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EARTH MATTERS

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Scientists Urge for Adaptation and Climate-resilient Planning

SPECIAL HIGHLIGHTS

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IN CONVERSATION

Mr Varun Puri,
Managing Director at Green Power International

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TerraGreen

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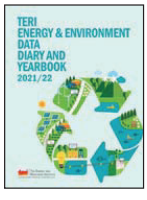

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A TERI Publication

TERI Energy & Environment Data Diary and Yearbook, or *TEDDY*, is an annual publication brought out by TERI since 1986. *TEDDY* is often used as a reference in other peer-reviewed books and journals for energy and environment-related data. It gives an annual overview of the developments in the energy supplying and consuming sectors as well as the environment sector. It also provides a review of the government policies that have implications for these sectors of the Indian economy.

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The Energy and Resources Institute
Attn: TERI Press
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EDITORIAL

> "The latest BIS revision introduces an updated assessment of earthquake risk across regions, reflecting evolving scientific understanding and the urgent need for strengthened disaster preparedness."

As we step into 2026 with a renewed resolve to mitigate risks emerging from the escalating threats of climate change and growing frequency of natural disasters, the memory of past catastrophes serves as a sobering reminder of irrevocable loss caused. One such moment—the devastating earthquake that struck Bhuj, Gujarat, on January 26, 2001, left an indelible mark on the nation's consciousness.

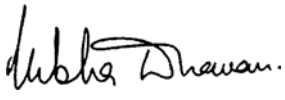
In the years since, India has experienced several significant seismic events, exposing the country's vulnerability to earthquake hazards. This reality has once again come into focus with the release of the revised Seismic Zonation Map by the Bureau of Indian Standards (BIS) in November 2025. The latest BIS revision introduces an updated assessment of earthquake risk across regions, reflecting evolving scientific understanding and the urgent need for strengthened disaster preparedness.

The cover story of this edition of *TerraGreen* issues a stark warning: India's revised seismic zonation places 61 per cent of the country, including the entire Himalayan arc, in zones of moderate to very high earthquake risk. This reassessment has prompted scientists and disaster experts to call for urgent and systemic adaptation measures.

The updated Seismic Zonation Map released by the BIS elevates the Himalayan region to the highest-risk Zone VI. This compounds existing climate-induced stresses—such as floods, landslides, and permafrost thaw—placing more than 50 million people at heightened risk.

Experts caution that the implications for infrastructure planning are profound. Major dams, multipurpose power projects, and rapidly expanding urban centres, including Delhi and Chandigarh, now demand stricter building codes, comprehensive structural audits, and large-scale retrofitting. While the re-evaluation of environmental clearances for existing projects remains a policy decision for the government, the adoption and enforcement of seismic-resilient design standards—particularly for large and critical infrastructure—must no longer be delayed. Equally critical is land-use planning: the construction of essential facilities such as hospitals, fire stations, and power plants must be avoided in vulnerable zones. Development on steep and geologically unstable slopes that are highly susceptible to quake-triggered landslides in the Himalayas must also be stringently regulated.

We believe you will find each article in this issue thought-provoking and motivating, reinforcing our shared resolve to protect the planet's fragile equilibrium and advance towards a sustainable, carbon-neutral future.



Vibha Dhawan
Director-General, TERI

The December 2025 cover story on COP30 is a good one. The post-COP30 reality necessitates a fundamental reassessment of the 'New Climate Economy' paradigm. This paradigm can no longer be based solely on voluntary private investment or market signals; it must be secured in the self-governing and legal obligations of developed nations. Further, the failure of the developed world to accept the Article 9.1 mandate confirms that the reliance on private capital to fill the NCQG gap is a political evasion of sovereign responsibility. The estimated annual needs of $310 billion for adaptation and $1.3 trillion for the total climate flows cannot be met without a massive addition of public, grant-based finance and a legally binding framework for MDB and private sector mobilization that does not impose new provisions on the Global South. And, the developed nations are expected to deliver a credible, quantified, and obligated finance package that addresses adaptation and avoids the coercive measures of unilateral trade policy.

Shubhankar Roy
New Delhi

Delhi wakes up every winter to toxic air, and every year the response remains depressingly familiar: blame stubble burning, announce emergency measures, shut schools temporarily, and wait for the wind to change. This cycle of denial and short-term firefighting has turned air pollution into a chronic public health emergency rather than a seasonal inconvenience. Multiple studies have linked Delhi's air quality to rising cases of asthma, heart disease, lung cancer, and reduced life expectancy. Children, the elderly, and outdoor workers bear the brunt, yet policy responses continue to treat pollution as an episodic crisis instead of a year-round governance failure. Construction dust, unchecked vehicular emissions, diesel generators, industrial pollution, and urban planning that prioritizes cars over clean mobility receive far less sustained attention. What is most troubling is the absence of accountability. Every agency has a role, yet no institution takes ownership. Action plans are announced with much fanfare, but monitoring, enforcement, and transparency remain weak. Citizens are asked to adjust their lives—wear masks, stay indoors, work from home—while systemic polluters continue largely unhindered.

Ajit Narang
New Delhi

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Head office
TERI
Darbari Seth Block, IHC Complex
Lodhi Road, New Delhi – 110 003
Tel. +91 (11) 2468 2100 or 7110 2100
Fax +91 (11) 2468 2144 or 2468 2145

Regional centres
Southern Regional Centre
TERI, CA Site No. 2, 4th Main, 2nd Stage
Domlur, Bangalore–560 071
Email: terisrc@teri.res.in

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Email: terine@teri.res.in

Western Regional Centre
House No. 233/GH-2, Vasudha Housing Colony,
Alto-St Cruz, Tiswadi, Goa-403 202
Tel: 0832-2459306, 2459328
Email: teriwrc@teri.res.in

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India's Solar Module Manufacturing Reaches 144 GW Capacity

India's solar module manufacturing capacity has more than doubled in the past year. Union Minister for New and Renewable Energy, Shri Pralhad Joshi, announced on January 6, 2026. Solar module production tracked by the government expanded 128.6 per cent year-over-year, reaching 144 gigawatts (GW) in 2025 – a dramatic increase from 63 GW in 2024. The figures indicate that India added approximately 81 GW of new module manufacturing capacity over the year. Since 2014, the nation's solar manufacturing base has grown over 62 times, rising from a mere 2.3 GW to its current 144 GW, underscoring the rapid pace of domestic clean energy industrialization.

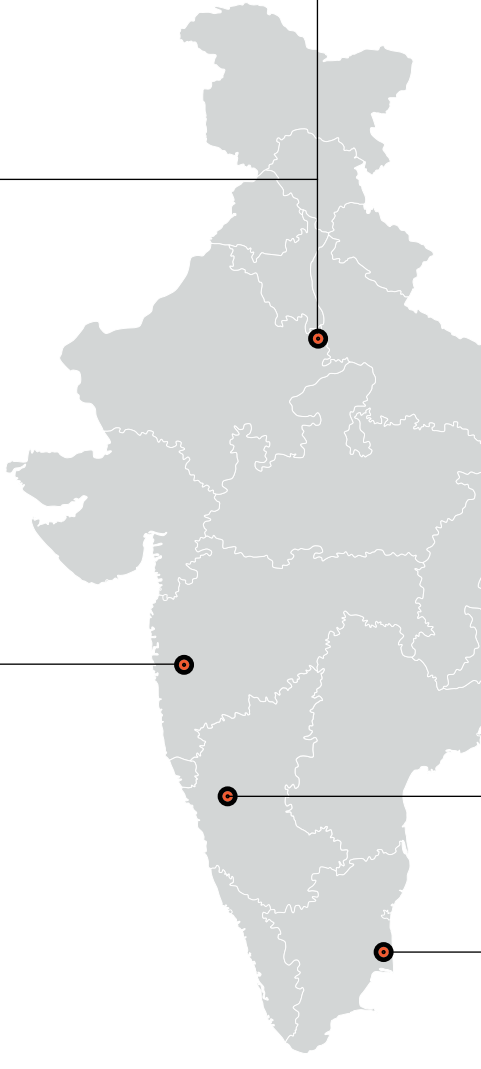
Source: https://www.saurenergy.com/

Delhi Experiences Worst Pollution Levels Since 2018

Delhi has experienced its worst December air since 2018 in 2025, with $PM_{2.5}$ averaging 211 µg/m^3 for the month. An analysis of data from the Central Pollution Control Board (CPCB) across the Capital's 40 monitoring stations shows that high pollution levels were widespread, affecting nearly all monitoring locations at least once.

Pollution was also not confined to brief episodes: $PM_{2.5}$ levels crossed 250 µg/m^3 at the city-wide level nearly one in three days. The most severe mid-December episode drove average particulate matter pollution to six to seven times the nationally permissible standard.

Source: https://indianexpress.com/



Mumbai Gets Ready for Ocean Cleanup

Mumbai is just one of many cities where The Ocean Cleanup, the international non-profit, is working to intercept and remove ocean-bound plastic pollution. The Ocean Cleanup entered into a Memorandum of Understanding (MoU) with the Maharashtra Pollution Control Board in October 2025 to develop methods to eliminate plastic pollution in Mumbai from entering the ocean through the city's waterways. The environmental company analysed the waterways to determine the trash flowing into them, identified the local environment, and deployed GPS trackers to understand the trajectory of plastic waste. The bustling financial city of Mumbai has four rivers, Dahisar, Mithi, Oshiwara, and Poisar, which flow into the Arabian Sea. However, due to unregulated economic activities, industrial growth, unplanned urbanization, and inappropriate waste management practices, these rivers have become drains.

Source: https://sustainabilitynext.in/

Migratory Bird Numbers Decline at Yamuna, NCR Wetlands: AWC 2026

The number of migratory birds at the River Yamuna and wetlands in NCR has declined due to global climate change and growing human intervention in the natural habitats, according to Wetlands International's annual Asian Waterbird Census (AWC) 2026. The AWC supports conservation of wetland and water birds globally, and it is an important supportive tool that generates the data for the Ministry of Environment, Forest and Climate Change (MoEFCC), Govt of India's "National Action Plan for conservation of Migratory Birds and their habitats along the Central Asian Flyway".

Source: https://dailypioneer.com/

Veteran Ecologist Madhav Gadgil Passes Away

Veteran ecologist Madhav Gadgil, known for championing community rights and sustainable development, passed away on January 7, 2026. He was 83. Best known for chairing the Western Ghats Ecology Expert Panel, Gadgil was regarded as one of India's foremost environmental thinkers, advocating an approach to conservation that placed local communities at the heart of ecological protection. In 2010, the Union government appointed Gadgil as the head of the Western Ghats Ecology Expert Panel (WGEEP), later known as the Gadgil Commission. The panel's report called for strict environmental safeguards in the ecologically fragile Western Ghats. The report sparked intense political and public debate across six states.

Source: https://indianexpress.com/

Madras HC Appoints 'Waterman of India' to Hold Study on Thamirabarani River Pollution

The Madurai Bench of the Madras High Court recently directed renowned water conservationist Rajendra Singh to conduct a detailed study into the current state of Thamirabarani River and suggest measures for its rejuvenation. A special bench, comprising justices G R Swaminathan and B Pugalendhi, dealing with cases relating to waterbodies passed the interim order on a contempt petition filed by S Kamaraj, alias Muthalakurichi Kamaraj of Thoothukudi over non-compliance of the directions issued by the court in March 2024. The judges observed that they had issued several orders to the state government and the Tamil Nadu Pollution Control Board to stop the pollution of Thamirabarani River.

Source: https://www.newindianexpress.com/

Scientists Predict Wildfire Smoke Will Be the Most Costly Climate-Related Health Hazard

Wildfire smoke is responsible for tens of thousands of deaths each year and will do more harm to US residents by midcentury than any other threat driven by climate change, including extreme heat. That's the conclusion of a new research paper that provides some of the most extensive modelling of the growing health toll of wildfire smoke on public health in the US. The study, which was published in the journal *Nature* recently, found that each year, on average, wildfire smoke is causing more than 41,400 excess deaths, or more than would be normally expected without smoke given the demographics of the US. That figure is more than twice what was previously recognized in other studies.

Source: https://www.nbcnews.com/

Bees Declared to Be the Most Important Living Being on Earth

The bees have been declared the most important living beings on this planet, the Earthwatch Institute concluded in the last meeting of the Royal Geographical Society of London. Seventy per cent of the world's agriculture depends exclusively on bees. Needless to mention the pollination is the bees' job, although the plants would not be able to reproduce, therefore the fauna would have been gone in a very short time. The recent studies show a dramatic decline of the bees' number as almost 90 per cent of the bee population has disappeared in the last few years. The uncontrolled uses of pesticides, deforestation or lack of flowers are the main reasons for their extinction.

Source: https://www.sciencetimes.com/

How AI's Predictive Power is Helping to Prevent Deforestation

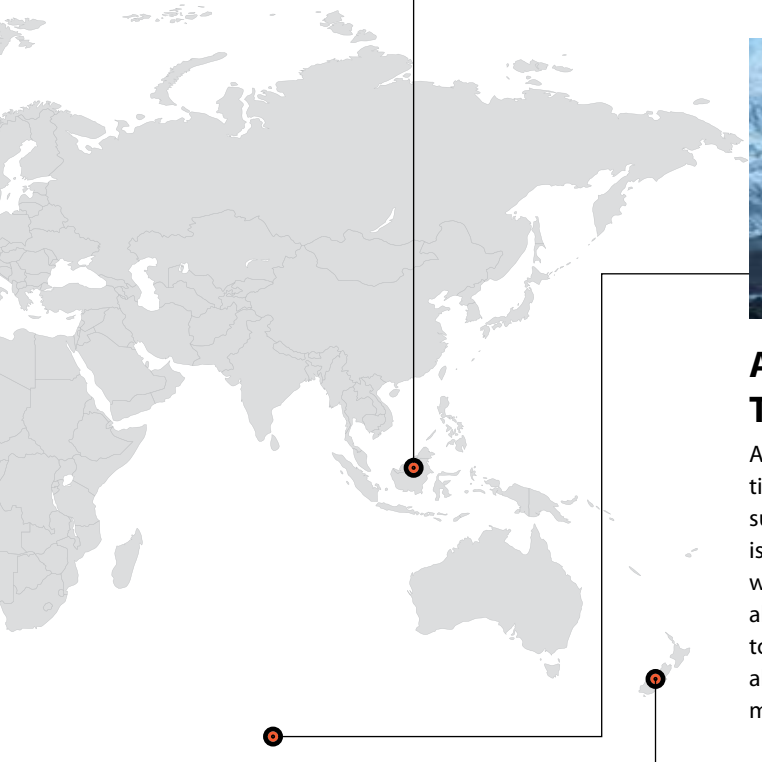
In the past decade, cloud-scale analytics tools have transformed the digital fight against deforestation. Instead of manual reviews of satellite images taking multiple months, land-use change can today be monitored in near-real time. Some artificial intelligence-enabled tools are even allowing authorities to intervene before forest-loss happens, deploying scarce manpower and equipment to areas where they can have the most impact. "The trend today is moving from retrospective measurement to proactive prediction," explains Juan Lavista Ferres, chief data scientist and corporate vice president at Microsoft.

Source: https://www.reuters.com/sustainability

Marine Protected Areas Expanded in 2025, But Still Far from 30 Per Cent Goal

In December 2022, nearly 200 nations committed to protecting 30 per cent of Earth's lands and waters by 2030. As of 2025, about 9.6 per cent of the world's oceans are now covered by marine protected areas, according to the latest global tracking data by the World Database on Protected Areas. This marks a 1.2 per cent increase in 2025, up from 8.4 per cent coverage in 2024. There are now 16,608 marine protected areas (MPAs) globally, covering nearly 35 million square kilometres (13.5 million square miles) of the ocean—an area more than twice the size of Russia. However, only 3.2 per cent of these areas are considered highly or fully protected, according to the Marine Conservation Institute's MPAtlas. This raises concerns about areas that are protected on paper only, including ones that allow bottom trawling and other highly destructive activities.

Source: https://news.mongabay.com/



A Stunning New Forecast Shows When Thousands of Glaciers Will Vanish

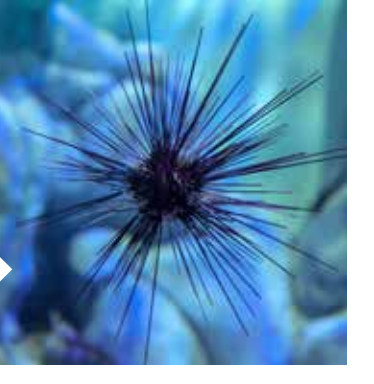
A major new international study led by ETH Zurich has, for the first time, estimated how many of the world's glaciers are expected to survive through the end of this century and how long each one is likely to last. The findings show a dramatic contrast between warming scenarios. If global temperatures rise to +4.0°C, only about 18,000 glaciers would remain worldwide. Limiting warming to +1.5°C could preserve roughly 100,000 glaciers. The researchers also introduced the concept of "Peak Glacier Extinction," which marks the year when glacier losses reach their highest level.

