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Vision,Voices, and Values for Sustainable Development



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The Hidden Side of Himachal's Apple Blossom

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TerraGreen

TerraGreen is India's most respected monthly magazine dedicated to informing and enlightening its readers on issues of environment, energy, and sustainable development. Launched in 2004, *TerraGreen* has made an indelible impression on the minds of readers, both in India and across the world. Today, it enjoys a readership of over 40,000 and a subscriber base of close to 10,000.

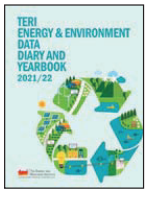
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TERI Energy & Environment Data Diary and Yearbook

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.

402 pages • Hardback • 220mm × 280mm • ₹1995/$129 (PDF only)

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EDITORIAL

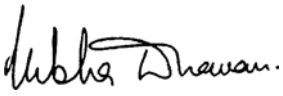


> "Marking its Silver Jubilee, WSDS returns at a time when transformation is no longer a matter of aspiration, but a necessity."

According to the first Global Stocktake, achieving the ambitious temperature goals requires a 43 per cent reduction in emissions by 2030, while the implementation of current nationally determined contributions (NDCs) will result in only a 2 per cent reduction. In the mid-point review of the Sustainable Development Goals (SDGs), of the 169 targets, only 13 per cent are on track, while 18 per cent are not even being tracked. These figures highlight gaps not only in implementation but also in the data needed to inform progress. The challenges confronting the world today are deeply interconnected, requiring long-term vision, diverse perspectives, and value-driven approaches to drive the transformations essential for sustainable development and climate action.

It is within this global context that the World Sustainable Development Summit 2026 convenes. Marking its Silver Jubilee, WSDS returns at a time when transformation is no longer a matter of aspiration, but a necessity. The Summit's theme "Transformations: Vision, Voices, and Values for Sustainable Development," reflects a growing recognition that enduring progress will depend not only on technologies and targets, but on shared direction, inclusive participation, and the principles that guide collective choices. The cover story of this issue on WSDS 2026 examines the defining challenges confronting global sustainable development in 2026. Nearly a decade after the Paris Agreement and the 2030 Agenda, progress remains uneven, with climate impacts, inequality, and geopolitical tensions reinforcing a widening implementation gap. The authors argue that fragmented approaches to climate and development limit transformative potential, calling for integrated, inclusive, and equity-centred pathways. Highlighting the importance of aligning NDCs with SDGs, the article positions the World Sustainable Development Summit 2026 as a critical platform to advance coherent, people-centred, and system-wide solutions in a decisive decade.

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 January 2026 issue of *TerraGreen*, featuring the cover story "India Braces for Disasters in Himalayas, Coasts," offers a timely and insightful perspective on the growing risks posed by climate change and environmental degradation. The article effectively highlights how fragile mountain ecosystems and vulnerable coastal regions are increasingly exposed to extreme weather events, glacial instability, sea-level rise, and unplanned development. What makes the piece particularly compelling is its emphasis on the need for preparedness, scientific planning, and community-based resilience. As India continues to experience more frequent floods, landslides, cyclones, and coastal erosion, strengthening early warning systems, climate-resilient infrastructure, and sustainable land-use practices becomes essential.

The issue also serves as an important reminder that disaster risk reduction must be integrated into development planning. Policymakers, researchers, and local communities must work together to safeguard ecosystems while protecting livelihoods.

Govindraj Awasthi
Lucknow, UP

The article "Green Farming through Circular Economy" provides a thoughtful perspective on how agriculture can move towards more resource-efficient and environmentally responsible practices. At a time when farming systems face mounting pressures from soil degradation, climate change, and rising input costs, the concept of circularity offers a promising pathway for sustainability. By emphasizing the reuse of agricultural residues, organic waste recycling, composting, and bio-based inputs, the article highlights how waste can be transformed into valuable resources. Such practices not only reduce environmental pollution but also improve soil health, enhance farm productivity, and reduce dependence on chemical fertilizers.

Equally important is the article's focus on integrating farmers, local communities, and agri-enterprises into circular systems that promote efficient resource use and minimize losses across the value chain. Articles like this are important in encouraging wider adoption of sustainable farming models. They remind us that the transition to greener agriculture lies in rethinking how we produce, use, and reuse resources within our food systems.

Amit Basu
New Delhi

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Methane, Black Carbon Threaten Glaciers, Warns Himachal Report

A report released by Himachal Pradesh chief minister Shri Sukhvinder Singh Sukhu recently has emphasized on urgent action against short-lived climate pollutants (SLCPs) such as methane and black carbon. According to the report titled 'Scientific Assessment of Tackling Non-CO_2 Emissions: Pathways for Himachal Pradesh', these "super pollutants" pose severe environmental and socio-economic risks for the Himalayan state. Black carbon deposits on snow reduce reflectivity, accelerating glacier melt, while methane drives near-term temperature rise, increasing the likelihood of extreme rainfall, floods, and landslides. The report identifies transport, livestock, and residential solid biomass use as the primary sources of SLCPs in Himachal Pradesh, directly affecting air quality and climate stability.

