture, who face barriers and inequalities.

In India, the percentage of women who own agricultural land is significantly lower than that of men, despite women constituting a substantial part of the farm workforce. Approximately 80% of economically active women are employed in agriculture. Yet, only 14% of landowners are women. According to the latest National Family Health Survey, female land ownership is even lower, at 8.3%.

The International Year of the Woman Farmer, in 2026, must ensure the promotion of resilient agricultural development and gender equality

Women farmers in India report that their lack of land ownership makes it difficult to obtain credit and limits their access to financial institutions. Regular access to information on agricultural planning and advisory is essential for farmers, but women have more limited access to technology, such as mobile phones. These obstacles hinder investments, technology adoption and improvements in livelihoods. While microfinance and self-help groups provide some access, such loans are often insufficient for significant investments.

The Government of India supports small women farmers to enhance skills and promote sustainable agriculture. The Mahila Kisan Sashaktikaran Pariyojana upgrades skills and increases resource access for women, while the Sub-Mission on Agricultural Mechanisation offers 50% to 80% subsidies for machinery. Additionally, 30% of the National Food Security Mission's budget is allocated for women farmers in a number of States and Union Territories.

Empowerment for resilience

Climate change disproportionately affects women farmers by increasing their domestic responsibilities and elevating their exposure to agricultural risks. "Our area has been witnessing rapid weather changes. The variety introduced by the project is designed to resist flood damage, and the crops can survive underwater. We are hoping for a better harvest," says Nirmali Bora Hazarika from Roha village in Nagaon.

By engaging with women farmers, it is possible to develop replicable models of climate adaptation at the village and community levels.

The women in agriculture symposia generated forward-looking ideas. The ENACT project primarily connects women farmers with experts through information technology, providing actionable agricultural and climate advisories weekly via their phones to over 300 farmers in 17 villages of Nagaon district.

Additionally, the Climate Adaptation Information Centres facilitate video conferencing and meetings, informing women farmers about agriculture and livelihoods. This shows how scalable impact can be achieved by combining technical expertise, diversification through farm-based livelihoods, information and weather advisories, use of technologies and social behaviour change interventions.

The project is leveraging partnerships with State and district administrations, which include the Department of Agriculture, the State Rural Livelihoods Mission, and the Departments of Meteorology and Environment. The technology partners include agricultural universities, institutions for sourcing climate-resilient crop varieties.

Rural ecosystems and dependent livelihoods are vulnerable. Responses to risks should reflect community needs and capabilities. The ENACT-project emphasises the promotion of flood-resistant rice varieties, livelihood diversification, and market linkages to mitigate crop damage from flooding and promote the cultivation of nutritious local varieties. Women's farmer groups engage in a community-based smart seed production system to enhance sustainability.

Steps to take

Policy design and implementation should take into account the unique needs of women farmers. Granular data with a gender lens are needed to develop solutions tailored to women's needs. These could range from rethinking farming tools to financial needs and practices around saving or credit.

There should be a strong focus on agri-value chains that support women farmers and are managed by women. Part of this could be to enhance women's access to financing mechanisms and information while supporting their collective action and networks, such as women's self-help groups.

We have a historic opportunity to mark 2026 as the International Year of the Woman Farmer, to promote resilient agricultural development and gender equality by recognising, supporting, and enhancing the role of women in ensuring food security, fostering economic prosperity, and promoting sustainability.

Tighten the process

The ECI must address legitimate concerns about voter rolls, transparency

The Leader of the Opposition in the Lok Sabha, Rahul Gandhi, has raised troubling questions about the conduct of elections based on what transpired in the 2024 Assembly elections in Maharashtra. There are specific issues: the abnormal increase in voters listed in electoral rolls between the general election and Assembly elections, higher turnout numbers after 5 p.m. on voting day, and the Centre amending the Conduct of Election Rules, 1961 to restrict access to CCTV footage of the polling process. Mr. Gandhi has also questioned the process of appointing Election Commissioners, with the Union government refusing to implement a Supreme Court judgment in 2023 that recommended having the Chief Justice of India as a part of the selection panel. While political parties, including the BJP and the Congress, have raised complaints about Electronic Voting Machines in the past, many did not stand scrutiny considering the administrative and technological safeguards. The Congress has now focused on the electoral process, raising more fundamental issues that need to be unpacked separately.