Source: https://www.sciencedaily.com/

A Silent Ocean Pandemic is Wiping Out Sea Urchins Worldwide

A sudden, unexplained mass die-off is decimating sea urchins around the world, including catastrophic losses in the Canary Islands. Key reef-grazing species are reaching historic lows, and their ability to reproduce has nearly halted in some regions. Scientists suspect a pathogen but haven't yet confirmed the culprit. The fate of these reefs may hinge on solving this unfolding pandemic. A recent study published in *Frontiers in Marine Science* reports that, over the past four years, a previously unrecognized pandemic killing sea urchins worldwide has also struck the Canary Islands. Scientists are still working to understand the full ecological consequences, but expect the effects on marine ecosystems to be significant.

Source: https://www.sciencedaily.com/



After COP30, the Climate Challenge Returns Home

COP30 has elevated land-based climate action on the global agenda while exposing the limits of international rulebooks. Ultimately, climate outcomes will depend on how countries design and govern their domestic systems. For India, the opportunity lies in showing that rights-based, institutionally grounded nature-based solutions can deliver both credibility and scale.

As the focus shifts from negotiation to implementation, one principle is clear: climate policy must work with nature, not around it. The success of Article 6.4—and climate action more broadly—will depend on how well this is put into practice, writes **Sayanta Ghosh** in this article.

The conclusion of COP30 in Belém has brought renewed attention to forests, land-based mitigation and the role of communities in climate action. Yet once the headlines fade, the real test of global climate diplomacy begins far from negotiating halls. For countries such as India, the challenge now lies not in negotiating new ambition, but in translating global frameworks into domestic systems that can deliver credible, inclusive and durable outcomes.

The approval of the Paris Agreement Crediting Mechanism under Article 6.4 marked an important procedural milestone at COP30. Years of technical debate have finally produced a framework that allows countries to cooperate through carbon markets under the Paris Agreement. But this shift from rule-making to implementation raises a more difficult question: can Article 6.4 be operationalized in a manner that strengthens nature-based climate action rather than marginalizing it?

From Global Rules to National Realities

Article 6.4 is often discussed in abstract terms, as a global carbon market governed by technical standards. In reality, its success will depend on how well it aligns with national land governance systems, ecological conditions and social institutions. Nowhere is this more evident than in the forestry and land-use sector.

Forests are not industrial assets. They are living systems shaped by climate variability, ecological processes and long-term human stewardship. Yet many of the design debates under Article 6.4 continue to apply logic drawn from engineered solutions, particularly around permanence and liability. While durability of carbon storage is a legitimate concern, rigid interpretations that demand century-scale guarantees risk overlooking ecological realities and excluding precisely those mitigation options most accessible to developing countries.

This approach could have unintended consequences. If land-based mitigation is deemed too risky or insufficiently durable, finance will gravitate towards technologies that are easier to insure and commodify. Such a shift may simplify accounting, but it would weaken biodiversity protection and adaptation outcomes at a time when ecosystems are under unprecedented stress.

India's Land Sector Opportunity and Risk

For India, the implications are immediate. The country's mitigation potential in the land sector lies primarily in forests, trees

outside forests, agroforestry systems, mangroves and the restoration of degraded landscapes. These systems are also central to rural livelihoods, water security, and climate resilience.

India already possesses a strong legal foundation for community-based forest governance through the Forest Rights Act, 2006. Yet climate finance mechanisms, including carbon market initiatives, often operate in parallel to this framework rather than being anchored within it. COP30 has underscored that such disconnects cannot be sustained if land-based mitigation is to scale with integrity.

Engagement with Article 6.4 without alignment to domestic governance risks producing projects that are technically compliant but socially fragile. Experience from earlier carbon market mechanisms shows that when local institutions are bypassed, projects struggle to maintain credibility and long-term viability. Conversely, where communities exercise real decision-making authority, mitigation outcomes tend to be more resilient.

Rethinking Integrity Beyond Durability

One of the unresolved debates emerging from COP30 concerns the tendency to equate integrity with durability alone. Integrity, however, is broader. It encompasses accurate baselines, transparent monitoring, equitable benefit-sharing and strong safeguards. Durability is only one component of this larger picture.

Treating forests as inherently inferior mitigation options because they are exposed to climate risks ignores the role of management and governance. Well-managed forests, supported by predictable finance and community stewardship, can maintain carbon stocks over long periods while delivering co-benefits that engineered solutions cannot replicate. These include biodiversity conservation, livelihood support, and ecosystem resilience.

The greater risk lies not in the dynamic nature of forests, but in poorly designed institutions. Losing biodiversity today in pursuit of narrowly defined durability targets tomorrow would be a strategic error for climate-vulnerable countries.

An Implementation Agenda that Matters

The true measure of COP30's success will lie in what follows. For India, the post-COP agenda should focus on strengthening institutions rather than maximizing credit volumes. Climate finance should support long-term forest management capacities, including restoration planning, fire management, monitoring systems and transparent revenue-sharing mechanisms grounded in gram sabha processes.

This requires a shift in perspective. Forests should not be treated primarily as offset suppliers, but as public goods that underpin climate resilience and sustainable development. International mechanisms under Article 6.4 must recognize this reality if they are to remain relevant for countries of the Global South.

India also has a broader role to play. As a country with diverse ecosystems, extensive community-managed forests and growing experience in climate policy, India is well positioned to articulate an approach to land-based mitigation that balances ecological realism with environmental integrity. This will require constructive engagement in future Supervisory Body discussions, backed by evidence and stakeholder participation.

Beyond Belém

COP30 has advanced the conversation on land-based climate action, but it has also exposed the limits of global rulebooks. Climate outcomes will ultimately be determined by how countries design and govern their domestic systems. For India, the opportunity lies in demonstrating that nature-based mitigation, when grounded in rights, institutions and long-term stewardship, can deliver both credibility and scale.

As the global focus shifts from negotiation to implementation, the challenge is clear. Climate policy must work with nature, not around it. The success of Article 6.4, and of climate action more broadly, will depend on whether this principle is reflected in practice. ■

Sayanta Ghosh is Associate Fellow, Land Resources Division, TERI, New Delhi.

Coral Reefs Could Feed Millions

If We Let Them Rebuild

Overfished coral reefs are producing far less food than they could. Researchers found that letting reef fish populations recover could boost sustainable fish yields by nearly 50 per cent, creating millions of extra meals each year. Countries with high hunger and nutrient deficiencies would benefit the most. Rebuilding reefs could turn ocean conservation into a powerful tool against global hunger.

The world is now home to about 8.3 billion people, and millions still do not have enough nutritious food. As concerns about food security grow, scientists are looking beyond land for solutions. New research suggests the ocean could play a much larger role than previously thought. A team led by scientists at the Smithsonian Tropical Research Institute (STRI) in Panama found that restoring coral reef fish populations could greatly increase the amount of seafood produced sustainably each year, providing food for millions of people.

The study shows that many reef fish populations have been heavily overfished and are producing far below what they could support over the long term. By allowing these fish stocks to rebuild, researchers say coral reefs could help address hunger on a global scale.

Measuring the Cost of Overfishing

"Our study quantifies how much is being lost by having overfished reef fish communities in terms of food provisioning and, in turn, how much could be gained from rebuilding reef fish stocks and managing them at sustainable levels," explains Jessica Zamborain-Mason, a professor at King Abdullah University of Science and Technology (KAUST) and first author of the recently published paper in the journal *PNAS*.

According to the findings, healthier reef fish populations could significantly expand the amount of seafood available to people while remaining within sustainable limits.

A 50 Per Cent Boost in Sustainable Fish Supply

The researchers found that coral reefs around the world could raise sustainable fish production by nearly 50 per cent if fish populations were allowed to recover. This increase could translate into anywhere from 20,000 to as many as 162 million additional sustainable fish servings per country each year. That amount is enough to meet recommended seafood consumption levels for millions of people, defined as eight ounces per week per person.

The largest gains would occur in countries already facing serious hunger and micronutrient deficiencies. Regions in Africa and Southeast Asia stand to benefit the most. Indonesia, in particular, was identified as having the greatest

potential increase in food supply from restored reef fisheries.

Hunger and Reef Recovery are Closely Linked

"There is a positive correlation between countries' potential increase in the number of fish servings with stock recovery and their global hunger index. Therefore, countries with higher malnutrition indexes could benefit more from recovered reef fish stocks," expressed STRI staff scientist and co-author of the study Sean Connolly.

This connection suggests that restoring reef fisheries could deliver the greatest nutritional benefits where they are most urgently needed.

How Scientists Estimated Reef Fish Recovery

To reach these conclusions, researchers analysed data from coral reef regions around the world. The study included territories in countries such as the Dominican Republic, Panama, Jamaica, Kenya, Mauritius, Oman, Jamaica, Madagascar, the Philippines, and Indonesia, among others.

Using statistical models, the team estimated current fish populations and projected how much they could increase if overfished reefs were managed more effectively. They calculated how large fish stocks would need to grow to reach "maximum sustainable yields" and "pretty good yields," as well as how long recovery might take under different fishing regulations. Depending on how depleted the reefs are and how strictly fishing is limited, recovery times were estimated to range from an average of 6–50 years.

Beyond Conservation to Food Security

The researchers emphasize that restoring coral reef fisheries is not only about protecting ecosystems. The study shows that rebuilding fish populations could directly improve nutrition and help reduce hunger. Reaching these benefits would require strong fisheries management that allows fish stocks to grow rather than be continuously depleted.

In some areas, successful recovery would also depend on providing alternative livelihoods for fishing communities during rebuilding periods, along with international cooperation and support. The next step, scientists say, is developing strategies that protect marine ecosystems while also supporting the people who depend on them.

"Our findings also reinforce that effective reef fisheries monitoring and management has substantial and measurable benefits beyond environmental conservation; it has food security and public health implications," explains Zamborain-Mason. ■

Source: https://www.sciencedaily.com/

Green Farming through Circular Economy

Sustainable Practices for Waste Reduction

Circular economy practices transform a burden of waste into long-term benefits. It enhances resource efficiency, preserves biodiversity, and reduces pollution. This article by **Sanjeev Reddy** discusses strategies for adapting to the circular economy, common challenges faced by farmers, and real-life success stories.

Farmers often overlook agricultural waste; it has more potential than they realize. Agro-waste not only opens possibilities for green farming but also provides renewable energy sources. Modern agriculture generates an abundance of waste from packaging and byproducts, which farmers treat as waste disposal.

This practice became a primary reason for soil degradation and environmental depletion. Over time, soil can become less resilient, and carbon emissions from burning waste intensify. This is where the circular economy steps in, which aims to reuse, recycle, and repurpose resources into useful agricultural inputs.

Understanding the Circular Economy in Agriculture

The circular economy is a switch from the linear economy, often known as a take-make-dispose system. Circular economy is an approach towards zero waste by recycling and reusing waste agricultural materials into valuable resources, such as compost or biogas.

This byproduct waste consists of crop residue, animal manure, and other materials that are reutilized to produce agro-inputs such as biofertilizers, biofuels, and renewable energy sources. This way, the products remain in use for a longer period and create a closed loop. The circular economy regenerates natural resources and combats climate change by keeping materials in use, thereby benefiting the economy, nature, and society.

Why Green Farming Needs Circular Practices

The whole idea of green farming is to protect natural resources and reduce agricultural pollution, which is possible with closed-loop production. The circular economy is a perfect way to stop the exploitation of natural systems like soil and water. Modern agriculture produces

a large amount of waste due to chemical inputs and overconsumption, leading to soil as well as air pollution.

It depends on synthetic fertilizers and remedies, which result in soil degradation, greenhouse gas emissions, and reduced biodiversity. The circular economy focuses on reusing unwanted materials to manage soil fertility and harmful pests through natural processes such as nutrient cycling and composting.

It also assists farmers to rely less on expensive chemical inputs and use their own waste by recycling it into biogas and manure. Without a circular economy, resources such as crop residues, byproducts, and manure are discarded, contributing to depletion and nutrient runoff. Therefore, the circular economy is vital for sustainable agriculture and longevity.

Rising Challenge of Agricultural Waste in Modern Farming

The end goal of modern farming is to achieve higher yields; consequently, farmers use methods like multiple cropping, intensive horticulture, and intercropping. This generates excessive residue of straw, husks, leaves, stalks, and plastic. According to a research, around 10 to 50 per cent of agricultural waste is discarded each year.[1] As a result, managing agricultural waste has become a significant challenge in modern farming. Here's how:

Crop residue

Cereal crops like wheat, corn, and rice produce a huge quantity of waste in the form of tops and leaves. The farmers quickly burn them in the field itself for the upcoming planting season. This not only pollutes the air with greenhouse gas emissions but also disrupts ecosystems.

Plastic waste

Modern farming uses an extreme amount of plastic through mulch films, drip pipes, packaging, seed trays, and greenhouse covers. Most of these plastics are difficult to recycle when they are contaminated with soil and other plant residues.

Microplastics damage the soil's overall structure and interfere with microorganisms, such as earthworms and microbes. It affects the environment, increases toxicity, and threatens food safety.

1 Details available at https://www.mdpi.com/2813-0391/3/2/18

Limited adoption

India is producing around 683 million tonnes of crop residue annually,[2] and around 682.6 million tonnes of agricultural waste from farming and livestock every year. They can be recycled with advanced technologies such as gasification and through biogas units.

However, rural-area farmers do not have access to this due to poverty and a technology gap. For this reason, most resources are left unmanaged or dumped, leading to soil degradation.

Major Circular Economy Practices for Sustainable Waste Reduction in Farming

If agricultural waste continues to increase, it will create major problems like infertile soil, climate change, and poor water quality. The circular economy not just minimizes waste but also protects the environment and prevents pollution. Check out these circular economy practices to reduce waste in agriculture.

Precise agriculture

Incorporating emerging technologies like the Internet of Things (IoT), Artificial Intelligence (AI), and sensors minimizes the use of agricultural inputs like pesticides, fertilizers, and herbicides.[3] This improves the product's efficiency and reduces waste, aligning with a sustainable farming system.

Sustainable permaculture

Permaculture is a practice of designing farming systems to be eco-friendly and long-lasting.

It mimics nature's closed loops that prioritize minimal waste and recycle resources into nutrient-rich compost or manure. This practice allows self-sufficient agriculture and elevates harmony with nature.

Restoring agriculture

Integrating practices such as no-till farming, agroforestry, cover cropping, and livestock integration to improve soil health reduces the need for chemical fertilizers, as nutrients are recycled naturally.

It also prevents soil erosion and enhances soil structure, reducing carbon erosion loss. Regenerative agriculture restores the ecosystem and eliminates waste by creating a closed-loop cycle of nutrients.

Recycle waste

Instead of dumping plant debris, livestock manure, byproducts, and other residues, farmers can convert these wastes into vermicompost, biogas, and organic matter. It benefits soil microbes and supports nutrient recycling within nature. This practice conserves biodiversity and also provides healthier crops at the farm.

Benefits of Circular Economy in Farming

The circular economy provides these economic, social, and environmental benefits in agriculture by reusing, reducing, and recycling waste:

Economic benefits

Cost-effective: Organic waste is converted into a beneficial renewable energy source and inputs such as fertilizers, reducing the cost of agricultural inputs.

Income source: Various recycled materials like crop residue, biofuels, and organic compost can be sold to other farmers, increasing cash flow.

Improve profitability: Closed-loop systems boost soil health by restoring nutrients and increasing yields, generating maximum earnings.

Environmental benefits

Soil enhancement: Embracing sustainable techniques such as crop rotation and no-tilling strengthens soil structure and improves water retention.

Preserves nature: Using natural remedies and compost reduces reliance on synthetic fertilizers, preventing chemical buildup and protecting natural habitats.

Reduce pollution: The circular economy recycles crop waste into biofuel, avoiding the burning of residues and reducing greenhouse gas emissions.

Water conservation: Methods like drip irrigation, rainwater harvesting, crop

2 Details available at https://www.global-agriculture.com/agriculture-industry/india-produces-683-million-tonnes-mt-of-crop-waste-fsii-calls-for-action-on-international-day-of-zero-waste

3 Details available at https://agribegri.com/

rotation, and precision agriculture save water, which restores the ecosystem.

Social benefits

Work opportunities: Composting and integrated livestock systems require strenuous effort and time, increasing the need for labour in rural areas.