Source: https://timesofindia.indiatimes.com/

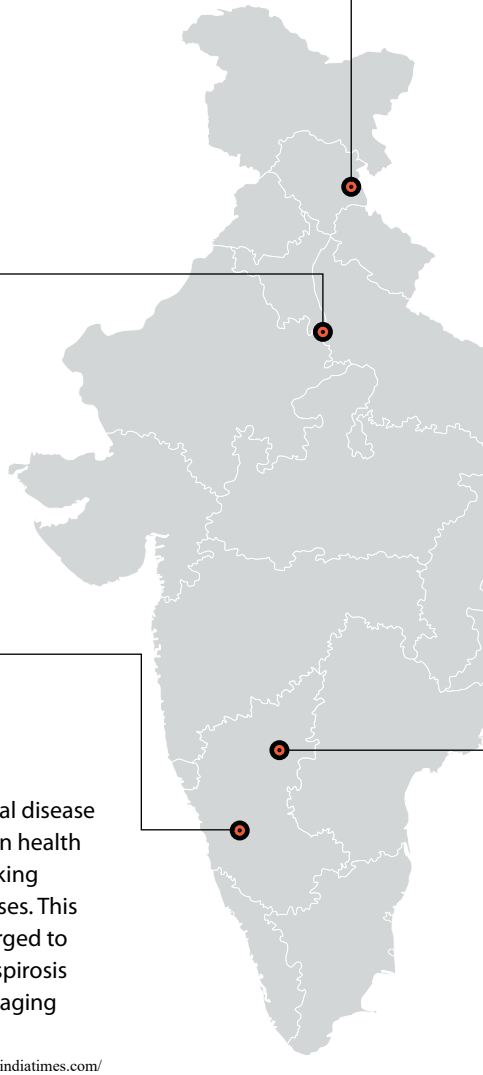
Him-CONNECT Launched at WSDS 2026

Union Minister for Environment, Forest and Climate Change, Shri Bhupendra Yadav, launched Him-CONNECT, a platform aimed at translating research under the National Mission on Himalayan Studies into scalable, on-ground solutions, at the silver jubilee edition of the World Sustainable Development Summit (WSDS) organized by TERI in New Delhi. Him-CONNECT is designed to bridge the gap between scientific research and societal application. The platform brought together 30 exhibitors and initiatives from 13 Himalayan states and Union Territories across India. On the occasion, TERI also launched the Himalayan Coalition to advance the second phase of the "Lighting a Billion Lives" programme, which focuses on community-centred and inclusive approaches to sustainable development.

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







Karnataka among Top for Water-Borne Diseases

Over the past five years, Karnataka consistently recorded a very high number of acute diarrhoeal disease (ADD) and typhoid cases—both major water-borne illnesses. In fact, data analysed by the Union health ministry for 2021–25 puts Karnataka among the country's significantly high-burden states, ranking third in typhoid and fifth in ADD. In 2021, the state reported 3.3 lakh ADD and 3021 typhoid cases. This dropped sharply in 2022 to 1.3 lakh ADD cases (a 61.1% decline from 2021) even as typhoid surged to 29,232 cases (an 867.4% increase). The number of cases largely rose later on. Meanwhile, leptospirosis (rat fever) also remained comparatively elevated, with 8697 cases reported over five years, averaging roughly 1739 cases annually.

Source: https://timesofindia.indiatimes.com/



Assam Gets New Hydro Project in Elephant Area

A Union government-appointed committee has given the go-ahead for the diversion of 442 hectares of forest land for a 1500 MW closed-loop pumped storage project in Assam. The INR 7273.23-crore project shares its boundary with an elephant reserve in Karbi Anglong district and will result in the submergence of 352 hectares, impacting over 1100 people in the region. A closed-loop pumped storage project is a type of hydroelectric energy storage system where the upper and lower reservoirs are not directly connected to rivers or lakes. Water is recycled between these reservoirs, operating as 'off-river' or 'water batteries'. The project is located in the villages of Lipgaon and Pankumar in Karbi Anglong and is being developed by the Assam Power Distribution Company Limited.

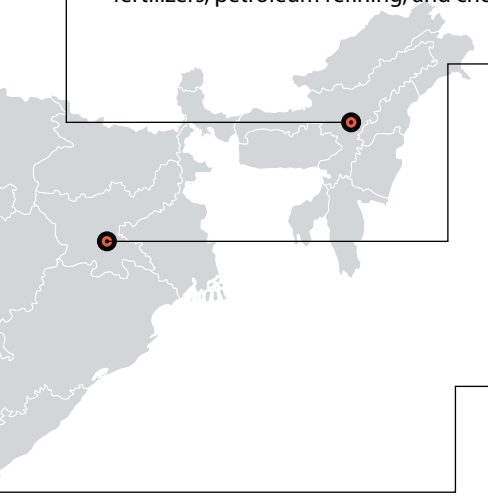
Source: https://www.newindianexpress.com/

Dhanbad IIT (ISM) Develops Low-Cost Catalyst to Boost Green Hydrogen Production

In a major breakthrough aligned with India's clean energy ambitions, researchers at Indian Institute of Technology, Indian School of Mines (IIT-ISM) – Dhanbad have developed a low-cost and efficient electrode material that could significantly reduce the cost of green hydrogen production by 400 to 500 times. The innovation comes at a crucial time when India is pushing forward with its National Green Hydrogen Mission, which aims to produce five million tonnes of green hydrogen annually by 2030. Green hydrogen, produced through water splitting using renewable energy, is considered a key solution to reducing carbon emissions from industries such as steel, fertilizers, petroleum refining, and chemicals.