A preliminary analysis by *The Hindu* of registered voters in States where the general election and Assembly elections were proximate showed that there were precedents of sharp increases in the electorate before Assembly elections. While the number of new voters added before the Assembly elections was high – more than 39 lakh voters in just six months following the general election – similar increases were observed in 2014 as well. The increase of nearly four million voters is a large number and the ECI should proactively release machine-readable data on the rolls for verification. Regarding the allegation that turnout increases were abnormal after 5 p.m, the argument does not hold water. This is based on provisional turnout figures, and Election Commission of India (ECI) data show that there was no significant increase in voting after 5 p.m. in Maharashtra. Provisional turnout figures shared via an app by the ECI are not entirely accurate as these are dependent on the manual entry of numbers during elections and may have discrepancies when compared to the accurate machine count. As final figures via Form 17C data from each booth are released only after a lag, it would be incorrect to rely on provisional turnout figures. However, there is another contention that merits the ECI's response: retaining CCTV footage and providing parties and their nominees access to it to scrutinise complaints. The process of updating electoral rolls must be more transparent and involve political parties for scrutiny and verification. It is also incumbent upon parties to show alacrity during this process than cry foul after the results are out. Ultimately, the onus lies on the ECI to enhance transparency in the electoral process and, specifically, in providing electoral rolls and retaining CCTV footage for scrutiny.

The Census and the remaking of a people

Varghese K. George

A population is a group of inhabitants in a particular place. A people, as in 'We the People,' in the preamble of the Constitution , is a political community. The counting and the labelling of the population under multiple categories, i.e., a census, is not merely a technical exercise. It mediates the transformation of the population to a people in a significant manner. The people – a political community – have a shared view of how they govern themselves and allocate their resources. The 2027 Census will so impact the notion of people that it is going to be a centennial event, like the COVID-19 pandemic that delayed the decadal census which was to happen in 2021.

A census counts the total population, and under various categories and qualities – rural and urban, Scheduled Castes (SC) and Scheduled Tribes (ST), economic activity, literacy and education, housing and household amenities, migration, fertility and mortality. It also enumerates the latest administrative map of the country. A census, technically speaking, only captures the reality that exists. But the very act of capturing it under definitive categories alters and creates realities. There are organic, natural demographic trends which are underway, whether you document them or not. For instance, we know that more people in Chennai or Mumbai speak Hindi today than 20 years ago. In the same time period, we know that Kerala received and sent out a large number of migrants, but we do not know the exact numbers. These patterns of birth, death, migration, languages, and economic activity will have political implications; their recording itself is an influencer of that process. The study of this link, between demography and politics (political demography), is an underdeveloped field the world over.

Issue of parliamentary representation

After half a century, India's parliamentary representation will be redistributed between the States. Article 81 of the Constitution mandates that the next inter-State redistribution representation according to population will be done after "the relevant figures for the first census taken after the year 2026 have been published". The Census of 2021 was delayed due to the pandemic, but it could have been done much earlier than now. In normal course, the first Census after 2026 would have been in 2031, with the new delimitation exercise after that. The delay in the 2021 Census has advanced delimitation by at least five years. This is going to be the first census in which all data will be captured digitally, and its processing can be much faster than previous ones which took up to three years.

The work of past Delimitation Commissions took years, but that too will be much quicker in the next round. All things considered, it is possible, and even likely, that the general election in 2029 can be conducted on the basis of a new parliamentary map of India.

The new Census will accelerate the social and political impacts of demographic changes

What happens if the distribution of population becomes the sole criteria for the redistribution of parliamentary seats? Some States have grown faster population-wise and slower economy-wise; for some States, the inverse holds true. People are moving from where there are more of them to where there are fewer of them such as from the north and central regions of the country to the west and southern regions, and also to Delhi NCR which is in the heartland. This movement is linked to demography and the economy. People are moving in search of better opportunities, and, in many cases, to escape distress. Regions of higher economic growth attract people from elsewhere, while their native populations age. If relative population remains the only and sole criteria for an inter-State reallocation of parliamentary representation, political power will move from regions with a 'stronger economy-low birth rate' combination to regions that have a 'weaker economy-high birth rate' combination. The Centre has said that the demand for fair delimitation from States that fear a reduction in their political representation will be discussed at the appropriate time, but there is no clarity as yet on its thoughts on this issue.