Health protection: By reusing and recycling waste, the risk of pollution in the environment is reduced, which improves the quality of life for the farmers.

Consumer satisfaction: Adapting to the circular economy enables farmers to produce healthier, safer crops with reduced chemical use, ensuring food security.

Challenges in Adopting Circular Economy in Farming

Even though the circular economy offers numerous benefits, adapting to a closed-loop system is difficult for farmers due to the following barriers:

Financial challenges

Although the circular economy provides long-term benefits to farmers through vermicompost, biogas, and drip irrigation, farmers need to invest a massive amount in the technologies and systems. These advanced technologies are easily accessible for wealthier farmers and larger farms, while small and marginal farmers struggle to get loans and have limited access to credit.

Technical barriers

Many farmers do not have expertise in technical knowledge, due to which they cannot convert waste into compost or fertilizers. In rural areas, farmers lack knowledge of data-driven technologies such as AI and IoT, which discourages and prevents them from adopting circular economy practices in their farms.

Market limitations

Despite recycling organic waste into usable resources, the demand for byproducts and compost is less. Many buyers are unaware of the benefits of organic inputs and consider them low-quality. Some consumers do not buy the products at fair prices because circular agricultural products are not certified. Therefore, it becomes difficult for farmers to continue circular economy systems.

Case Study, Examples, and, Real-World Success Stories

Circular economy in agriculture is showing promising success by turning waste into resources. Here are some real-life examples from India where farmers accomplish financial and environmental benefits by incorporating circular economy practices into agriculture.

Case Study 1

Earth5R is a sustainable organization that focuses on reusing resources through its circular economy model. This organization has executed closed-loop system practices in the villages of Karnataka, Tamil Nadu, and Uttarakhand. Many residents of Maharashtra converted the organic waste of the farms into natural fertilizers rather than dumping it into garbage.

The women-led groups were also taught vermiculture techniques and other composting methods. As a result, farmers noticed a 40 per cent reduction in agricultural input costs.[4] They successfully replaced chemical fertilizers and began adopting compost made from crop residues. Earth5R also collaborated with youth in Karnataka to reduce post-harvest losses of vegetables and fruits by building solar dryers.

This helped in drying and preserving the resources with a renewable energy source. As per the report, this operation

4 Details available at https://earth5r.org/zero-waste-farming-villages-circular-economy-india

minimized post-harvest waste by 60 per cent, boosted circular farming, and increased farmers' income.

Case Study 2

Every year, some farmers in Punjab burn crop residues like paddy stubble and abandon organic waste. However, this year, due to an increase in pollution in Delhi, a major shift towards a circular economy was perceived.

Farmers from over 800 villages[5] sent crop stubble to the factories and recycling unit to form the waste into valuable biogas and fertilizer. This action not only reduced pollution and smoke emissions but also created income opportunities for some farmers as they started selling recycled products. This brought a positive change in Punjab, because farmers are now recycling nutrients by collecting the farm leftovers, residues, and byproducts, and breaking the linear loop.

Case Study 3

Uttar Pradesh produces 20 million tonnes of agricultural waste,[6] including paddy straw, annually. Most of this organic waste was carbonized, while only some was used as animal feed. ICAR NBAIM (National Bureau of Agriculturally Important Microorganisms) is an Indian Council of Agricultural Research institute that focuses on observing microorganisms such as bacteria, fungi, and viruses.

They developed a Rapid Composting Technology for sustainable farming practices and promoted it in several districts of Uttar Pradesh. The institute established 200 composting bags in 14 villages and encouraged farmers to utilize the technology. They also trained small farmers on composting by

chopping crop residues into small pieces.

This institute educated farmers on mixing these wastes with decomposers, including Biofast and molasses, and on securing the mix in decomposting bags. The organic waste turned into a high-value compost in just 60 days, which not only improved soil health but also provided economic benefits to the farmers.

Research indicates that reductions in input costs ranged from 25 per cent to 30 per cent, saving farmers INR 5000 per acre per year. It also created a new revenue stream through trading and marketing, generating INR 60,000 as a secondary income for the farmers.

Conclusion

Embracing circular economy practices in agriculture is expanding and transforming green farming by reclaiming nutrients from the biowaste. Converting post-harvest residues into organic fertilizer and compost is diminishing dependency on chemical inputs and revamping closed-loop farming systems.

Circular economy practices such as agroforestry, permaculture, and precision agriculture enabled farmers to increase returns from recycled materials and brought a fundamental

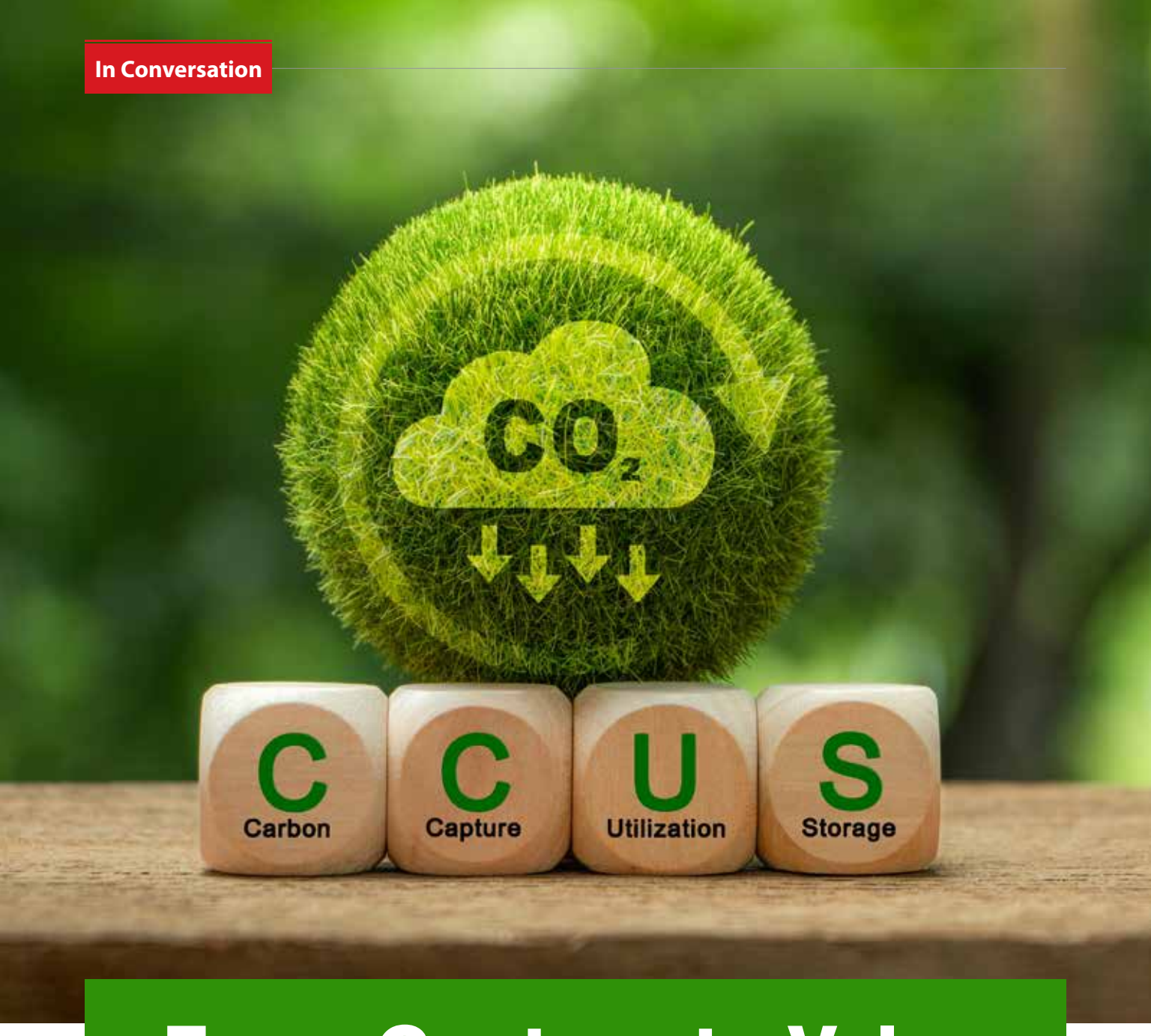
economic change. In spite of the countless advantages of circular economy practices, farmers tackle financial, technical, and other barriers when adopting closed-loop production practices. However, with proper training programmes and policy support, farmers can engage in circular economy practices.

Some institutes and organizations, such as Earth5R, and ICAR NBAIM, demonstrated success by building composting units and solar dryers. Shifting from a Take-Make-Waste model to a Waste-to-Wealth model will help farmers improve green farming practices, conserve resources, and ensure sustainability. ■

Sanjeev Reddy works as Chief Agronomy Officer at AgriBegri, India's leading online agriculture platform that helps farmers access genuine agri-inputs and expert guidance.

5 Details available at https://www.reuters.com/sustainability/climate-energy/farmers-indias-punjab-recycle-crop-waste-aim-reduce-pollution-2025-11-17

6 Details available at https://www.icar.org.in/en/empowering-farmers-rapid-composting-technology-eastern-uttar-pradesh



From Capture to Value

Why CO_2 Utilization Must Anchor India's CCUS Strategy

India's planned ₹38,900–₹39,000 crore carbon capture, utilization, and storage (CCUS) programme will begin with a six-year first phase targeting hard-to-abate sectors such as power, steel, and cement to meet 2070 net-zero goals. In this exclusive email interaction with *TerraGreen*, **Mr Varun Puri**, Managing Director at Green Power International, discusses the realism of timelines, the primacy of CO_2 utilization, policy enablers, and how CCUS can evolve from pilot projects to scalable industrial hubs in India.

Is a six-year first phase realistic for scaling up such high-cost technologies?

The six-year window for rolling out the first phase of the ₹39,000 crore carbon capture programme, expected to be proposed by the Government of India, is somewhat challenging but not impossible. Considering the scale of Indian industries, achieving a significant milestone is feasible if the focus remains on demonstration and cluster-scale projects rather than full-scale national deployment in the initial phase. Finding potential avenues to utilize this CO_2, such as making green hydrocarbon fuels, wherein the hydrogen is generated from renewable sources via electrolysis, should be prioritized. The real challenge lies in securing regulatory approvals, securing financing, and constructing CO_2 transport and storage infrastructure.

The real objective of CCUS is not only capturing carbon but also utilizing it the right way to add value, like turning emissions into fuels or materials that drive economic growth. Green Power International's project in NTPC Vindhyachal, the largest thermal power station in the country, is one fine example of how captured carbon can be utilized efficiently. We provided a 20 TPD CO_2 capture plant, which is used to make 10 TPD green methanol for commercial purposes. Actively utilizing the CO_2 through such processes minimizes the cost and needs associated with storage.

With new technologies, the amount of land needed for CCUS facilities can be reduced or used more efficiently. Also, building large process equipment—like separation columns, should be encouraged during this early phase, because doing so will help the CCUS sector develop and become more mature.

The six-year period can therefore be seen as a foundation-laying phase, where the focus should not be only on deployment but also on learning, process optimization, and policy creation. In this timeframe, India could create regional CCUS hubs, particularly in industrial clusters such as Gujarat, Tamil Nadu, and Odisha, where heavy industries are concentrated. Public-private partnerships and international collaborations, especially with countries already experienced in CCUS such as Norway, Japan, and the US, can help India accelerate both learning and implementation. Moreover, pilot-scale projects across different sectors (cement, steel, and power) will allow policymakers to refine guidelines based on real-world data. Thus, while ambitious, the six-year target can become a strong starting point for a scalable national model if there is coordinated effort across industry, academia, and government.

With 97 GW of new coal-based capacity planned by 2032, can CCUS offset the emissions effectively?

CCUS will play a crucial role in reducing emissions from both new and existing coal plants. It is one of the more viable and available solutions that can help achieve India's decarbonization goals. To offset emissions effectively, CCUS must work in parallel with renewables and efficiency measures to balance India's energy demands with its decarbonization goals. Hydrogen technologies and their costs will take their own time to stabilize to a point where they become viable, not just from a fuel price perspective, but also the capital cost of equipment, like a fuel cell.

While CCUS alone cannot neutralize all emissions from coal-based generation, it can substantially mitigate their impact when integrated strategically. The success of CCUS in the power sector depends on co-location with industrial users that can absorb captured CO_2, such as cement and fertilizer plants. Retrofitting existing plants with capture technology, though capital intensive, will also prevent early retirement of assets and provide a bridge towards cleaner operations. Additionally, efficiency upgrades, biomass co-firing, and hybrid renewable systems must complement

CCUS to reduce the dependency on unabated coal. In this way, India can manage its growing electricity needs while gradually lowering overall carbon intensity. International examples, like Petra Nova in the US and Boundary Dam in Canada, have already demonstrated that CCUS retrofits are technically viable, though cost reductions will require policy incentives and scale. For India, the next step should be to identify suitable emission clusters and establish CO_2 corridors connecting multiple plants to shared utilization hubs.

Is government support (40–100%) sufficient to attract industry participation and private capital?

The level of government support for advancing CCUS seems encouraging, but we will have to wait for the complete policy to be announced to assess its potential impact on industries and adoption rates.

Funding is only one aspect; attracting private capital requires more than that. Investors need clear revenue models through incentives, clarity on the end use of CO_2, long-term policy stability, and well-defined liability for stored CO_2. Government backing should act as a de-risking mechanism. Private players are likely to step in once proof of concept and revenue models are clearer.

Based on our experience, when we tried to implement our CO_2 capture

solution for multiple customers, most of them rightly asked, "What do we do with the CO_2?" Therefore, it is essential to integrate the complete value chain in collaboration with the government in order to achieve the country's Net Zero 2070 goals.

Beyond fiscal support, the government can stimulate participation by establishing a carbon credit framework and mandating partial carbon capture for new high-emission facilities. Tax incentives, viability gap funding, and inclusion of CCUS under green financing mechanisms can further enhance investor confidence. Moreover, a national carbon capture roadmap, outlining sectoral priorities, infrastructure plans, and technology standards, would help reduce uncertainty and guide investments. India can also benefit from linking CCUS with the circular economy narrative, positioning captured CO_2 as a feedstock for products like methanol, urea, and construction materials.

Should India prioritize permanent geological storage of CO_2 or focus more on utilization technologies with economic value?

The right approach, not only for India but for any country, would be to adopt a dual strategy. Geological storage offers the scale and permanence needed for deep decarbonization, while utilization pathways help create economic value and reduce initial costs.

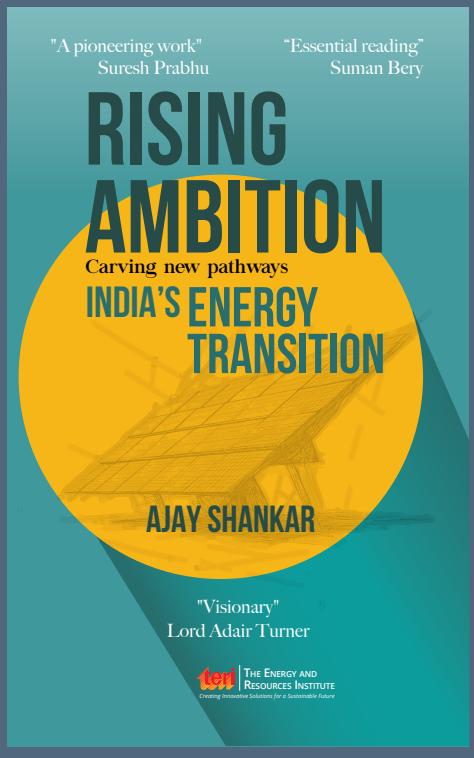
In the long term, utilization will continue to remain a key driver for decision makers, especially for private players, to decide whether or not to invest in CCUS. Storage should be treated like peaking plants for a large IPP. It should be used only when demand exceeds supply. Our primary focus should be on generating demand, i.e., increasing utilization, to minimize storage requirements, which are costly and do not contribute directly to ROI. True returns will materialize only when the CO_2 is effectively utilized.

In India's case, prioritizing utilization makes particular sense because of the abundance of industries capable of consuming captured carbon. CO_2-to-methanol, synthetic fuel generation, algae cultivation, and enhanced oil recovery are just a few examples that can simultaneously address emissions and economic growth. Geological storage, though important for long-term climate commitments, requires extensive geological surveys, monitoring frameworks, and liability mechanisms, all of which take time to develop. Hence, focusing initially on utilization technologies will allow India to build expertise, infrastructure, and investor confidence while gradually transitioning towards large-scale storage. Over the next decade, pilot storage projects in regions like the Cambay Basin could help India build the technical foundation for future deployment. The dual pathway, therefore, not only supports environmental goals but also strengthens industrial competitiveness.