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







Science and Nature Restore Lalbagh Lake's Ecosystem

Lalbagh Lake restored using science-led nature-first methods, boosting dissolved oxygen, reducing nutrients, controlling algae, enhancing biodiversity, and improving overall ecological balance spread across 30 acres in Bengaluru's Lalbagh Botanical Garden. Lalbagh Lake had fallen into severe ecological distress, showing foul odour, pale-yellow water, eutrophication, and dangerously low dissolved oxygen levels. In December 2024, a long-term ecological restoration project was launched, not as a beautification effort but as a science-driven recovery mission. Combining nature-first approaches with biological and mechanical treatment systems, the initiative tackled core ecological failures, achieving a sustainable revival of the historic waterbody.

Source: https://bangaloremirror.indiatimes.com/



Wild Spaces for Butterflies to Be Created in Glasgow

Dozens of new wild spaces are set to be created to attract butterflies, moths, and other wildlife across Glasgow in Scotland. Working with Glasgow City Council, the Butterfly Conservation charity hopes to open 40 habitats for wildlife during the two-year project. Their aim is to fight the decline in common butterflies and moths across the UK by creating habitat in urban areas, and inspire people to take more actions to help wildlife. The project team also hopes to recruit at least 40 volunteers to maintain the new areas in parks, schools, and community hubs.

Source: https://www.bbc.com/





Alterations Specialist Urges Shoppers to Avoid Fast Fashion

A clothing alterations specialist has urged people to think about the environment when choosing what to buy and avoid fast fashion garments. Cosmin Diaconu, who set up Repair my Denim in Cambridge in 2024, said a high-quality pair of jeans made of 100 per cent cotton were easy to repair, but often fast-fashion jeans contained elastane, making the fabric thinner and more difficult to fix. The term "fast fashion" describes the quick turnover of clothing trends and the move towards cheap, mass-produced garments – with new lines constantly released. "Most of the fabric [of higher-quality jeans] can be recycled and is biodegradable... and it doesn't have plastic in it," he added.

Source: https://www.bbc.com/

Earth's Heat to Power 10,000 Homes in Renewable Energy First for UK

The UK's first geothermal power plant has been turned on, providing a completely new type of renewable electricity using hot water from underground. The Cornish plant will be switched on after nearly two decades in development which required Geothermal Engineering Ltd (GEL) to drill the deepest on-shore well in the UK. The water, super-heated by rocks, will help drive turbines to generate electricity for 10,000 homes, but will also provide the UK's first domestic supply of lithium - a critical mineral used in green technology. The British Geological Survey said it was a "major step forward" for geothermal but high drilling costs could make replicating the project difficult.

Source: https://www.bbc.com/





Golden Eagles Flourish despite Deaths and Disappearances

Ten years ago the iconic golden eagle was a rare sight over the rolling hills of southern Scotland. Numbers had fallen to a handful of breeding pairs and action was needed to turn around the "dwindling population". In 2018, a pioneering project began to relocate birds from the Highlands to a secret location in the Moffat Hills in a bid to reverse the decline. There have been setbacks along the way—with deaths and disappearances—but the numbers of the majestic bird have now risen to record levels.

Source: https://www.bbc.com/





India's Energy Demand to surpass US by 2040s and China by 2060s, Report Reveals

India's role in the global energy system is expected to grow considerably, with its energy demand projected to exceed that of the United States in the 2040s and surpass China in the 2060s, PTI reported, citing a new India-focused scenarios sketch released by Shell India. The analysis also indicates that the share of fossil fuels in India's energy mix is expected to peak this decade. However, even as their proportion declines afterwards, total consumption could still increase if global energy demand doubles over the next two to three decades. Titled 'India's energy transition in a security-focused age', the report presents three potential futures influenced by geopolitics, digitalization, and climate needs: Archipelagos, Surge, and Horizon.

Source: https://www.livemint.com/

India and Nepal Sign MoU to Strengthen Cooperation in Forests, Wildlife, Environment

Union Ministry of Environment, Forest and Climate Change, Government of India, recently signed a Memorandum of Understanding (MoU) with the Ministry of Forests and Environment, Government of Nepal, to promote bilateral cooperation in the areas of forests, wildlife, environment, biodiversity conservation and climate change, including restoration of wildlife corridors and interlinking areas, and exchange of knowledge, technical expertise and best practices. The signing ceremony took place in New Delhi, in the presence of Shri Bhupender Yadav, Union Minister of Environment, Forest and Climate Change, Government of India, and Shri Madhav Prasad Chaulagain, Cabinet Minister for Forests and Environment, Government of Nepal.