Factors of caste, revenue sharing

There are other adjacent factors that are inherent and contingent upon Census 2027, which will be determinants in this remaking of the people. For the first time since Independence, all castes will be counted separately as against the counting of only SCs and STs now. The caste census until 1931, during British rule, triggered multiple claims and resultant politics. It will be difficult to predict the political impact of a new caste census, but it is certain that the clamour for removal of the 50% ceiling on quotas will get louder. The next delimitation will allocate one third of the seats in Parliament and Assemblies for women. The Centre has made it clear that it will push for simultaneous elections to Parliament and the State Assemblies.

The individual citizen is considered to constitute the elementary unit of people, in liberal democracy. But a simple reading of the relevant provisions of the Constitution makes it clear how group identities were accepted in the constitutional scheme of things – before that in the national movement, and later in governance. National unity of the modern Republic of India was designed in three dimensions – unity of religions, castes and regions as highlighted in an article in this daily, "National unity, a three-dimensional view" (Editorial page, October 6, 2023). That contract of unity is now being renegotiated to make place for the changes and the learnings of at least 50 years. Census 2027 is a milestone in this ongoing process and will unleash unpredictable forces.

There is also a simultaneous development that is also relevant in this context. The Sixteenth Finance Commission (tasked with making recommendations for revenue sharing across States and between the Centre and the State for five years and commencing its work from April 1, 2026), is in deliberations with stakeholders. It is required to make its recommendations available by October 31, 2025. The mechanism devised by the previous Finance Commission for revenue sharing remains a source of grievance for many States. The Sixteenth Finance Commission's report will have the additional import of its timing, coming as it does on the cusp of a dramatic realignment of political power across social groups and regions.

From a population to a people, the transition is achieved by administrative measures and politics. Census categories have been a key determinant in Indian identities. The first Census of 1881, under the colonial administration, had rigid religious and caste categories of its Indian subjects – which have remained key determinants of politics since then. All politics in India has been about various attempts to slice and dice and aggregate and disaggregate these categories. Population management involves the absolute numbers of people, their spatial distribution and their quality through health care and education. None of this is apolitical; education is a particularly notable field.

Integral to political strategies

The Bharatiya Janata Party (BJP) seeks to achieve its goal of national consolidation through a change in thinking of how Indians see themselves as a people. It is not a disinterested actor in this emerging scenario of a demographic transition. A population-based inter-State delimitation will shift political power to its strongholds and weaken its political opponents. Gender and caste are national categories. By introducing these factors, the BJP can shift the delimitation debate beyond the conflicting demands of regions, and create new political constituencies. The Congress and the Left too are theoretically national formations, which require them to balance regional aspirations and national requirements. The Congress is trying to reclaim some space in heartland politics by joining the caste debate, but it remains to be seen how its contest with the BJP will progress on this count. The BJP has a totalising vision of national identity, and a population-based delimitation is a tempting route for it to follow. Alternatively, if it wants to emerge as a truly national party which reassures interests across castes, regions and religions, then this is a good opportunity for it.

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The team focused on what the BBX32 gene does in the model plant Arabidopsis thaliana. Representative photo. MARKUS SPISKE/UNSPLASH

How does the first shoot rise safely through soil, towards daylight?

Vasudevan Mukunth

Researchers from the Indian Institute of Science Education and Research (IISER), Bhopal, have found that a single protein helps plants time their first step from darkness into light.

When a seed sprouts in darkness under the soil, its stem curves into a small hook shape that protects the delicate shoot tip as it pushes upward. The hook needs to stay 'closed' until the seedling breaks through the soil and meets light. In the study, the team wanted to know how two common signals – ethylene, a plant hormone that builds up underground, and light – work together to decide exactly when the hook opens.

The team focused on what a gene called *BBX32* really does in the model plant *Arabidopsis thaliana*. By comparing seedlings modified to lack *BBX32*, to churn out extra copies, to carry extra mutations, or to glow blue or green when the gene was activated or its protein moved around, the scientists could pinpoint how the protein made by the gene helps keep the hook closed.