How prepared are industries such as green hydrogen, petrochemicals, and coal gasification to adopt CCUS?

Industries like petrochemicals and coal gasification are relatively better placed to adopt CCUS since they generate concentrated CO_2 streams. Integration of CCUS in synthetic fuel pathways is also possible and presents a readily available opportunity to kickstart a green revolution in this segment. Overall, readiness is still limited. These industries will need strong policy incentives, infrastructure, and demonstration projects to build confidence and scale adoption.

Currently, the green hydrogen ecosystem is still at a nascent stage in India. However, its synergy with CCUS can be transformative, captured carbon can be combined with green hydrogen to produce synthetic fuels such as methanol, ammonia, and sustainable aviation fuel. Petrochemical industries, given their existing process infrastructure, can quickly adopt capture units once clear offtake mechanisms are defined. Coal gasification projects already produce CO_2-rich streams, which makes capture integration technically simpler. Yet, to unlock full potential, industry collaboration with research institutes and technology providers is critical. Establishing pilot clusters, supported by shared pipelines and utilization facilities, will enable scale while keeping costs manageable. Moreover, developing local manufacturing of capture equipment and absorbents can help reduce dependence on imports and lower the overall cost curve. As India pushes towards decarbonization, these sectors will play a pivotal role in demonstrating that CCUS can be both an environmental necessity and a business opportunity. ■



Rising Ambition Carving New Pathways India's Energy Transition

Ajay Shankar
Distinguished Fellow
The Energy and Resources Institute (TERI)

India aims to become net zero by 2070. This book sets out the pathways to net zero with key milestones. It suggests policy choices and ways to minimize the cost of this fundamental transition deriving lessons from the remarkable success that has been achieved in renewables. It makes the case that moving away from fossil fuels would also help India become a developed country with a competitive green economy.

Year: 2025
Size: 5 inch x 8 inch
Pages: 244
ISBN: 978-93-94657-19-9
Price: ₹495.00

"A meticulously documented analysis of India's decarbonization possibilities by one of our most thoughtful and experienced administrative scholars."

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The Energy and Resources Institute (TERI)
Darbari Seth Block, India Habitat Centre, Lodhi Road, New Delhi – 110 003, India
Telephone: +91-11-2468 2100 • : teripress@teri.res.in • : http://bookstore.teriin.org


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India Braces for Disasters in Himalayas, Coasts

Scientists Urge for Adaptation and Climate-resilient Planning

In this article, **Athar Parvaiz** highlights that India's revised seismic zonation has placed 61 per cent of the country, including the entire Himalayan arc, in moderate to very high earthquake risk, prompting scientists to call for urgent adaptation. The new BIS map, based on probabilistic hazard assessment, upgrades the Himalayas to the highest-risk Zone VI, compounding climate-driven threats such as floods, landslides and permafrost thaw affecting over 50 million people. Experts warn that infrastructure, dams and cities such as Delhi and Chandigarh require stricter building codes, retrofitting and audits. Simultaneously, intensifying, rain-heavy cyclones along India's coasts highlight the growing need for climate-resilient planning, preparedness, and adaptation.

Reacting to the radical upgradation of India's seismic zonation which has placed the country's 61 per cent landmass in moderate to high-risk category and the entire Himalayan arc in the highest-risk or Zone VI, scientists say that the upgrade (in November 2025) calls for re-evaluation of infrastructure in high-risk zones, especially in the Himalayas where the overlay of climate stress and the upgraded tectonic hazard assessment deepen the vulnerability of around 52 million people living in Himalayan states.

The Himalayan communities, already under threat from climate-driven floods and slope failures, will now have to also reckon with major seismic risk. A surge in disasters has been witnessed in recent months and years in the Himalayas,[1] including a 2025 debris-flow in Uttarakhand that was traced to moraines and thawing permafrost rather than a cloudburst.

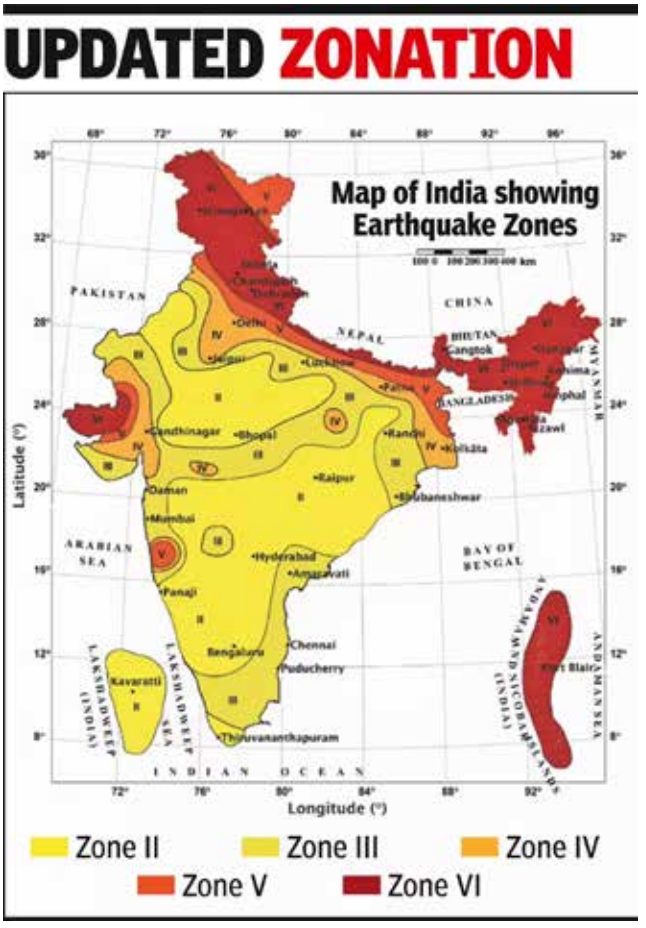
In 2022, disasters struck on 63 per cent of the days in the entire year in Indian Himalayan region, with 1058 deaths while the numbers rose to 68 per cent in 2023 and 70 per cent in 2024, killing 837 and 870 people respectively in these years, according to *Down to Earth*,[2] a weekly magazine published by the Centre for Science and Environment.

The revised seismic zonation was done in late November by the Bureau of Indian Standards (BIS), India's National Standard Body which develops seismic zoning map of India and operates through various committees to help set up standards. The BIS classifies regions based on their earthquake risk, a vital aspect for planning and construction practices. In BIS's latest revision of earthquake-risk, a key change from previous versions is the introduction of a revised earthquake zone map.

This new map, unlike its predecessors, is based on a probabilistic earthquake hazard assessment (PEHA), incorporating known faults, potential event sizes, ground shaking attenuation, tectonics, and lithology across India, the BIS upgradation report says. The country is now divided into five zones: II, III, IV, V, and VI, reflecting relative peak ground accelerations (PGA) correlated with the 1964 MSK intensity scale, a system which measures seismic severity based on observed effects on humans, buildings, and the environment.

1 Details available at https://www.science.org/content/article/himalayas-expanding-lakes-signal-growing-flood-risks

2 Details available at https://www.downtoearth.org.in/natural-disasters/disaster-zone



Seismic Hazard Higher than Previously Projected

"The change in the Himalaya is significant," Vineet Gahalaut, the Director of Wadia Institute of Himalayan Geology, Dehradun, told the author of this article and added: "The important thing in this upgradation is the realization that the seismic hazard in the Himalaya is actually higher than previously projected in the earlier map." He said that the Himalayan region has now been put in seismic zone VI whereas earlier it was in zone IV and V.

"These zones are directly related to the strengthening measures in construction of large structures. Thus, all the critical structures in the Himalaya will require much more strengthening [as per the new map]," Gahalaut said.

Navin Juyal, senior geologist who was formerly with Physical Research Laboratory, Ahmedabad, said: "Under the changing climate, coupled with the seismic threat, assessment of vulnerable zones is utmost important because of the fact that disaster happens when hazard meets vulnerability." This is also equally important for making the proactive disaster resilient policies in the Himalayan region," Juyal said.

According to Jayangonda Perumal, Head Structure and Tectonic Group, Wadia Institute of Himalayan Geology, the updated seismic map, based on active fault studies and continuous GPS measurements, reveals that earlier zonation maps were not in tandem with the actual seismic risk. This makes the upgradation very significant, he said.

It highlights highly vulnerable zones V and VI, covering areas between the foothills of the Higher Himalaya and along the Himalayan foothills, including cities such as Chandigarh, Delhi, and Upper Assam, Perumal told the author of this article. "This new understanding indicates that cities south of the Main Frontal Thrust (MFT) or Himalayan Frontal Thrust (HFT) could experience significant surface uplift (6 to 8 m) during earthquakes, leading to large amplitude shaking, liquefaction, and ground fissures," he added.

"For densely populated cities like Delhi and Chandigarh, the implications are severe, necessitating strict enforcement of building code norms. While the re-evaluation of environmental clearances for existing projects is a government decision, adopting seismic resilient building codes, especially for large infrastructures, is crucial. A nodal agency comprising experts from all relevant institutions should be identified to oversee this," he said.

Om Prakash Mishra, the Director of National Centre of Seismology (NCS) said that there are some major multipurpose power projects and other important infrastructure in the Himalayan region which need to be re-evaluated for in the light of this risk assessment upgrade. "Their design is based on geological and seismological assessments. Earlier, the

seismic information was limited, mainly focusing on the immediate subsurface. Now, with this new map and the shift to Zone VI, the expected shaking values have increased. That means structures have to be re-evaluated for resilience," Mishra said and added that some structures might not have been designed to capture or withstand this level of motion.

Mishra said that seismicity in the Himalayas is very complex, with strain accumulating in some places very fast. Though there was no recent occurrence in some, the stress is still there, he added. The revised seismic zonation map, Mishra said, provides crucial insights into which zones are most vulnerable to seismic activity. This detailed investigation, particularly with the new Zone VI, allows for the implementation of engineering and scientific solutions for infrastructure and structures, adhering to an "earth's critical resilient building code." According to Mishra, this code considers the type of materials beneath the surface and how seismic shaking can amplify them. "If the shaking frequency of an earthquake matches a building's frequency, it can lead to resonance and collapse. Understanding the PGA value in a zone is key, as it is a parameter engineers use to ensure buildings are resilient enough to withstand specific ground accelerations.

This detailed study is vital for designing and constructing critical infrastructure such as power plants, electric stations, nuclear plants, hospitals, schools, and prisons. These structures can be built to be resilient and attenuate seismic waves, preventing destruction. Rapid urbanization necessitates better-designed, earthquake-risk-resilient infrastructure," he said and added that the National Centre for Seismology (NCS) and the National Disaster Management Authority (NDMA) are working towards making India an earthquake-resilient country by 2047.

He further said: "For existing infrastructure, particularly in the Himalayan region, retrofitting and auditing are being undertaken. For instance, the Devang multipurpose project in Arunachal Pradesh was designed with an integrated physical and sociological method, ensuring that shaking would be averted and attenuated by the foundation design, similar to earthquake-resilient structures in Japan. For vital installations, precautions are being taken, and designs are being reinforced with new models."

A Wake-up Call

The new seismic zonation map, said C P Rajendran, Indian Geologist (National Institute of Advance Studies), is a necessary wake-up call and provides India with, scientifically, the most accurate picture to date of its earthquake risk.

"Special care is needed to avoid the construction of critical facilities (e.g., hospitals, fire stations, power plants) on the most vulnerable land and also to regulate development on steep, unstable slopes that are prone to landslides during quakes in the Himalayas," Rajendran said.

Major cities outside the Himalayas, including Delhi, Kolkata, and Guwahati, fall into high-risk zones, Rajendran said. "Considering the updated Seismic Zonation Map, the National Building Code of India must be rigorously updated and enforced, especially for high-rise structures, hospitals, schools, and critical infrastructure. This includes design standards for lateral loads (earthquake forces) and the use of modern engineering techniques like base isolation," he said.

According to the NDMA, the increase in earthquake risk is due to a spurt in developmental activities driven by urbanization, economic development and the globalization of India's economy.

"The increase in use of high-technology equipment and tools in manufacturing and service industries

has also made them susceptible to disruption due to relatively moderate ground shaking. As a result, loss of human life is not the only determinant of earthquake risk anymore," NDMA notes on its official website and adds: "Severe economic losses leading to the collapse of the local or regional economy after an earthquake may have long-term adverse consequences for the entire country. This effect would be further magnified if an earthquake affects a mega-city, such as Delhi or Mumbai."

The NDMA, headed by the Prime Minister of India, is the apex body for Disaster Management in India. Setting up of NDMA and the creation of an enabling environment for institutional mechanisms at the State and District levels is mandated by the Disaster Management Act, 2005. The NDMA is mandated to lay down the policies, plans and guidelines for Disaster Management. India envisions the development of an ethos of Prevention, Mitigation, Preparedness and Response.

According to the NDMA, the Indian government strives to promote a national resolve to mitigate the damage and destruction caused by natural and man-made disasters, through sustained and collective efforts of all government agencies, non-governmental organizations, and people's participation. This is planned to be accomplished by adopting a Technology-Driven, Pro-Active, Multi-Hazard and Multi-Sectoral strategy for building a Safer, Disaster Resilient and Dynamic India, NDMA says.

'A Trend of Intensifying Storms' in Coastal Regions

Meanwhile, scientists say that a new type of disasters in Asian coastal regions, characterized by intense rainfall rather than intense winds was recently observed adding that such disasters are likely to occur frequently in future.

Despite early warnings reportedly reaching communities before the cyclones (Ditwah and Senyar) struck coastal regions in Sri Lanka, parts of southern India and Southeast Asia late November, over 1500 people lost their lives and hundreds went missing even as millions were impacted by these disasters which caused massive destruction. Scientists say that these disasters reflect a changing climate system which is making cyclones more hazardous than what we considered "typical" in the past.

Highlighting that the latest cyclones in South and Southeast Asia reflect a changing climate system, Professor Benjamin Horton, Dean of the School of Energy and Environment (SEE) at City University of Hong Kong said: "While Senyar and Ditwah are still

tropical cyclones in a meteorological sense, what makes them different is their intensity, rainfall patterns, and the regions they are impacting."

Historically, he said, cyclones in this region were less frequent and less severe. "Today, warmer ocean temperatures and shifting atmospheric circulation are fuelling storms that are stronger, wetter, and sometimes slower moving, which is leading to prolonged flooding and greater destruction," Horton explained and added that climate change is amplifying the characteristics of these storms, making them more hazardous than what was considered "typical" in the past. "And it is only going to get worse," he warned.

Horton underlined that a multi-layered approach is needed to deal with these climate-driven disasters in future which include: Providing accurate forecasting and rapid communication to communities at risk; designing buildings, roads and critical facilities to withstand extreme winds, heavy rainfall and flooding; avoiding high-risk zones for development besides restoring natural buffers like mangroves and wetlands; training local populations on evacuation plans and emergency responses; integrating climate risk into government planning and allocating resources for adaptation, not just for recovery.

"Ultimately, reducing greenhouse gas emissions globally is essential to slow the trend of intensifying storms. But locally, proactive adaptation and preparedness will save lives and reduce economic losses," Horton emphasized.

Indian climate scientist, Roxy Mathew Koll, opined that the latest cyclones (Ditwah and Senyar) are a new class of disasters characterized by winds which are not intense in ferocity, but by the amount of rain they contain.

According to Koll, neither Senyar nor Ditwah ranked among the strongest storms of recent decades. Their wind speeds (60–80 km/hr), he noted, did not approach the ferocity of super cyclones (often reaching 200–250 km/hr), but they carried extraordinary amounts of water.

Koll believes that Senyar and Ditwah revealed something uncomfortable yet undeniable for which adaptation strategies need to be in place as early as possible. According to him, unless homes, roads, schools, farms and local institutions adapt at the same pace as forms of such disasters are changing, warnings will remain as weather reports only.

Ligin Joseph who researches on physical oceanography at the University of Southampton said that it is still too early to say definitively whether these cyclones were fundamentally different from past events. "A thorough scientific assessment, including peer-reviewed analyses, will be required to establish whether climate change played a significant role. That said, Cyclones Senyar and Ditwah did have some unusual characteristics. For instance, Senyar formed very close to the equator, where the Coriolis force (the spin needed for cyclones to develop) is weak. While equatorial cyclone formation is rare, it is not unprecedented, but it does make Senyar noteworthy," Joseph said.

Another peculiarity, he said, is that both cyclones had relatively low wind speeds, yet the impacts were severe, primarily due to extreme rainfall and flooding rather than wind damage. Both systems also formed close to the coast and moved slowly, which can enhance rainfall accumulation and worsen flooding, Joseph added.