Source: https://www.pib.gov.in/



Inventors Revolutionize Power Grid Stability

With "Universal Shock Absorber"

Engineers at Ramboll have developed the patent-pending Universal Damping STATCOM, a "universal shock absorber" designed to stabilize aging power grids integrating diverse renewable energy sources. By detecting and neutralizing voltage oscillations at critical nodes, the technology converts disruptive energy into usable power, reducing outage risks and improving resilience. It offers a cost-effective upgrade over conventional systems, enabling utilities worldwide to integrate renewables more reliably, lower energy costs, and accelerate decarbonization efforts.

Engineers at Ramboll have developed a new breakthrough technology that substantially eliminates a primary cause of global power grid instability: too many different power sources added to an aging energy infrastructure. It is a growing problem that likely contributed to the national-level power outage of Portugal and Spain in April 2025, and that Ramboll, a global architecture, engineering, and consultancy company, has now found an answer to.



The Universal Damping STATCOM (patent pending), acts as a "universal shock absorber" for the grid, making it easier and less risky for operators to add renewable energy sources to grids, preventing power outages, cutting costs of developing power systems around the world, and significantly increasing resilience.

"This breakthrough technology will not only lower energy costs for everyone from consumers to utilities and private investors, we will also see fewer outages and less outage time. By bridging our innovative capacity with a leading role in power system solutions, Ramboll is helping pave the way towards more sustainable, resilient societies," says Cheryl Ginyard-Jones, Managing Director of Ramboll in the Americas.

How It Works

Adding new sources of renewable energy such as solar plants, wind farms, and battery storage systems to the grid impacts reliability due to the introduction of potential oscillations, or fluctuations into the transmission system. When designing the system, operators currently try to predict all potential devices that will be plugged into a grid, along with all potential oscillation modes and future operating conditions. Then operators fine tune or add damping controllers for specific identified modes to address potential oscillations. This can still cause outages and other issues down the road because of unanticipated technological advancements, unexpected new devices connecting to the system, or unpredicted operating conditions.

The Universal Damping STATCOM, installed at critical nodes in an existing power system, will detect and neutralize any observable oscillation in system voltage by absorbing energy from the oscillations and converting it to useable power. Coupled with energy storage capabilities, this new technology promises to revolutionize the way transmission system operators and regional transmission organizations keep our power grids stable and reliable and encourages the adoption of renewable sources of energy in the age of rising energy prices and power-intensive data centres.

"One of the biggest challenges in adopting renewable energy is the cost of maintaining grid reliability. It is difficult



handling the ever-changing power generation and load patterns, especially when the grid is outdated. Upgrading the grid with our new technology is a relatively inexpensive step that unlocks enormous potential," says Mojtaba Mohaddes, senior technical manager at Ramboll and the inventor of this innovation.

Power outages are extremely costly and can sometimes result in billions of dollars of losses. By preventing oscillations at the source, the Universal Damping STATCOM can save utilities and their customers enormous sums and provide more uninterrupted power. The cost for grid operators to implement this new technology is estimated to be a modest increase from a current STATCOM, with costs scaling down as adoption increases.

"This invention is a game-changer for power systems, and opens up incredible opportunities for more renewables in our power mix around the world," says Joanne Hu, Chair of Study Committee B4 at CIGRE. "Not only can developing countries now decarbonize their power grid, they can also have more reliable power for their people."

Ramboll is actively in talks with potential partners—OEMs, utilities, and investors—to bring this technology to market and help deploy this innovation worldwide.

Ramboll is a global architecture, engineering, and consultancy company founded in Denmark in 1945. They create sustainable societies where people and nature flourish, lifting and empowering businesses, schools, and communities towards a brighter future. Their worldwide network of more than 18,000 experts combines deep local insight with a global knowledge base to transform value chains and business models for extraordinary outcomes.

With more than 50 years of experience in energy solutions, Ramboll's energy practice works across the full spectrum of technologies and project phases: from permitting to developing business cases, executing design engineering, long-term operation and maintenance, and lifetime extension. ■

For more information, please contact Jim Smith at jimsmith@farrerkane.com



PFAS

Ubiquitous but Invisible High-Risk Chemicals

Per- and polyfluoroalkyl substances (PFAS), widely used since the 1940s for their water- and grease-resistant properties, have emerged as persistent, bioaccumulative, and toxic pollutants in India. Increasing research reveals their presence in rivers, groundwater, sediments, food packaging, wastewater, and even human blood and milk. Industrial discharge, urban runoff, landfills, and firefighting foams are key sources. Despite rising contamination, India's research and regulatory frameworks remain fragmented and limited. **Dr Kriti Akansha** and **Avanti Roy Basu** call for nationwide monitoring, stricter regulations, advanced treatment technologies, and a comprehensive national PFAS management framework.


Water Supply
Contamination
emica
FAS
Hazardous



Since the 1940s, per- and polyfluoroalkyl substances (PFAS) have been extensively used in industrial operations and consumer products, owing to their unique strength, stain resistance, grease protection, and water resistance properties. Once released into the environment, these man-made organic compounds break down slowly over time due to strong carbon-fluorine bonds. Consequently, PFAS are now found in almost all environmental matrices. Research has revealed that PFAS are persistent, bioaccumulative, and toxic, affecting human health and the environment.