The team also grew seedlings in darkness, red, blue, far-red light, and normal light, in plates with or without a compound that raises ethylene levels, and in thin layers of sand to imitate soil pressure.

They photographed three-day-old seedlings and used software to measure the hook angle as it opened over time. They also used genetic tools to track the performance of the *BBX32* gene and counted how many seedlings breached a sand layer and turned green.

The findings were published in *New Phytologist* on May 28. The team

When a seed sprouts in darkness its stem curves into a small hook shape that protects the delicate shoot tip as it pushes upward. The hook needs to stay closed until the seedling breaks through the soil and meets light

comprised Nevedha Ravindran, Kavuri Venkateswara Rao, and Sourav Datta of the Department of Biological Sciences at IISER Bhopal.

They found that ethylene turns *BBX32* on and that light protects *BBX32* from being destroyed. The role of *BBX32* itself is to keep the hook closed for longer. Without extra ethylene, *BBX32* mutants behave like normal plants whereas with high ethylene or a sand cover, the hook opens too soon.

BBX32 was found to work by raising the activity of the PIF3 protein, which switched on HLS1, which kept the hook closed. If PIF3 was missing, *BBX32* couldn't prevent the hook from opening.

In the sand test, only about a quarter of seedlings ever reached the surface compared to 40% of normal seedlings and 80% of over-expressors. Keeping the hook closed just a bit longer clearly helped a sprout survive its climb.

The researchers also worked out why *BBX32* accumulates only when it's most useful. In total darkness, an enzyme called COP1 latches onto *BBX32* and sends it to be degraded, keeping the hook flexible. Ethylene partially shields *BBX32*, but once the emerging seedling first senses daylight, COP1 activity drops, allowing the protein to build up on the concave side of the hook and hold it shut a little longer.

This finely tuned handshake offers a way to breed crops whose seedlings can breach denser soils – a trait that may be valuable as climate change brings heavier rains.

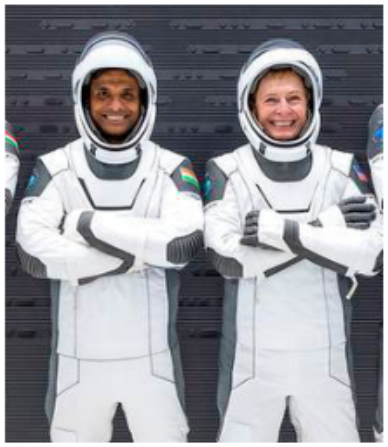
Weather plays spoilsport with Shukla's mission; NASA moves launch to tomorrow

The Hindu Bureau
BENGALURU

The launch of Indian astronaut Group Captain Shubhanshu Shukla's mission to the International Space Station (ISS) has once again been postponed.

The Axiom-4 Mission to the ISS, which was scheduled from Launch Complex 39A at the National Aeronautics and Space Administration's (NASA) Kennedy Space Centre in Florida at 8.22 a.m. Eastern Time (ET) on Tuesday, has been postponed to Wednesday.

"Due to weather conditions, the launch of Axiom-4 mission for sending Indian Gaganyatri to International Space Station is postponed from 10th June 2025 to 11th June 2025. The targeted time of launch is 5:30 p.m. IST on 11th June 2025," ISRO said in a post on X, attributing it to ISRO Chairman V. Narayanan.



Group Captain Shukla's mission to ISS was earlier scheduled for June 8, then moved to June 10.

SpaceX, which will launch the Ax-4 crew aboard its Dragon spacecraft, said that it was now targeting June 11 for Falcon 9's launch.

In a post on X, it said the launch was postponed due to high winds in the ascent corridor.

"Now targeting no earlier than Wednesday, June 11 for Falcon 9 to launch @Axiom_Space's Ax-4 mission to the @Space_Station due to high winds in the ascent corridor," SpaceX posted.

Group Captain Shukla's mission to ISS was earlier scheduled for June 8 but then postponed to June 10. As per the earlier plan, the crew was scheduled to dock at the space station on June 11 at approximately 12:30 p.m. ET.

Once docked, the Ax-4 astronauts will spend about 14 days aboard the space station conducting microgravity research, technology demonstrations, and outreach events.