According to him, from a climate change perspective, a warmer atmosphere holds more moisture, which can increase the rainfall associated with cyclones. "So, climate change may have contributed to the intensity of the rainfall, but at this stage, it is too early to quantify its exact influence," he said and added: "While climate change is projected to increase the intensity of tropical cyclones globally, the frequency does not necessarily increase. What we are more certain about is that cyclones are becoming wetter, which raises the risk of flooding."

Regarding the prevention of loss of lives and property in future from such events, he said that while early warning systems have improved significantly, and in this case (Ditwah and Senyar) the forecasts were timely, however, ground-level preparedness remains crucial, particularly ensuring that people can be moved quickly to safe shelters, improving drainage infrastructure, and planning land use to reduce exposure in vulnerable areas. "These measures save lives, though property damage may still occur," Joseph said. ■

Athar Parvaiz is an environment and science journalist based out of Jammu and Kashmir, India.

WORLD SUSTAINABLE DEVELOPMENT SUMMIT 2026

परिवर्तन I TRANSFORMATIONS: VISION, VOICES, AND VALUES FOR SUSTAINABLE DEVELOPMENT

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Aravalli on the Edge

Saving India's Ancient Green Shield from Collapse

The Supreme Court's recent verdict on the Aravalli issue has sparked fresh controversy. The ruling adopts a definition of a "hill" that requires a terrain to rise at least 100 metres above the surrounding land to qualify as hilly. Environmentalists argue that applying this definition would effectively strip nearly 85–90 per cent of the Aravalli range of its hilly classification. Read more in this article by **Shamim Haque Mondal**.

The Aravallis, one of the oldest mountain ranges in the world, is facing an existential crisis. This 150–250 crore year old mountain range, spread across Rajasthan, Haryana, Delhi, and Gujarat, has served as a fundamental pillar of the ecological balance of North India. However, a recent Supreme Court ruling has triggered deep concern and strong protests about the future of the Aravallis, the expression of which is the 'Save Aravalli' movement. This movement is not just a demand to protect a mountain; it is also a serious question mark against the political approach of destroying nature in the name of development.

The Aravalli Range extends from the Palanpur region of Gujarat, crossing Rajasthan, through Haryana, to the historic Ridge of Delhi. Geologically, it is one of the oldest fold mountains on Earth, whose eroded structure is its natural feature. Despite the lack of high peaks, the Aravallis play a significant ecological role, balancing the water, air, and land systems of northwest India.

Historically, the Aravalli region was home to many civilizations and settlements. The mineral resources here were associated with the economic activities of ancient India. But in modern times, that mineral wealth has become the main tool for the destruction of this mountain.

To understand the importance of the Aravalli hills, it is important to look at their ecological role. First, these hills virtually block the eastward expansion of the Thar Desert. If the Aravalli system weakens, the desertification is likely to spread rapidly to Rajasthan, Haryana, Delhi, and western Uttar Pradesh. Secondly, Aravalli is a natural 'lung filter' for Delhi and the NCR region. The mountain blocks a large part of the dust, sand, and polluted air coming from the west. The deterioration means that Delhi's already critical air quality becomes even more dangerous.

Thirdly, the rocks, forests, and natural slopes of the hills play an important role in groundwater conservation. "Today, when vast areas of Haryana and Delhi are identified as 'dark zones' in terms of groundwater levels, the erosion of the Aravallis means an even greater depth

of water crisis." Fourth, the Aravallis are home to many rare flora and fauna. A number of plant and animal species are associated with the mountain.

Since independence, mining activities in the Aravalli region have increased rapidly. People in Rajasthan and Haryana have indiscriminately cut down hills for stone, marble, and other minerals. Often, despite the court's ban, illegal mining continues in administrative silence or under direct influence.

Add to the mix the unchecked real estate encroachment in the Delhi-NCR region. Luxury housing, farmhouses, and commercial projects have come up in the foothills of Gurgaon, Faridabad, and Mewat. Concrete urbanization by clearing forests and levelling hills has disrupted the normal structure of the Aravallis.

A recent ruling by the Supreme Court has sparked a new debate. The ruling adopted a definition of 'hill,' which states that for a terrain to be classified as a hill, its height must be at least 100 metres higher than the surrounding land. According to environmentalists, if this definition is implemented, about 85–90 per cent of the Aravalli area will no longer be considered as a hill. Because the Aravallis are an ancient and eroded mountain range, the main feature is the low-altitude hills that are wider than the high peaks. Experts say that this definition contradicts the reality of nature. The importance of a mountain is not determined by height alone—its geological composition, water-holding capacity, and biodiversity are the real criteria.

This definition puts large parts of the Aravallis at risk of falling outside the scope of environmental protection. As a result, mines and quarries can be restarted easily, roads for large construction and corporate projects will be opened, forest conservation laws will be virtually weakened, groundwater recharge systems will collapse, pollution and temperature will increase in the Delhi-NCR region, and desertification will spread rapidly in Rajasthan and Haryana. This is why environmental activists are calling it virtually a death warrant for the Aravallis.

In such a situation, the 'Save Aravalli' movement has been formed. Environmentalists, scientists, students, and common people are together raising a fundamental question—does changing the definition on paper change the reality of nature? This movement challenges the conventional notion of development. Is it necessary to destroy nature? Are corporate interests above people's environmental safety?

The Aravalli hills have silently protected northern India for centuries—as a natural bulwark against desert invasions, water scarcity, and pollution. Today the mountain is in the fight for survival. Changing the definition of mountains does not change the character of nature. Only the mask of people's responsibility and the state's priority changes. Will we destroy this ancient mountain for development, or will we save it for future generations? ■

Dr Shamim Haque Mondal, Physics Division, State Forensic Science Laboratory, Kolkata, West Bengal, India.

CNFF-25

Highlights Environmental Concern Amid India's Cultural Heritage

The 9th Chalachitram National Film Festival (CNFF-25), held in Guwahati on November 29–30, 2025, showcased over 30 short films and documentaries highlighting India's cultural heritage and environmental concerns. Organized by Chalachitram, the festival featured award-winning films from across the country, with special focus on sustainability and tradition. Opening with ***Aham Bharatam*** and closing with ***The First Film***, CNFF-25 reinforced cinema's role in cultural preservation and ecological awareness.

The 9th Chalachitram National Film Festival (CNFF-25) showcased over 30 short features and documentaries at the Jyoti Chitraban premises in the Kahilipara locality of Guwahati, Assam, on November 29–30, 2025.

Organized by Chalachitram, a subsidiary of Vishwa Samvad Kendra–Assam, CNFF-25 screened entries in both competitive and non-competitive categories, including at least three short films documenting efforts to make the Earth greener and healthier.

Molai: Man Behind The Forest, directed by Dhiraj Kashyap, speaks about Assam's adored forest man Jadav Payeng, who has created a 550 hectares forest reserve (Molai Kathoni) at Aruna Chapori on the bank of Brahmaputra with relentless hard work to win several national and international awards including the Padma Shri. On the other hand, *Brikhya Boli,* directed by Dwip Baruah, opens up a melodrama to teach the audience about the importance of trees and affection towards nature for the survival of the human race. *Bhoomi Jivanar Spandan*, directed by Suraj Kr Duwarah, defines the land as a solid supporter of human tradition, culture and livelihood, where the age-old Vaishnavite rituals enrich the social fabrics connecting Assam with India's Vedic past.

Koli, directed by Jyotirmoy Mazumder, was adjudged as the best short film in the north-eastern category of the unique film festival and *Joba*, directed by Indira Baikerikar, got the award for best short feature in the rest of India section. Best documentary award was conferred on *The String Master*, directed by Biswajit Das, whereas best director's award went to Bismita Borah for her short feature *Who Will Call Out Father Father*. The *Expectation* team comprising Ramjyoti Krincharan, Ajijul Islam and Elvachisa Sangma received the best cinematography award, whereas best editing award went to Samujjal Kashyap for the film *Muga* and best screenplay award to Irungbam Manisana for *The Silent Performer*. The jury board consisting of renowned filmmaker, critic & writer, Vijayakrishnan, national award winning filmmaker Maipaksana Haorongbam and leading sound designer & mixer Debajit

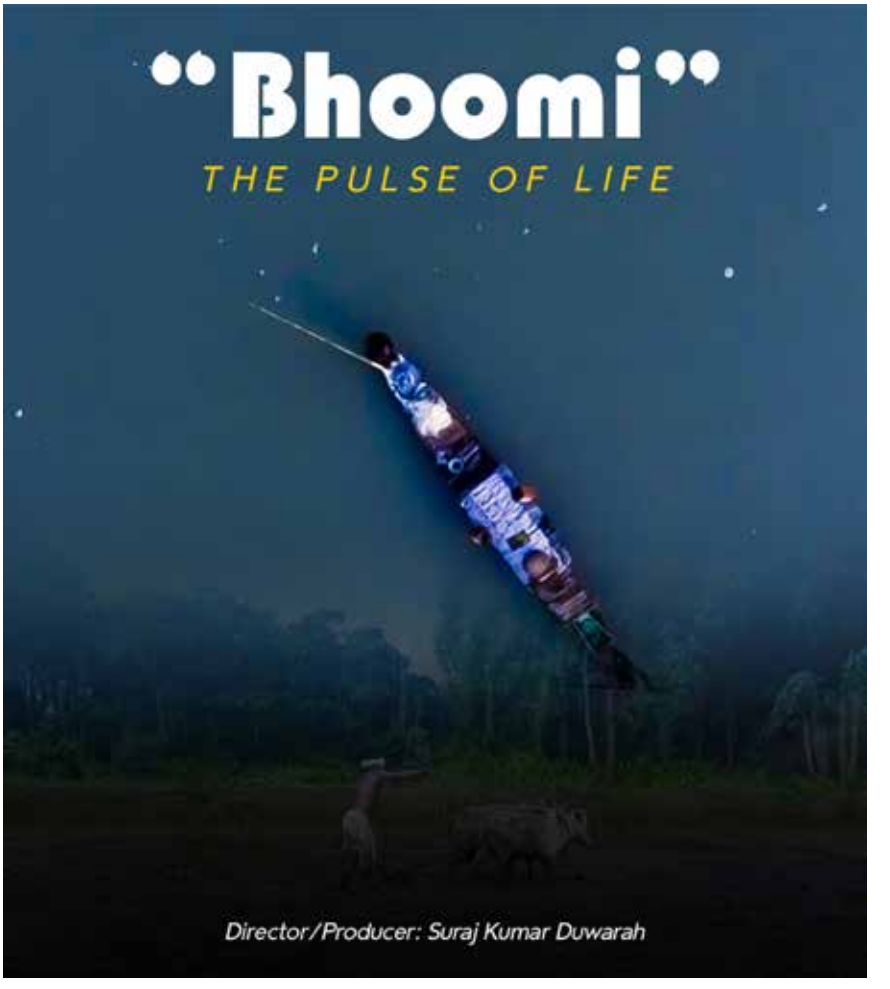
Gayan made a special mention to Shreyas S Gautam's *Just Breath.*

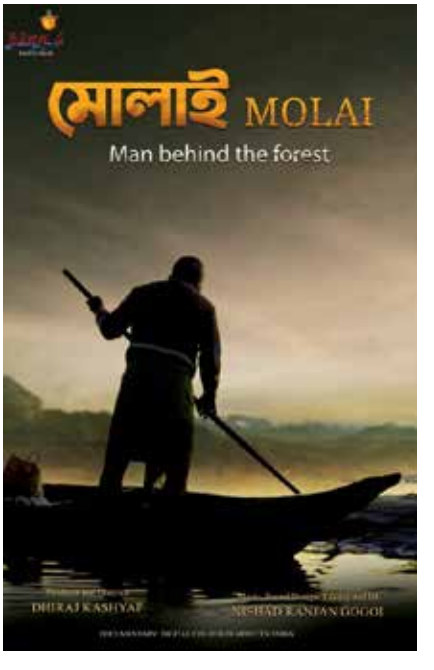
Aham Bharatam, directed by Bharat Bala, which projects India's growth on a strong cultural foundation enriched by thousands of years of history and offers a visual journey across vast landscapes, ancient languages, practices, arts, and oral traditions, was screened as the opening film of the festival.

The First Film, directed by Piyush Thakur, was screened as the closing film. Set in orthodox India of the 1960s, it narrates a poignant story of a young girl obsessed with cinema and a voiceless teenage boy who recounts stories from films. One day, the girl finally finds herself in a cinema hall—possibly for the last time before her arranged marriage.

The unique visual feast for film buffs with the central theme 'Our Heritage Our Pride' received nearly hundred entries (produced between November 1, 2024 and September 15, 2025 with the duration of maximum 25 minutes), out of which the preview committee comprising veteran filmmaker Bibhu Dutta, award winning director Jhulan Krishna Mahanta and accomplished cinematographer Hiten Thakuria selected the package for screening. The visual feast for the cine-goers was inaugurated by Dr Sunil Mohanty, Asom Khetra prachar pramukh of Rashtriya Swayamsevak Sangh by lighting sacred lamps in front of Bharat Mata's portrait and also three Assamese cultural icons namely Bharat Ratna Dr Bhupen Hazarika, heart-throb Zubeen Garg (recently deceased) and flutist Deepak Sarma.

The distinctive film-fest under the mentorship of Bharatiya Chitra Sadhna was initially launched as Guwahati Film Festival in 2017 and it was renamed in 2019 with the central theme of 'Our Heritage Our Pride' with an aim to bring film-works closer to the common people. The inaugural edition was organized at Rabindra Bhawan and nearby institutions, but later it was renamed and permanently shifted to Jyoti Chitraban film studio premises since its third edition (CNFF-2019). Gracing the GFF-2017, the then Assam Chief Minister Shri Sarbananda Sonowal, opined that cinema reflects the philosophy of life, reality and expectations of society, and it plays an important role in transforming society.





Gracing the closing function, Assam legislative assembly speaker Biswajit Daimary appreciated the move to encourage the short duration filmmakers with a great platform. India today witnesses a number of intriguing national film festivals across the nation and the CNFF joins the elite clubs with a major concern for the environment. ■

This article is contributed by Nava Thakuria, a journalist based in Northeast India and a regular contributor to this publication.

Motor Efficiency

The Silent Catalyst of India's Green Industrial Revolution

With India's industrial sector consuming nearly half of the nation's electricity and motors accounting for close to 70 per cent of this demand, this article by **Mayur Karmarkar** argues that motor efficiency is one of India's most underleveraged yet high-impact pathways to industrial decarbonization. In advanced economies such as the EU, USA, China, and Japan where IE3 has long served as the baseline, the article emphasizes the pressing need for India to swiftly elevate its Minimum Energy Performance Standards (MEPS) in order to maintain its global competitiveness, curb emissions, and reinforce the resilience of its manufacturing sector. The article also emphasizes the critical role of copper in enabling this efficiency shift, improving reliability, reducing heat losses, and supporting India's circular economy and Atmanirbhar Bharat goals.

India's industrial sector consumes 42 per cent of the nation's electricity—about 1,622 TWh—and nearly 70 per cent of its powers electric motors. These machines silently drive production across sectors, yet their efficiency remains largely ignored. With industry contributing around 30 per cent of India's greenhouse gas emissions, improving motor efficiency represents one of the fastest and most cost-effective routes to decarbonization as India targets Net Zero by 2070.