PFAS and related emerging contaminants are now considered an emerging environmental challenge in India. This is evident from the rapid growth of the environmental testing industry, which was worth around $240 million in 2024 and is expected to expand further.[1] It is also due to stronger regulations, companies' transitions towards environmental sustainability and increased public awareness. PFAS are difficult to detect due to their chemical complexity, requiring advanced analytical instruments and continuous monitoring. Addressing PFAS pollution will require coordinated efforts among scientists, regulators, and investors to advance research and regulations and build treatment and monitoring infrastructure.

PFAS Research: What we know so far

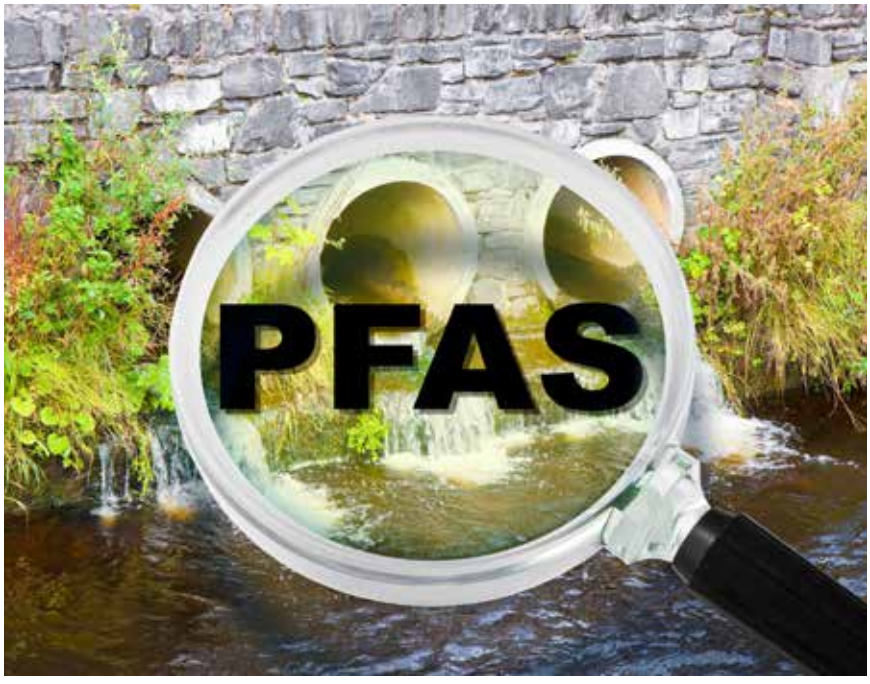
PFAS research has expanded significantly recently. Most studies from 2000 to 2010 were done in the US and Europe, with very few done in India. However, in 2015, research on PFAS in India picked up, largely due to improved detection technologies and enhanced public

1 Kalathil, N. (2025, June 28). Forever chemicals in India: An emerging environmental challenge. Manufacturing Today India. Link: https://www.manufacturingtodayindia.com/forever-chemicals-in-india

awareness. Initial studies in the river and coastal areas of West Bengal and Assam detected PFAS in sediments and surface water samples.[2]

During this period, the concern over PFAS contamination in non-industrialized regions prompted broader national study initiatives. For instance, research into road dust pollution in Uttar Pradesh revealed new and unrecognized sources of PFAS that led to further studies in Indian cities.[3] Despite these efforts, India's research output remains limited. A search for "PFAS contamination" shows that India only published 35 to 45 peer-reviewed papers in 2023–2024. This is very few compared to the 1200 papers published in the US and 950 papers published in Europe in 2023.[4] This difference indicates the relative under-prioritization of PFAS research in India.

PFAS research in India has expanded to include groundwater pollution, consumer goods and food packaging, industrial and municipal wastewater treatment plant effluents, and environmental transportation. For example, research in Maharashtra and Andhra Pradesh found PFAS contamination in tea bags, indicating a transition in research focus towards food-contact packaging materials and household items.[5] While research between 2010 and 2015 focused on



industrial discharges, studies conducted between 2016 and 2024 covered both urban and rural regions. Increased emphasis on states such as Assam, West Bengal, and Uttar Pradesh highlights the nationwide effects of PFAS pollution and reinforces the need for advanced research and regulatory responses.[6]

Global PFAS research has primarily been conducted in regions with strict regulatory provisions (the US and the EU), where established standards, monitoring programmes, and accessible databases enable more extensive studies. On the other hand, research on PFAS in India is still in its early stages and remains largely fragmented, often focusing on isolated industrial areas or specific environmental matrices. This calls for better research funding, interdisciplinary collaboration, and the establishment of effective national monitoring programmes to support evidence-based decision-making on PFAS management in the country.