The Ax-4 crew is currently in quarantine.

This is the third time the launch has been rescheduled.

PM to visit Cyprus, Croatia during his trip to Canada

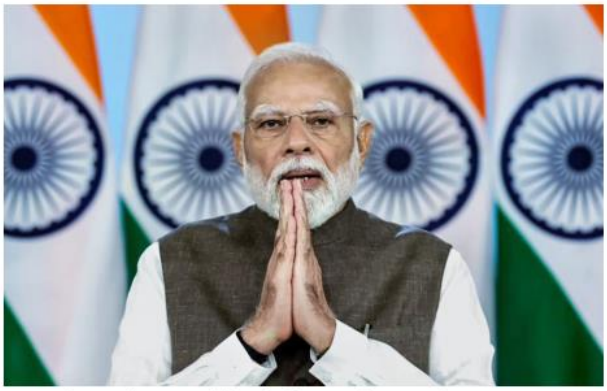
Trip to Cyprus is seen as message to Turkiye, which had aided Pakistan during Operation Sindoor; stopover at Croatia important in the context of the India-Middle East-Europe Economic Corridor

Kallol Bhattacherjee
NEW DELHI

Reiterating India's traditional foreign policy goals, Prime Minister Narendra Modi will visit Cyprus and Croatia, official sources said here on Monday.

Mr. Modi will visit Cyprus on his way to Canada to participate in the G-7 summit (June 15-17), and on the way back, he will pay a visit to Croatia, which will be the first Prime Minister-level visit from the Indian side since the formation of Croatia in 1991, after the dissolution of former Yugoslavia.

Both visits are being described as important from a political as well as commercial point of view. Sources here hinted that the Cyprus visit will serve as a message to Turkiye that had assisted Pakistan during Operation Sindoor in May. It will also act as a timely revival of top-level contacts as Cyprus is set to take over the Presidency of the Council of the European Union in the first half of 2026. Cyprus had condemned the terror attack in Pahalgam on April 22 and indicated that it would raise the issue of cross-border terrorism from Pakistan at the EU-level discussions.



Narendra Modi's visit will be the first trip by an Indian Prime Minister to Croatia since its formation in 1991. ANI

Cyprus has been consistent in its support to India on the Kashmir issue and cross-border terrorism from Pakistan. That apart, the Mediterranean country, which has a territorial dispute with Ankara regarding the Turkish Republic of Northern Cyprus, has also supported India in its campaign for a permanent seat at the UN Security Council, the Nuclear Suppliers Group, and the International Atomic Energy Agency. In a reciprocal gesture, India has supported the resolution of the Cypriot territorial dispute as per UNSC resolutions, international law, and the EU acquis, the collective EU body on laws and regulations.

Officials said Mr. Modi is expected to meet President of Cyprus Nikos Christodoulides.

Croatia trip

Mr. Modi's visit to Croatia is also being described as a tribute to the strong tradition of Indology that exists in the country. The University of Zagreb has been a seat of serious study of Indology, and Croatia is noted for the presence of ISKCON (International Society of Krishna Consciousness). In recent years, these cultural contacts were supplemented by growing defence and technological relationships. Croatian Foreign Minister Gordan Grlić-Radman participated in the Raisina Dialogue in March 2023, when he signed a memorandum of understanding on defence cooperation with Mr. Jaishankar.

Sources said the Croatia visit has additional diplomatic importance as it indicates India's continued commitment to partners of the non-alignment as the erstwhile Yugoslavia's founding father, Josip Broz Tito, was a Croatian. Officials here indicated that both Cyprus and Croatia have acquired growing significance in recent years after the India-Middle East-Europe Economic Corridor (IMEC) was launched during the G-20 summit in New Delhi in 2023. Croatia and Cyprus are being viewed here as "potential participants" and investors in the IMEC-related projects. Croatia, with its extensive maritime facilities and ports on the Adriatic Sea, is attractive for India's commitment to the IMEC, sources said, setting the context of Mr. Modi's upcoming visit.

India's first e-waste recycling park to be built in Delhi, says Minister

The Hindu Bureau
NEW DELHI

Environment Minister Manjinder Singh Sirsa on Monday announced that the Delhi government has undertaken a project to develop India's first electronic waste (e-waste) eco park in north Delhi's Holambi Kalan.