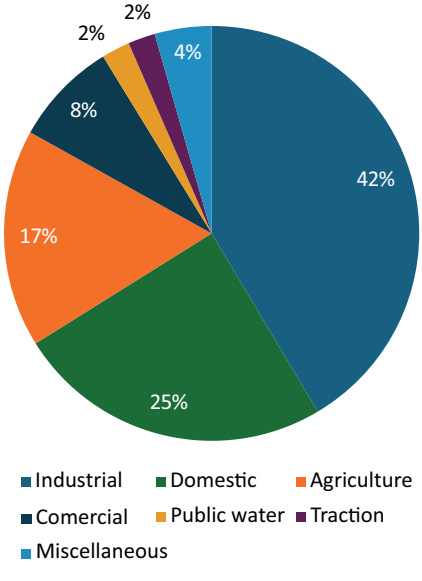
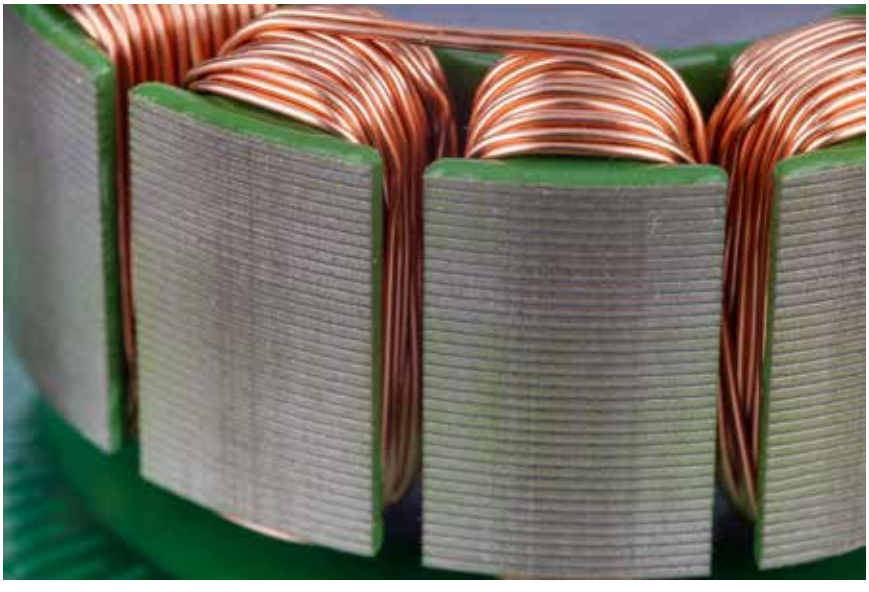


Figure 1: Sector-wise energy consumption in India



While rising share of renewable energy in India's energy mix is already reducing emissions, but as per the Central Electricity Authority (CEA), the share of power generation through fossil fuels remains high at 78 per cent. This presents a significant opportunity to reduce fossil fuel-based power consumption by implementing energy-efficiency measures on the demand side.

India has more than 40 million motors in operation, many still below IE2 efficiency levels. In contrast, over 80 per cent of global motor markets—from the US and EU to China and Japan—have already moved to IE3 as the minimum standard. In 2023, the EU took a global lead by introducing regulations for even higher efficiency standards (IE4) for rating between 75 kW and 200 kW. India's reliance on outdated, energy-intensive motors increases energy costs and emissions while weakening industrial competitiveness.

Around 2 million motors are sold in India with total rated power of 20 GW. Of this, 60 per cent are IE2 motors, while the remaining 40 per cent are a mix of IE3

and IE4. The opportunity is enormous. Upgrading to IE3 standards can save about 5 billion kWh annually, avoiding 3.6 million tonnes of CO_2, and delivering energy equivalent to powering 6 million households. With payback periods of 2–4 years, deployment of efficient motors presents economically viable solutions for industry that may reduce plant energy bills by 5–10 per cent, making them both an economic and sustainability win.

Copper is central to this efficiency shift. IE3 motors require 20–25 per cent more copper in windings, reducing resistance, heat loss, and improving reliability and lifespan. As a fully recyclable material that requires 85 per cent less energy to recycle than to produce from ore, copper also strengthens circularity and aligns with India's Atmanirbhar Bharat goals.

Driving this transition will require coordinated action. India must upgrade its Minimum Energy Performance Standards from IE2 to IE3, supported by strong compliance systems, financial incentives, widespread awareness and strengthening the motor manufacturing sector in the MSME segment as it holds a significant part of supply chain of efficient motors within the industrial clusters in state.

The MSME sector is sometimes equipped with obsolete technologies and poor operating practices, which offers significant potential for deploying energy efficiency through technology upgradation and adoption of best operating practices in manufacturing processes.[1]

A major barrier is that motors are often treated as low-priority assets, and procurement is driven by upfront cost rather than lifecycle cost. As per the International Energy Agency (IEA), purchase cost represents only 2–3 per cent of lifecycle cost while the energy consumption and maintenance account for 97–98 per cent of cost. Improving energy efficiency not only lowers operating costs but also extends motor lifespan by reducing heat losses. Training plant managers, procurement teams, and financial decision-makers is essential to shift the market towards high-efficiency choices.

The National Motor Replacement Programme by the EESL, in partnership with the International Copper Association India (ICA India), shows how government–industry collaboration can accelerate change. This has driven a significant market transformation, with the share of IE3 motors rising from about 5 per cent in 2018 to approximately 35 per cent by 2024.

1 Bureau of Energy Efficiency (BEE), Ministry of Power, Government of India. Energy Conservation Guidelines for MSME Sector, 2019. Section 1: Background, Page 1.

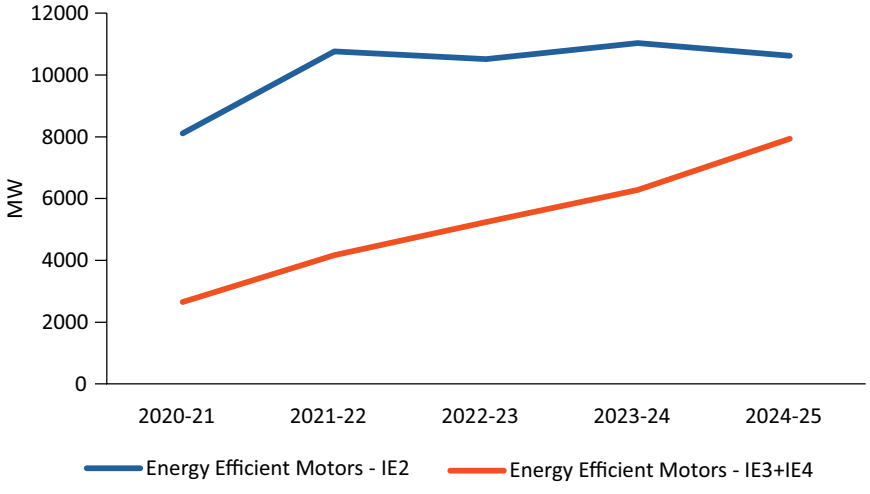


Figure 2: Energy efficient motor adoption in India as per the IEEMA statistics

Energy-efficient motors are the low-hanging fruit of India's industrial decarbonization. For motors operating more than 4000 hours annually, the cost of saving 1 kWh by upgrading to IE3 efficiency is comparable or even lower than—the cost of generating an additional kilowatt-hour from renewable sources. This underscores that demand-side efficiency can be as impactful as clean energy.

In May 2022, Egypt became one of Africa's leaders in motor efficiency by enforcing nationwide IE3 standards, following a 2020 decree by its Minister of Trade and Industry. This achievement was the result of the six-year STEP programme led by the International Finance Corporation (IFC), which developed a clear seven-point roadmap covering leadership, technical standards, industry consultations, market surveillance, and supply-chain upgrades. Egypt's experience demonstrates how transparent communication, evidence-based planning, early stakeholder engagement, and institutional coordination can enable a smooth transition to higher Minimum Energy Performance Standards (MEPS). As India prepares to advance its own motor efficiency standards, it can draw valuable lessons from this successful African model.

India's green future will not be powered by renewables alone—but also by smarter, more efficient use of the energy we already produce. Efficient motors offer a proven, scalable pathway requiring no major overhaul. We shouldn't wait for India to become a destination for low-efficiency motors from countries where higher MEPS is in place. Instead, we should seize this opportunity to strengthen our efficiency, manufacturing capabilities, and quality standards to compete effectively in global markets. The time to act is now. ■

Mayur Karmarkar is the Managing Director of the International Copper Association (ICA) India. He oversees ICA's national programmes on clean energy transition, green and healthy buildings, and market transformation, working closely with policymakers, industry, and supply-chain stakeholders to advance India's sustainability agenda. International Copper Association India (ICA India) is a member of the Copper Alliance and the Indian arm of the International Copper Association Limited (ICA), the leading not-for-profit organization for the promotion of copper worldwide. ICA has been operating since 1998 in India and has built an active association with the growing number of copper users through its programmes.

Terra Youth

Joining Hands
for a Greener
Tomorrow

From Orchard to Table

Apple Picking, Family Time, and Fall Colours

For **Dr Marianne Furtado de Nazareth**, a month-long holiday in South Carolina offered more than just family time—it opened the door to quiet moments in nature. One autumn weekend, her son planned a visit to an apple farm, giving her a chance to indulge in her fondness for apple picking. From apple cider donuts to hands-on learning in the orchard, the experience captured the essence of autumn. In her own words, it was a weekend that blended learning, leisure, and lasting memories!

I was on holiday for a month with my son and his family in Greenville, South Carolina and come the weekend, he found time to take me out to various nature spots. It was the weekend and knowing my penchant for apple picking, my son, Andrew booked a trip to Jeter Mountain Farm.

A Scenic Drive amid Golden Autumn Foliage

Jeter Mountain Farm is a popular family-owned u-pick (pick your own) orchard offering a variety of fruits and activities during their open season (typically July through October, and some Christmas dates). Located just minutes away from downtown historic Hendersonville and Brevard, it is also a quick trip from Asheville or Greenville in South Carolina. We were driving up from Greenville and

being autumn, the drive up too was outstanding with all the trees dressed in their autumn colours.

"It is free to visit the farm, and no reservation is required," said Andrew. "Once there, one can pay to participate in whatever activity they choose, through the children's play area, live bluegrass music, and breathtaking surrounding mountain views which are always free!"

Cider, Rocking Chairs, and Nature's Bliss

Once we reached and parked in the overfull parking area, we went straight for the delicious and hot off the pan, crisp apple cider donuts. Armed with a glass of warm apple cider we all walked towards the lineup of rocking chairs, to enjoy the breathtaking view. Rocking chairs are quite evocative of the south and quite a lovely tradition, which takes a little getting used to. However, it is easy to see why it is such a favourite pastime.

To participate in what they call 'u-pick', you must purchase a basket from the counter at the reception for $35 and then board a u-pick wagon. The u-pick wagon is a covered wagon trailer, with benches, hitched to a large John Deere tractor! The driver is a twinkling blue-eyed, flowing bearded man, in blue overalls and a big floppy hat.

"Ladies and gentlemen," he said over his mike, "when you visit Jeter over the

year you can pick peaches, flowers, blueberries and apples which are all handicap accessible. We offer large parking lots, a market with home-made products, a taproom, a coffee shop, a bakery, besides a beautiful back porch, and restrooms which are all handicap accessible."

Into the Orchard: Apples and Their Stories

When we reached the reception there was a beautiful board which showed us the varieties of apples, we were able to pick that day—Pink Lady, GoldRush, Granny Smith, and Fuji. We were free to pick all the four varieties from the trees.

We headed for the wagon queue, to be driven down to the apple orchard. Upon reaching the orchard, after a bumpy ride, we gathered around a guide, who told us all about the apples we were to pick.

Fuji apples are a popular, sweet, crisp, and juicy apple variety, a cross between Red Delicious and Ralls Janet, developed in Japan. They have creamy white flesh, a thick, reddish skin and are great for eating fresh or cooking due to their high sugar content and firmness, offering vitamins A and C and fibre. Known for excellent shelf life, they are available from fall to mid-winter.

The GoldRush apple is a late-season, disease-resistant variety (especially to scab) developed by Purdue, Rutgers, and Illinois universities, known for its crisp, golden-yellow fruit. The variety has a complex sweet-tart flavour, and exceptional storage life, making it great for eating, baking, drying, and cider. It starts tart but mellows beautifully in storage, developing a rich, spicy taste and maintaining its firm texture for months.

Originating in Australia in the 1860s, the Granny Smith is a popular, bright green apple known for its firm, crisp, juicy texture and distinctly tart-sweet flavour. Excellent for both eating fresh and baking (especially pies) because it

holds its shape, it is rich in fibre, vitamin C, and antioxidants, making it a healthy choice with relatively lower sugar than some other varieties, aiding digestion and immune function.

Pink Lady epitomizes the trend towards product marketing and branding in the sale of apples. It was one of the first apples to be marketed under a specific brand name rather than by its variety name which is Cripps Pink. Cripps Pink was developed in the 1970s by John Cripps in Western Australia and is a cross between Golden Delicious and Lady Williams.

We ran towards our favourite variety, mine being Pink Lady. Since the trees were all superior graft trees, the fruit were close enough for us to pick. They were grown organically, so we just picked a fruit, wiped it against our jeans and bit into them, letting the juice squirt out and run down our chins!

Marks of Nature's Havoc

This year, our guide explained, the apple crop was hit badly by a freak hailstorm and so they had developed a sort of scab to cover up the wound. We were curious, wanting to see what the hail damage looked like. We were told that, depending on when that hail event occurred, apple fruit can be injured in a variety of ways. Sometimes the damage appears as small dents which will lead to some bruising of the apple fruit and some discolouration. Other injuries can appear as gashes in the fruit as the hail falls, cratering that will eventually lead to broken skin, or the fruit will be completely knocked off the tree.

Since we are fussy about how our fruit looked, the question was—Are the apples still safe to eat after a hailstorm? Our guide took time to explain—apples that have been subjected to hail damage can still be consumed either fresh or processed if the damage is not severe. Depending on when the hail event occurred will give a better idea of how edible the fruit is. If the storm occurred earlier in the season, the apples may be too damaged by harvest to eat fresh or even process. One needs to look for broken skin, black marks, any type of mould that grows in the wound, or other rotting discolouration. It is unsafe to eat rotting apples. However, if the hail event occurred very close to harvest, processing the apples for sauce, jams and jellies or cider as quickly as possible is obviously what Jeter Mountain Farm does. ■

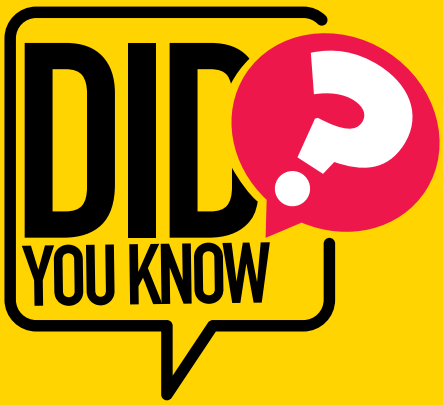
Dr Marianne Furtado de Nazareth is a freelance Science and Environment journalist and former Assistant Editor, The Deccan Herald.

Bizarre Facts

1. Ants won't get injured from falling, no matter how high they fall, they won't get injured.
2. Tuna needs to swim constantly, and if it stops, it will suffocate and die.
3. The fastest jet in the world can fly almost 10 times the speed of sound (11,854 km/h).
4. You can't fold a piece of A4 paper more than eight times.
5. Glass sponges can live for 15,000 years.
6. If the Earth doubled in size, trees would immediately fall over.
7. The world's oldest cat lived to 38 years and three days old.
8. Football teams wearing red kits play better.
9. Due to being rich in potassium, every banana is actually slightly radioactive thanks to containing the natural isotope potassium-40.
10. Deaf people are known to use sign language in their sleep.

Did You Know?

- Most of the oxygen on the earth does not come from trees, but is dominated by algae in the ocean.
- Laughing came before language.
- Hibernating animals don't dream.
- You can see stars as they were 4,000 years ago with the naked eye.
- 'New car smell' is a mix of over 200 chemicals.
- People who eat whatever they want and stay slim have a slow metabolism, not fast.
- A lightning bolt is five times hotter than the surface of the Sun.
- Football players spit so much because exercise increases the amount of protein in saliva.
- Mirrors facing each other don't produce infinite reflections.
- The Universe's average colour is called 'Cosmic latte'.



Source: Internet

India's Clean-Air Innovation at Risk

Nationwide Assessment by WeNaturalists

Fragmented datasets, slow regulatory approvals, and declining early-stage capital are hindering climate solutions in Delhi, Mumbai, Bengaluru, Chennai, Kolkata, Pune, Indore, Surat, Lucknow, and other major cities. Recently, WeNaturalists released a nationwide assessment highlighting urgent challenges in India's clean-air innovation ecosystem.

On December 16, 2025, WeNaturalists released a nationwide assessment highlighting urgent challenges in India's clean-air innovation ecosystem. Based on more than 1.2 million environmental observations and insights from over 300 climate innovators, NGOs, and researchers, the study finds that systemic hurdles including fragmented air-quality datasets, shrinking early-stage funding, and regulatory delays are slowing the development and deployment of clean-air technologies across over 70 cities, including Delhi, Mumbai, Bengaluru, Chennai, Kolkata, Pune, Indore, Surat, and Lucknow.

According to the report, 62 per cent of innovators lack access to reliable or standardized Air Quality Index (AQI) and emissions data across states and regions, making it difficult to design, test, or validate solutions. Funding remains a critical barrier, with 54 per cent of innovators reporting shortages of early-stage risk capital, particularly for hardware-led and monitoring technologies. Regulatory approvals further compound these challenges, with over 40 per cent of innovators experiencing timelines of 6–18 months for piloting or deployment.