Key Sources and PFAS Precursors

PFAS contamination in India stems from industrial activities, urban systems, waste management practices, consumers' products, and agriculture. A major issue is that PFAS precursor compounds can break down over time into persistent and toxic PFAS such as perfluorooctanoic acid (PFOA) and perfluorooctanesulphonic acid (PFOS). Chemical manufacturing, textile processing, paper production, and surface-coating industries are among the most significant contributors. Industrial effluents from Gujarat, Maharashtra, and Tamil Nadu frequently contain PFAS and their precursors, reflecting regulatory gaps and inadequate effluent treatment infrastructure.[7]

Urban wastewater is another major pathway for PFAS release. Most municipal wastewater treatment plants in large cities, including Delhi, Mumbai, and Chennai, lack advanced PFAS removal technologies. As a result, these substances pass through treatment

2 Sharma BM, Bharat GK, Tayal S, Larssen T, Bečanová J, Karásková P, Whitehead PG, Futter MN, Butterfield D, Nizzetto L. (2016) Perfluoroalkyl substances (PFAS) in river and ground/drinking water of the Ganges River basin: Emissions and implications for human exposure. Environ Pollut.; 208(Pt B):704-13. doi: 10.1016/j.envpol.2015.10.050. PMID: 26561452.

3 Yamazaki, E., et al. (2024). Comprehensive assessment of per- and polyfluoroalkyl substances (PFAS) contamination in groundwater of Kamrup, Assam, India: Occurrence, health risks, and metabolomic insights. Environmental Science, 26(9), 1601–1617.

4 Ismail, U. M., Elnakar, H., & Khan, M. F. (2023). Sources, fate, and detection of dust-associated perfluoroalkyl and polyfluoroalkyl substances (PFAS): A review. Toxics, 11(4), 335.

5 Jala, A., Adye, D. R., & Borkar, R. M. (2023). Occurrence and risk assessments of per- and polyfluoroalkyl substances in tea bags from India. Food Control, 151, Article 109812.

6 Jha, G., et al. (2021). Per- and polyfluoroalkyl substances (PFAS) in integrated crop–livestock systems: Environmental exposure and human health risks. International Journal of Environmental Research and Public Health, 18(23), Article 12550.

7 Koulini, G., & Nambi, I. M. (2024). Occurrence of forever chemicals in Chennai waters, India. Environmental Sciences Europe, 36(1), 60.



processes and enter rivers and lakes, with monsoon-driven runoff further amplifying contamination in urban water bodies.[8]

Landfills and waste incineration facilities act as long-term PFAS reservoirs. PFAS-containing products accumulate in landfills, where leachate can migrate into surrounding soil and groundwater. This slow but continuous release poses sustained risks to nearby ecosystems and human populations.

Consumer products contribute to widespread, low-level PFAS exposure. Grease-resistant food packaging and disposable containers contain PFAS-based coatings. Many of these products include precursor compounds like polyfluoroalkyl phosphoric acid diesters (diPAPs), which can transform into more persistent PFAS during waste treatment or following environmental release.

Firefighting foams, particularly aqueous film-forming foams (AFFF), represent important point sources of PFAS contamination. Their use at airports, military installations, and industrial facilities has led to localized contamination of soil and groundwater, with documented cases near airports and riverine systems in several Indian states.

Agricultural pathways extend PFAS contamination into the food system. The application of biosolids derived from treated sewage sludge and the use of contaminated surface or groundwater for irrigation introduce PFAS into agricultural soils that can accumulate in crops and enter the food chain, particularly in intensively farmed regions such as Punjab, Haryana, West Bengal, and Uttar Pradesh.[9]

Research indicates that industrial effluents, textile and tannery byproducts, urban runoff, and insufficiently treated wastewater contaminate the Ganga, Cauvery, Vellar, and Tamiraparani rivers.[10] In Chennai, groundwater concentrations ranged from 0.1 to 136 ng/L, raising concerns about the potential exceedance of international drinking water guidelines. Sediments act as long-term sinks, progressively releasing PFAS into aquatic systems and extending environmental exposure.

Tracing PFAS across India

PFAS detection in surface water, groundwater, sediments, air, road dust, biota, and human biological samples highlights its extensive dispersion and long-term persistence.[7] PFAS contamination of Indian surface water is evident in urban and industrial settings. Major sources of pollution are effluents from the chemical, textile, and tannery sectors; untreated municipal wastewater; and urban runoff.[11] High population density and intense industrial activities along major rivers (Ganga) make them susceptible. PFAS compounds like perfluorohexanoic acid (PFHxA) and PFOS have been found in the Cauvery, Vellar, and Tamiraparani rivers, with concentrations ranging from ≥1 ng/L to above 10 ng/L, likely from textile and tannery industries.[10]

PFAS concentrations in the groundwater in Chennai vary from 0.1–136 ng/L, indicating significant localized pollution.[7] International drinking water guidelines limit PFOA and PFOS to 4 ng/L, but observed

8 Kurwadkar, S., et al. (2022). Per- and polyfluoroalkyl substances in water and wastewater: A critical review of their global occurrence and distribution. Science of the Total Environment, 809, Article 151003.

9 Ghisi, R., Vamerali, T., & Manzetti, S. (2019). Accumulation of perfluorinated alkyl substances (PFAS) in agricultural plants: A review. Environmental Research, 169, 326–341.

10 Sunantha, G., & Vasudevan, N. (2016). Assessment of perfluorooctanoic acid and perfluorooctane sulfonate in surface water—Tamil Nadu, India. Marine Pollution Bulletin, 109(1), 612–618.