Mr. Sirsa made the announcement after chairing a meeting on Monday, in which it was decided that the Delhi State Industrial and Infrastructure Development Corporation would issue a global tender to invite "the world's best green technology partners" to build the park.

The park will also have training centres to upskill informal workers who handle hazardous e-waste. FILE PHOTO

According to a statement by the Delhi government, the facility, spanning 11.4 acres, will be built under a Design, Build, Finance, Operate, and Transfer (DBFOT) model on a Public Private Partnership (PPP) basis for a concession period of 15 years. It will be designed to process up to 51,000 tonnes of e-waste, including all 106 categories of waste listed under the E-Waste Management Rules, 2022. The park, which is one of four such facilities planned in the country, is expected to generate over ₹350 crore in revenue.

In 18 months

Mr. Sirsa said, "The eco park will not just manage waste. It will be the symbol of Delhi's transition into a circular economy, where no resource is wasted and no worker left behind."

Construction of the park is expected to be completed within 18 months.

A new water harvesting model promises to help Rajasthan's farmers

Mohammed Iqbal
JAIPUR

In the dry heartland of Rajasthan, a transformative rural water conservation model is set to benefit farmers in the upcoming monsoon. Those behind the initiative, which relies on 50 scientifically designed and climate-resilient farm ponds at Kukas village in the State capital of Jaipur, claim it has a 10-crore-litre seasonal monsoon run-off conservation potential.

The village panchayat in Jaipur district's Amber block is the second place in the State selected for the rainwater harvesting enterprise, following the successful installation of farm ponds in the rain-fed land of Dausa district. As many as 250 ponds dug in the agricultural land of Dausa have enabled the farmers to get perennial crops.

An aerial view of a farm pond in Jaipur's Kukas village. As many as 50 such ponds have been dug up in the area. SPECIAL ARRANGEMENT

Nearly 99.4% of the agricultural cultivable land in Jaipur is dependent on groundwater for irrigation. The district extracts 2.22 times the water recharged through rain every year. The project in Kukas emphasises the sustainability and livelihoods of peasants, with a focus on the availability of water for irrigation.

The initiative involves constructing 10-foot deep, plastic-lined ponds on 5% of each farmer's land, reinforced with fencing.

The ponds are designed to capture rainwater, ensuring year-round irrigation for rabi and kharif crops and enabling the return of sustainable livestock rearing and high-value horticulture.

Person behind initiative

An alumnus of the Indian Institute of Technology (IIT), Kharagpur, Vipra Goyal, who has been working with the farmers, said while the construction of 50 ponds had been completed recently, 25 more were being dug to secure sustainable water supply to the rural households, which would help about 50,000 villagers in the region in the long term.

Farmer Ram Phool of Kacherawala village, near Kukas, told *The Hindu* that he planned to sow crops like groundnuts and chaula (cowpeas) following the inflow of water into the pond installed at a corner of his land spread across eight bighas (nearly five acres). "One has to dig as much as 500 feet to extract groundwater in our area. I was growing bajra earlier as it needs less water," said the 58-year-old farmer.

Kukas sarpanch Radheyshyam Meena said the sustainable irrigation model will help farmers in his area to diversify into cultivating more profitable and water-efficient crops. "The model offered to us has great potential to make farmers self-reliant. They are set to get a better yield with the year-long water supply," said Mr. Meena.

Catching rainwater

Mr. Goyal said 14 lakh to 21 lakh litres of good seasonal monsoon run-off was flowing unutilised at every farm of one hectare in Jaipur. "In areas like Amber block, lacking river and canal networks, farm ponds offer the most viable solution. The continuous irrigation will also help in recharging the groundwater," he said.

The IITian, who had earlier organised awareness programmes about farm ponds through Ward Sabhas, Gram Sabhas and camel cart rallies in Dausa, said that the continuous availability of water could pave the way for dairy and food processing units, as well as market linkages for agricultural produce. He has sought the Central government's endorsement to partner with multilateral agencies for grant-based infrastructure and capacity building.

Mr. Goyal previously worked with the NITI Aayog. He has partnered with a two-wheeler manufacturing company to raise funds for the installation of ponds in Kukas.