Public concern is rising alongside these structural challenges. Citizen queries on air pollution have surged 37 per cent in the last quarter, driven largely by inconsistencies in AQI readings, which in multiple cities show 30–70 per cent variation between government monitors, private devices, and community sensors. The health impact is evident: hospitals and clinics in Delhi, Jaipur, Nagpur, and Bengaluru report 22–28 per cent increases in pollution-related outpatient visits. Additionally, 35 per cent of healthcare workers surveyed in high-pollution cities report increased exposure risk and health strain due to poor air quality, highlighting the urgent need for protective measures and targeted monitoring.

Despite these obstacles, WeNaturalists identifies strong growth potential in industrial emissions monitoring, hyperlocal sensor networks, indoor air-quality solutions for schools and hospitals, AI-driven climate-health advisory tools, and predictive pollution-alert technologies. Innovators note that scaling these solutions across Tier 1, 2, and 3 cities is possible with interoperable data systems, streamlined regulatory processes, and clear pilot frameworks.

"As a country, we have the ideas, the talent, and the urgency but innovators still lack foundational support," said Amit Banka, Founder & CEO of WeNaturalists. "Without reliable datasets, simplified approvals, and access to early-stage risk capital, India risks slowing down clean-air innovation at a critical time."

WeNaturalists urges policymakers, investors, and urban administrations to collaborate on a cohesive national clean-air innovation framework, including open-access environmental data, dedicated funding for climate hardware, defined pilot zones, and integrated environmental and healthcare data to support early-warning systems, public-health preparedness, and protection for frontline healthcare workers.

WeNaturalists is a global digital ecosystem empowering individuals and organizations driving climate action and sustainability. With a community of over 500,000 members and 1,000+ partner organizations worldwide, the platform enables scalable impact through climate education, professional pathways, project management tools, and technology-led solutions supporting climate action and the SDGs. ■

Resting on Deodars

How Fallen Trees are Being Reimagined as Urban Assets in Shimla

After unprecedented rains and landslides in Himachal Pradesh, uprooted deodar trees in Shimla have been creatively repurposed into seats, benches, and tables across public spaces such as the Mall Road and Ridge Maidan. Crafted with minimal processing, these installations enhance the town's aesthetics while addressing safety risks, decay, and waste. The initiative reflects a practical response to climate-induced tree damage, promotes circular use of natural resources, and demonstrates how fallen timber can be transformed into functional urban assets that benefit both residents and tourists. Read more in this article by **Sarita Brara**.

Dwarfed tree trunks moulded into seats, dot the Mall Road and the Ridge Maidan giving a new and artistic look to the heart of the tourist town of Shimla. Well these are all made from the uprooted and mangled deodars that fell alongside the hills and roadsides during the unprecedented rains two years back in Himachal Pradesh that caused untold havoc in the state.

Even before the start of the peak tourist seasons last summer (2025) over 300 of such pieces were ready for tourists and locals to sit on and enjoy their food and snacks in parks and in open where these seats, tables and benches have been kept and the people find them

quite comfortable to sit. Now a number of them can be seen at different locations in the town. Some of the damaged trees have been crafted into robot-like structures on which children love to sit and take selfies. These robots are

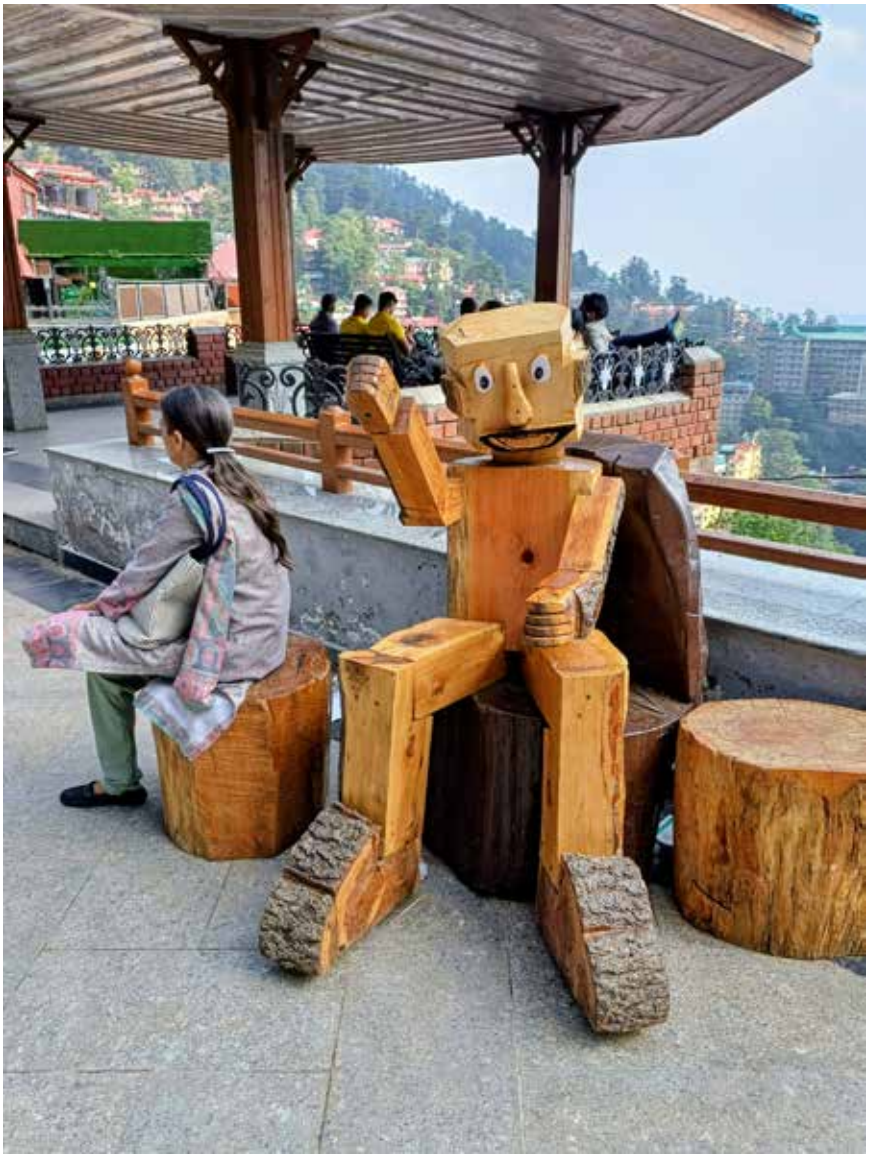
message in themselves but later, as some officials pointed out, could have short and crisp messages inscribed on them on environment and keeping the historic town clean. Some of these seats made out of the deodars also have simple but

aesthetic designs carved not by artists but laymen workers.

Several lakhs of trees were uprooted in a number of landslides caused by unprecedented rains and cloud bursts in 2023 across Shimla and other places in Himachal Pradesh. These landslides also damaged a number of roads and buildings. It was gigantic task to remove the fallen deodars and other trees and their branches. While trees that fell in forest areas and had commercial value were removed by the HP Forest Corporation for sale, many others fell along hillsides and roads within Shimla town's municipal limits and had no commercial value. In order to ensure that they were not left to decay, the MC Shimla came up with the novel idea of using broken and detached parts of trees like trunks and branches. By removing their barks and a bit of chiselling, parts of these trees rendered useless, were turned into seats, benches and tables retaining their original shape to the extent possible. This gave an artistic but raw touch that appealed to aesthetic sense and more importantly were put to use and this was done without too much of effort or technique or involving experts or cost. In fact, even some of the traders in wooden goods have made artistic pieces which are fetching a good price.

According to Shimla Mayor Surendra Chauhan, there is strong demand for seats made from dwarfed tree trunks, and the municipal corporation can generate significant revenue from fallen deodar trees. He has already approached the state government to replicate this initiative across the hill state. Chauhan said trees damaged by rains and other natural calamities could be transformed into artistic pieces through the traditional wood-carving techniques for which Himachal Pradesh is renowned. He also suggested that Industrial Training Institutes (ITIs) could help promote these skills, creating employment opportunities for local youth.

As a result of climate change, storms, squalls, and high-speed winds are occurring more frequently than ever before, leading to large-scale uprooting of trees, broken branches, and widespread damage—not only in forests but also along roadsides, within towns, and in suburban areas. Similar incidents were reported in several other parts of the state in 2025.



If damaged trees are not removed and are left unattended along roadsides, they become more vulnerable to uprooting or falling during storms or heavy rains, posing risks to life and property. They can also obstruct the smooth flow of traffic and create visual blight. More importantly, if left to decay, such trees attract pests that can spread diseases and even harm healthy trees.

The need is not only to ensure that uprooted trees with no commercial value are put to use and do not harm other vegetation or property, but also to reinvigorate tree-planting campaigns to compensate for the loss of green cover caused by rains and other natural calamities, which have now become an annual occurrence. ■

Sarita Brara is a Delhi-based senior freelance writer.

The Invisible Microbes That Help Keep Us Healthy

Viruses and bacteria are often viewed as harmful, but researchers at Flinders University are drawing attention to a lesser-known side of the microbial world. Their work highlights the important ways microbes can support human health, challenging the idea that all microorganisms are threats. Flinders microbial ecologist Dr Jake Robinson and his colleagues explore this shift in a new paper published in *Microbial Biotechnology*. The research encourages moving beyond a fear-based view of microbes and biogenic compounds and instead recognizing their potential health benefits. The study introduces the 'Database of Salutogenic Potential', a first-of-its-kind, open-access prototype that gathers information on microbes and natural compounds linked to positive health outcomes. The goal is to make this growing body of evidence easier to access and apply. "Emerging evidence shows that exposure to diverse environmental microbiomes and natural biochemical products also promotes health and resilience," says Dr Robinson. "Rather than viewing biodiversity as something to be eliminated, contemporary approaches recognize the vital role of diverse ecosystems in creating salutogenic, or health-promoting, environments."

Source: https://www.sciencedaily.com/

The Poison Frog that Fooled Scientists for Decades

Scientists at the University of Kansas Biodiversity Institute and Natural History Museum recently uncovered a mistake that dates back decades involving a poison frog specimen from Peru. The frog had been incorrectly identified and designated as a holotype, which is the single preserved specimen used to officially define a species. While modern taxonomy may also rely on supporting materials such as photographs or genetic information, the holotype remains the primary reference point. The research team published its findings in the journal *Zootaxa*. "When you describe a species, you assign one specimen that bears the name of that species," said lead author Ana Motta, collection manager of herpetology at the Biodiversity Institute.

Source: https://www.sciencedaily.com/

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POLLUTION SOLUTIONS
FOR A CLEANER, GREENER EARTH

Urmi A Goswami

We are living in a fast changing world. Pollution of natural resources, such as air, water, and land is one of the biggest banes of our times. Under such precarious circumstances, it is needed that the young generation is not only made aware about the different kinds of pollution but also about the solutions. This is what this book *Pollution Solutions – For a Cleaner, Greener Earth* is all about.

Filled with eye-opening facts, informative illustrations, and multiple activities, this book is the perfect guide to help the young generation become environmental crusaders.

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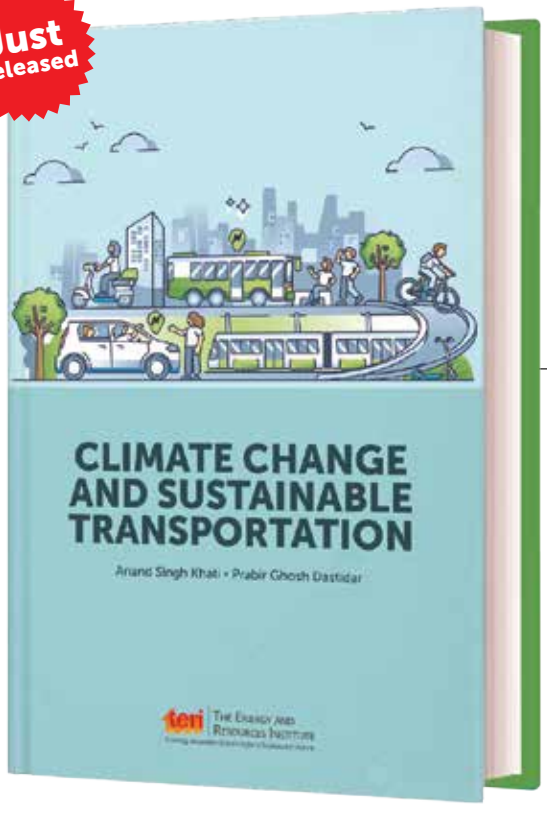

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Winter Wonders

Top Five Indian Tiger Reserves for a Wildlife Escape

In this article, **Manav Khanduja** tells us about his top five favourite tiger reserves in India for a magical winter wilderness experience—destinations where ecological integrity, community involvement and decades of conservation work continue to safeguard some of the subcontinent's most majestic species.

Winter casts a unique spell over India's forests. The air grows crisp, hill slopes glow under soft sunlight, and mist pools through valleys, revealing landscapes in their truest form. It is a season when tiger reserves reveal their full grandeur, offering travellers a rare blend of serenity, adventure and untamed beauty, when wildlife can be seen with their beautiful winter coats. From Satpura's hills to Tadoba's bamboo groves and Pench's teak forests, winter reveals each reserve as a thriving home for wildlife, complemented by a spectacular display of migratory birds arriving from across Eurasia, who reshape the soundscape of these protected areas.

Satpura National Park

Hidden in the heart of Central India, Satpura National Park is a treasure waiting to be discovered. Its very name—derived from the "seven mountains" of the Mahadeo Hills— hints at the topographic complexity that makes Satpura a biodiversity refuge. Spread across 1427 sq. km and formed by combining the Satpura, Pachmarhi and Bori sanctuaries, the landscape offers a striking mix of sal and teak forests, sandstone escarpments, riparian zones, and riverine islands.

Winter imparts an ethereal quality to Satpura. Morning mist blankets the forests, streams sparkle under sunlight and wildlife moves with effortless grace.

Sloth bears forage along quiet trails, while leopards slip silently through the undergrowth. Chital and sambar can be seen grazing at the water's edge, while rare albino gaurs graze in open meadows. Crocodiles can be spotted sunbathing along the rivers, while chital and sambar are frequently sighted. The wetlands transform into important wintering grounds for migrants such as northern pintails, garganeys and common teals arriving from Siberia and Central Asia—a reminder of how Indian landscapes anchor global flyway networks. Painted storks and grey wagtails add flashes of colour across the backwaters.

Denwa Backwater Escape, with its riverside cottages and treehouses, provides a perfect base to explore Satpura's safari ranges. The lodge blends eco-luxury with panoramic river and forest views, offering a tranquil retreat amidst raw wilderness. What's more, Satpura's commitment to low-impact tourism is central to its conservation model. Non-motorized experiences—walking safaris, kayaking and canoe rides—allow travellers to experience the winter forest from a different perspective, without intruding on its rhythm.

Pench National Park

Spanning nearly 1200 sq. km across Madhya Pradesh and Maharashtra, Pench is the jungle that inspired Rudyard Kipling's *The Jungle Book*. Though Kipling never visited, tales from British officers painted vivid images of tigers, wolves

and dense teak groves—the backdrop for Mowgli's adventures.

Winter transforms this vital link in the Central Indian tiger landscape—a corridor that supports tiger movement, genetic exchange and long-term species survival, into a serene haven. Teak and mahua trees glow amber, bamboo thickets sway in the cool breeze and streams meander quietly through lush foliage. Its thriving prey base and healthy predator numbers are indicators of a functioning, balanced ecosystem. Tigers, leopards, wild dogs, jackals and gaurs traverse dry deciduous forests, while over 210 bird species fill the crisp air with life. Winter migratory birds are especially spectacular here: blue-tailed bee-eaters and rosy starlings bring colour and movement, while white-throated kingfishers, pintails and black-winged stilts enrich the wetlands along the Pench River.

Pench Tree Lodge offers intimate eco-luxury with handcrafted treehouses and cottages nestled in 40 acres of wilderness, providing guided safaris that capture the park's winter charm.

Tadoba Andhari Tiger Reserve

Maharashtra's Tadoba Andhari Tiger Reserve stretches across 1727 sq. km of dry deciduous forests, grasslands, and shimmering waterbodies. Named after the legendary Gond warrior and deity Taru, and the Andhari River, it has earned its reputation as one of India's premier tiger habitats.