11 Singh, N., et al. (2022). Challenges of water contamination in urban areas. In Current directions in water scarcity research (pp. 173–202). Elsevier.



total PFAS levels raise concerns that individual compounds may exceed safety thresholds.[12] In Chennai, industrial discharges, inadequate wastewater treatment, landfill leachate, and poor PFAS-containing waste disposal pollute groundwater. In contrast, groundwater PFAS levels in West Bengal are typically below measurement standards, although industrial seepage and air deposition may pose long-term environmental and public health risks. The use of polluted groundwater for drinking, agriculture, and livestock rearing raises exposure hazards, especially in rural Ganga River basin areas.

Sediments act as a long-term PFAS sink. PFOS and PFOA concentrations in sediment samples from the Ganga River and Sundarbans wetlands range from below the technique quantification limit to 14 ng/g dry weight, indicating contamination of riverbeds and wetland ecosystems.[13] Coastal sediments in Tamil Nadu and West Bengal show PFAS concentrations ranging from 1.7–8.2 ng/g dry weight.[10] These residues may originate from contaminated surface water bodies, industrial discharges, urban runoff, and atmospheric deposition. PFAS in sediments can affect benthic organisms and higher-up aquatic food web species (that depend on sediment-dwelling fauna), resulting in prolonged exposure.

PFAS bioaccumulate in aquatic and terrestrial organisms and have been found in fish, prawns, marine animals, and dolphins in environmentally vulnerable areas, including the Ganga river system. High PFAS levels in biota have been associated with impaired reproduction, developmental defects, and immune dysfunction, threatening ecosystem structure and resilience. The persistence of PFAS indicates that ecological impacts may endure well

12 INOPOL (2025) PFAS in drinking water in India - A review. India-Norway Cooperation Project on Capacity Building for Reducing Plastic and Chemical Pollution in India. Link: https://www.mugammaconsultants.com/wp-content/uploads/2024/06/INOPOL_2021_Baseline_Report_Persistent_Organic_Pollutants_in_India.pdf

13 Corsolini, S., Kannan, K., Tao, L., Sinclair, E., & Focardi, S. (2012). Perfluorinated compounds in surficial sediments from the Ganges River and Sundarban mangrove wetland, India. *Chemosphere, 87*(11), 1201–1207. https://doi.org/10.1016/j.chemosphere.2012.01.056

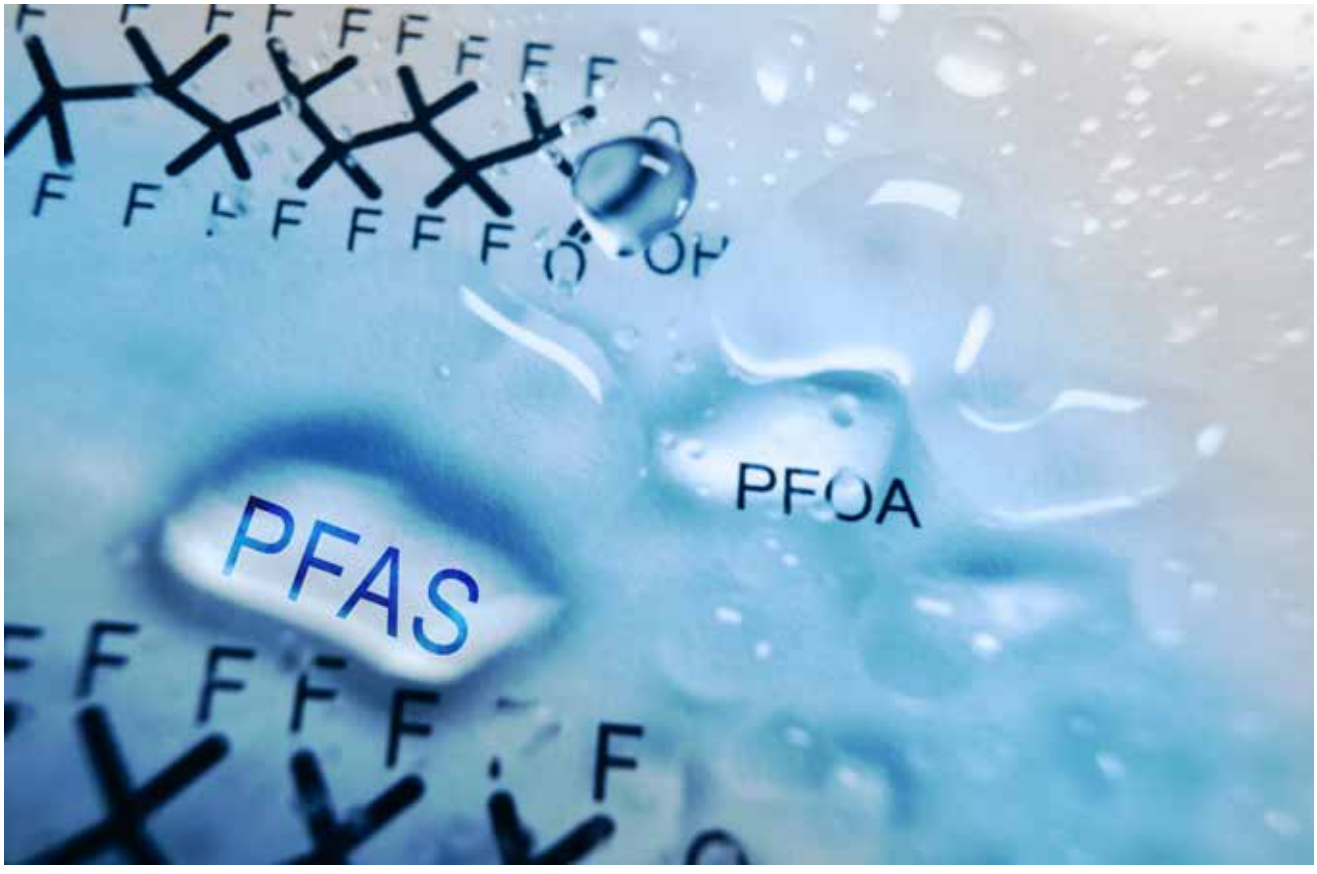
beyond the cessation of direct emissions.