Over the last decade, Tadoba has seen tiger numbers stabilize and the forest mature into one of India's most reliable landscapes for sightings—a testament to consistent conservation efforts and close monitoring. Winter amplifies this story, unveiling crisp mornings, a vibrant ecosystem, and Tadoba's raw beauty. Grasslands take on golden hues, lakes like Irai and Tadoba mirror clear skies and tigers patrol their territories with remarkable visibility. Tigers patrol their territories with striking visibility; leopards, wild dogs and gaurs move confidently across revitalized habitats. The wetlands come alive with various winter migrants such as red crested pochard, common coot, pied kingfisher, painted snipe, night heron, northern shoveler and the Indian spot-billed duck. Visitors can also witness bar-headed geese during this period, the highest flying birds who cross the

Himalayas to make their annual journey. The forests also welcome pied bushchats and Siberian stonechats, adding colour to the drier landscapes.

Waghoba Eco Lodge embodies this spirit, with eco-luxe cottages crafted from adobe, stone and recycled materials. A shaded pool, hill-view lounge and photography hide overlooking a perennial waterbody make it ideal for wildlife lovers and photographers seeking an intimate winter safari experience.

Bandhavgarh National Park

Nestled in Madhya Pradesh's Vindhya Hills, Bandhavgarh spans over 1100 sq. km and boasts one of the world's highest densities of Bengal tigers. Once the hunting grounds of the Maharajas of Rewa, the park today combines history, rugged terrain, and exceptional wildlife.

Winter brings remarkable clarity to Bandhavgarh. Bamboo thickets and sal forests shimmer in the soft sunlight, while thirty-two hills roll across the landscape, dotted with waterholes, ancient sandstone cliffs, moss-covered caves, and the iconic Bandhavgarh Fort. Tigers, leopards, sloth bears, jackals, civets and sambar move with remarkable ease. Birdlife flourishes as well: winter migratory species such as northern pintails, Eurasian coots and wood sandpipers enliven the rivers and meadows, alongside drongos and serpent eagles.

Kings Lodge and Tree House Hideaway offer elevated cottages and treehouses amidst sal forests, combining privacy, immersive tiger-country experiences and expert naturalist-led safaris—ideal for winter wildlife adventures.

Kanha National Park

Sprawling across 1949 sq. km in Madhya Pradesh's Mandala and Balaghat districts, Kanha remains a sanctuary where tigers reign supreme. Set within the Maikal ranges of the Satpuras, the park's hillocks, dense sal forests, bamboo groves and open meadows create a living mosaic of life and colour. Kanha's grassland restoration efforts, including the creation of meadows that now support large hard-ground barasingha populations, brought back from the brink of extinction, are a shining example of long-term ecological recovery. Winter accentuates Kanha's charm. Streams glint under sunlight, grasslands turn golden and wildlife—including tigers, leopards, wild dogs, barasingha, sambar and chital—moves freely through open vistas. Birds enliven the forest edges and wetlands, with migratory species such as northern pintails, garganeys, black-tailed godwits and marsh sandpipers arriving from colder climes, alongside resident jungle owlets, crested hawk eagles and Indian peafowl. The four core safari zones—Kanha, Kisli, Sarhi and Mukki—along with the buffer zones, provide unrivalled opportunities to explore the park's pristine wilderness.

Kanha Earth Lodge offers eco-luxury cottages amidst 16 acres of forest bordering the reserve. With Gond-inspired architecture, sustainable design and guided wildlife safaris, it provides an intimate, serene retreat for immersing fully in Kanha's winter wilderness.

Winter in India's tiger country is more than a season; it is an invitation. Forests hum softly, meadows glisten under golden light and every encounter with a tiger, leopard or barasingha becomes a memory etched forever. From Satpura to Kanha, these destinations combine breathtaking landscapes, thriving biodiversity and immersive safari adventures.

Each of these reserves represents some of India's strongest conservation success stories—spaces where predator recovery, forest protection, and community-led stewardship converge. Winter, with its clear light and thriving birdlife, offers a chance not just to see wildlife, but to understand the ecological systems that sustain them. Eco-lodges and expert naturalists ensure travellers enjoy comfort, guidance and unrivalled access to the wild. In winter, India's tiger reserves are at their most majestic—a perfect canvas for adventure, tranquillity and a profound connection with nature. ■

Manav Khanduja is Co-Founder, Pugdundee Safaris.

Farming Innovation Addresses Food Shortages

Also Halves Methane Emissions

Straw Innovations, an award-winning UK- and Philippines-based agritech company, has launched a world's-first rice-farming machine that addresses both food security and climate change. Unveiled in London in October 2025, the Straw Traktor can increase rice yields by up to 65 per cent by enabling an additional harvest, while cutting methane emissions from paddy fields by half. Designed for flooded conditions, it collects rice straw and converts it into biochar, clean fuel, and soil amendments, supporting circular farming. Demonstrated at the Rice Straw Bioenergy Hub in the Philippines, the innovation is being rolled out across Southeast Asia and India to tackle a looming global rice crisis.

On October 9, 2025, in London, Straw Innovations—an award-winning agritech company—launched a rice-farming machine designed to strengthen food security and address climate change. The move follows the company being selected as one of the "Net Zero Future50" companies by PwC UK, and will support its rollout across the Philippines, Indonesia, and India. Straw Innovations is a UK- and Philippines-based agritech company transforming rice straw into valuable products – from clean fuel to sustainable materials. Its integrated harvesting and processing system reduces methane emissions, boosts crop yields, and supports circular farming at scale. Backed by international partners, the company is rolling out its solution across Asia to address food security and climate challenges.

With a global rice crisis looming, the company's Straw Traktor provides a much-needed solution at a critical moment. This first-of-its kind innovation unlocks an additional rice harvest per year and improves soil health, enabling farmers to boost rice production by up to 65 per cent a year while slashing methane emissions in half.

Manual rice straw collection

Straw Innovations launched its machine at the world's first Rice Straw Bioenergy Hub (RSBH) in Pila, Laguna, Philippines. This milestone facility demonstrates how rice straw—often treated as waste—can be upcycled into biochar, renewable energy, soil amendments, and livestock bedding, while also providing farmers with new business opportunities and reducing harmful methane emissions. The Hub is developed by Straw Innovations Inc. in partnership with Aston University, SEARCA, Koolmill Systems, and with funding support from Innovate UK. The event was attended by the Economic and Climate Counsellor Lloyd Cameron of the British Embassy Manila, Regional Executive Director of the Department of Agriculture (DA) Region IV-A Fidel L Libao, representatives from other DA agencies, and local government officials from the province of Laguna.

Innovate UK, UKAid—the UK's innovation agency and the country's development assistance agency—and Earthshot Prize winner Takachar are

Rice straw collection

working with the company to rollout the Straw Traktor in Indonesia and India via the 'Energy Catalyst' programme, with plans to launch in 2026.

A Global Crisis, Grounded in Asia

As a staple food for over half the world's population, rice is an essential part of people's lives and culture. However, 'traditional' farming machines are unable to effectively operate in wet seasons, which locks farmers into two harvests per year, and we are seeing poor hauls in Asia, where 90 per cent of it is grown. These factors, combined with our planet's growing population, are creating a global crisis.

Adding to the problem, extreme weather is impacting food security the world over, with many staple crops struggling to survive. While countries have endured the worst flash floods on record in recent months, England similarly suffered its wettest winter and second worst harvest last year.

Straw Traktor

With studies showing[1] rice is able to withstand extreme weather better than other staple crops, it provides a resilient lifeline.

But it currently comes at a steep climate cost, producing higher greenhouse gas emissions than the global aviation industry. As the straw that is found in paddy fields is burned or rots, it releases significant amounts of methane, a greenhouse gas more than 80 times more potent than CO_2.

Founder and Director of Straw Innovations, Craig Jamieson, said: "This new system brings together world-leading technologies and business models for the first time to set a new benchmark for rice processing globally. For rice-producing communities and

1 Details available at https://www.bloomberg.com/news/articles/2025-06-18/why-rice-is-poised-to-survive-better-in-a-warming-world

the environment, it's nothing short of transformational."

A Game Changing Solution

The Straw Traktor offers a sustainable solution to the global rice crisis. Designed for flooded conditions, the machine collects straw from rice fields and rotavates the land, unlocking a third harvest. As such, it represents a major step towards more secure, affordable rice. This innovation also increases yields by a further 10 per cent by spreading soil amendments such as biochar.

Additionally, the Straw Traktor bolsters food security by helping farms stay economically viable, through providing additional revenue streams. The machine transforms straw, which would otherwise be burned or rot, into valuable agricultural products, such as biochar and compost, as well as clean fuel. Developed with smallholder farmers in mind, it is easy to operate and delivers a high, rapid return on investment.

The machine plays a vital role in reducing the climate cost too, halving methane emissions from paddy fields through collecting rice straw and turning it into these products. But the Hub goes further. With Koolmill's energy-efficient rice milling technology, Takachar's biochar innovation (Takavator™), and the Biogas Hub, RSBH provides a holistic model for low-emission rice farming. Alongside these, Aston University and

SEARCA are conducting vital research on the socio-economic, environmental, and policy impacts, ensuring that the technologies are scalable, inclusive, and aligned with national development goals. Together, these efforts show how rice straw can become the foundation for food security, sustainable energy, cleaner air, healthier soils, and circular rural economies.

Economic and Climate Counsellor at British Embassy Manila, Lloyd Cameron, said: "Businesses which treat climate risks as opportunities will define the markets of the future. When UK science meets Philippine innovation, rice straw becomes more than a byproduct; it becomes part of the solution. That partnership lies at the core of the Rice Straw Bioenergy Hub: harnessing new technology, developing local business models, and increasing productivity."

Director of the Department of Agriculture's Climate Resilient Agriculture Office (Philippines), Agnes Catherine Miranda, said: "DA-CRAO welcomes partnerships that can help integrate rice straw solutions into local programmes and pilots, supporting productivity, emissions reduction, and rural livelihoods."

SEARCA Center Director, Dr Mercedita Sombilla, said: "Aligned with SEARCA's mission to empower farmers, the development of rice straw management solutions will not only contribute to reduction of greenhouse gas emissions but also enable communities to turn agricultural wastes into livelihood opportunities that increase incomes. The promotion of policy-backed innovative technologies and strategies indeed help drive the use of climate smart practices that are beneficial to agriculture and environment."

Farmer, Leonard Lospe Jr, said: "What Straw Innovations has done is a huge help—not only are they a business, but they are truly helping the farmers. Not just for us, but we are also able to provide our services to our fellow farmers at a lower cost. That's why Straw Innovations' arrival is such a big deal." ■

Solution Straw Innovations Team

Beauty That Betrays!

The Quiet Invasion of An Ornamental Plant

A few months back, I had the pleasure of visiting a stunningly beautiful, lush green campus of Anil Agarwal Environment Training Institute (AAETI). Regarded as an ideal model of sustainability, the Institute is nestled amidst the rolling hills of Aravalli. Powered primarily by solar energy, the campus boasts of nature-based waste and wastewater treatment systems, rainwater harvesting facilities, and well-insulated buildings that minimize energy requirements for heating and cooling purposes. For environmentalists and nature lovers, it feels like a paradise.

A Beautiful Encounter, A Stark Reality

Amidst all this environmental harmony, one seemingly innocent ornamental plant caught my attention and not for the right reasons. To my surprise, *Lantana camara*, a highly invasive species, had found a place there too as an ornamental plant. When I pointed it out to the caretaker, she admitted she hadn't recognized it as a harmful species but promised to address the issue.

This is not the first time I had seen Lantana camara posing as an ornamental plant. I have come across the plant at prior occasions on a government office campus in New Delhi and, more recently, at Hotel Taj Palace, New Delhi. These encounters compelled me to write this article. A colleague of mine, curious about my concern, asked me, "What's the big deal about this plant?" I told him that *the plant* is like the *fast fashion culture* of invasive species, charismatic yet ubiquitous, silently taking over wherever it grows.

Many people remain unaware of its harmful impacts, and I don't blame them. My understanding of the invasive species like *Lantana* stems from learning under brilliant professors during my Master's

in Ecology and Environment Studies. So, let's dive in—What exactly is *Lantana camara*? How did it arrive in India? And what ecological and economic havoc is it wreaking?

Origins of the Devil in Disguise

Lantana camara was introduced to India in the early nineteenth century by the British, primarily as an ornamental plant for gardens due to its vibrant flowers and adaptability.[1,2] Historical records suggest that it was brought from Central or South America—its native region—around the 1800s. Its popularity grew because it was hardy, required minimal care, and could thrive in various climates (Figure 1).

Initially, Lantana camara was planted in botanical gardens and ornamental landscapes. However, its robust nature and ability to adapt to diverse ecological conditions soon allowed it to escape cultivated settings. Its invasive potential was not foreseen, and within decades, it began to establish itself in forests, grasslands, and agricultural areas across the Indian subcontinent.

covering millions of hectares of land.[3,4] It poses a significant threat to native ecosystems, biodiversity, and agricultural productivity, particularly in regions like the Western Ghats, the Himalayas, and central India.[3]

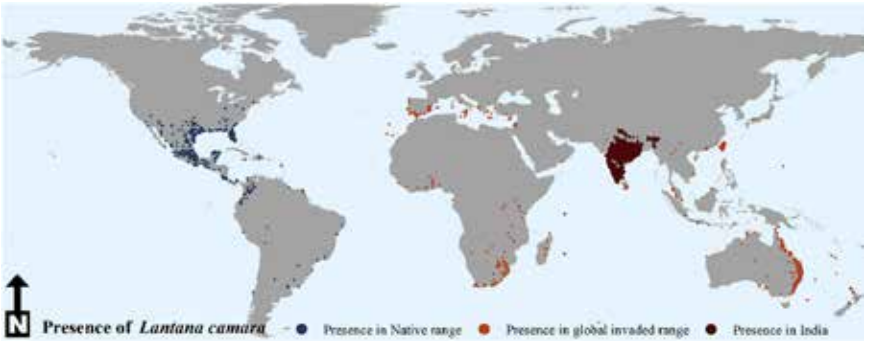

Figure 1: The global geographical spread of *Lantana camara*[3]

It is among the top ten worst invasive species and a major concern in India,

High Resilience behind Invasive Behaviour

Lantana camara is highly adaptable to various environmental conditions,

1 Bhagwat, S. A., Breman, E., Thekaekara, T., Thornton, T. F., & Willis, K. J. 2012. A battle lost? Report on two centuries of invasion and management of Lantana camara L. in Australia, India and South Africa. PLoS One, 7(3), e32407.

2 Kannan, R., Shackleton, C. M., & Uma Shaanker, R. 2013. Reconstructing the history of introduction and spread of the invasive species, Lantana, at three spatial scales in India. Biological Invasions, 15, 1287-1302.

3 Mungi, N. A., Qureshi, Q., & Jhala, Y. V. 2020. Expanding niche and degrading forests: Key to the successful global invasion of Lantana camara (sensu lato). Global Ecology and Conservation, 23, e01080.

4 Richardson, D. M., & Rejmánek, M. (2011). Trees and shrubs as invasive alien species–a global review. Diversity and distributions, 17(5), 788-809.

including drought and nutrient-poor soils.[5] Its ability to produce a vast number of seeds, coupled with effective seed dispersal mechanisms via birds and other animals, ensures rapid propagation.[6] Lantana camara reduces biodiversity by crowding out native flora, disrupting habitats, and threatening endangered species.[5] The plant also demonstrates allelopathy, releasing chemicals into the soil that inhibit the growth of nearby native plants. Its woody stems increase fire risks, facilitating its regrowth while suppressing native vegetation.[7] Furthermore, it can regenerate quickly after being cut or burned, making eradication efforts difficult.[5]

The plant invades farmland, reducing crop yields and poisoning livestock, affecting livelihoods.[8] Managing its spread requires costly and continuous efforts using labour, chemicals, or biological controls. It diminishes eco-tourism by degrading landscapes.[9] The economic cost of managing Lantana camara in India is estimated to be around $18,700 per sq. km and with the current extent of the plant's invasion, the total cost of managing it in India is estimated to be more than $5.5 billion.[3,9]

Lantana: A Silent Burden

Recent studies suggest that with the changing climate, the spread of the invasion will expand up to 65 per cent by 2070 in India, South Africa, Zimbabwe, and China.[10,11,12] At this rate, it is bound to become an even bigger ecological and economic burden.

The governments and official machinery must act decisively now and initiate deliberations with relevant agencies issuing directives to them to deal with such invasive species planted at several campuses and institutions. It is imperative to restrict the use of Lantana camara and other top invasive species as ornamental plants to safeguard the ecosystems and promote truly sustainable landscapes. ■

Dr Anurag Verma is Associate Fellow at The Energy and Resources Institute, New Delhi.

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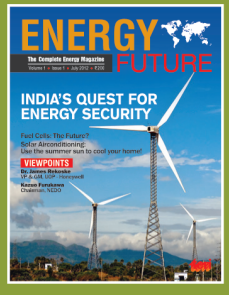

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