PFAS are linked to serious health problems in India, such as cancers, hormone and immune system issues, and harm to development and reproduction, especially affecting pregnant women, infants, children, people with weakened immune systems, and those exposed for a long time. Bioaccumulation of PFAS compounds in fish, prawns, and marine mammals affects ecosystem health and facilitates food-web transfer. In animals, PFAS can affect reproductive, developmental, and immune functions, destabilizing already fragile ecosystems. Exposure pathways for infants may include contaminated food, drinking water, or environmental media, leading to long-term health consequences. PFAS has been detected in human blood and milk samples, indicating direct transmission to newborns during key developmental stages that may be linked to immune suppression, developmental effects, and endocrine disruption.

Looking Ahead: Priorities for PFAS research and management in India

Despite research on environmental and human health exposure, India lacks credible data on PFAS occurrence across environmental matrices and population groups. This knowledge gap hampers the development of effective mitigation remedies. There is an urgent need for the government and scientific community to urgently act now on various aspects, as discussed below.

- To quantify PFAS pollution in water, soil, food, animals, and human population groups, systematic and nationwide monitoring of PFAS is needed. A real-time map may be developed showing PFAS monitoring results in public and private water systems, pollution hotspots, and affected population groups.
- Clear, transparent and effective communication on the public health and environmental concerns of PFAS is essential to inform policymakers and the public.
- Aligning with global trends (US/EU), stricter regulatory controls on the manufacturing, usage, and disposal of PFAS-containing products are needed.
- Specific stakeholders require technical assistance and capacity-building initiatives, particularly for managing PFAS in vulnerable communities.
- Strategic investments are required for advanced water treatment and PFAS





removal technologies, along with targeted research on PFAS sources, transmission pathways, and effective management options.

Public and political awareness must be raised through concerted action involving government agencies, environmental organizations, industry groups, and civil society organizations to inform about the risks of PFAS exposure and encourage safer consumer choices.

India now needs to take immediate regulatory action on PFAS management. Although certain PFAS are listed for restriction under the Stockholm Convention, which India ratified in 2006, the country still lacks a comprehensive regulatory framework. Hence, India needs to develop a national PFAS management framework that would define contamination sources, enforce regulatory limits, and promote sustainable remediation practices. Drawing from the regulatory approaches of the United States and the European Union, the framework can focus on establishing enforceable discharge limits, especially for PFAS hotspots, like industrial sources, landfills, airports, and fire training sites. This will also support India's progress towards achieving several United Nations Sustainable Development Goals (SDGs), particularly SDG 3 (good health), SDG 6 (clean water), SDG 12 (responsible consumption), and SDG 14 (life below water).

The National Green Tribunal (NGT) has stressed establishing PFAS standards under the Water Act (1974). The Central Pollution Control Board (CPCB) has highlighted increasing PFAS levels in Indian water sources, due to polluting businesses shifting from developed to developing nations like India. The CPCB has emphasized that India lacks a clear framework for monitoring and regulating PFAS. While standardized testing for PFOA/PFOS has commenced and a countrywide survey on PFAS usage is underway, regulatory measures must be supported by robust enforcement mechanisms. The Bureau of Indian Standards (BIS) has reviewed PFAS rules for food contact materials due to concerns regarding dietary exposure. In tandem, national research organizations (IITs/CSIR laboratories) are conducting monitoring and analytical investigations to evaluate PFAS in environmental and biological samples. They are early but crucial steps towards evidence-based PFAS management in India. Without strong and sustained enforcement, regulations risk remaining symbolic. Delaying action will only increase the public health and environmental risks, whereas timely interventions can safeguard both current and future generations. ■

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Heat without Respite

Mapping India's Rising Thermal Stress

India's heat waves have become a year-round crisis, which has health and economic implications. A paper on "Spatiotemporal changes in heat stress exposure in India, 1981–2023," was recently published in *Nature Communications*. This is the first district-level study on the subject. The paper analyses how heat stress exposure has changed at the district level in India over time (1981–2023) using high resolution (~11 km) hourly data on the Universal Thermal Climate Index (UTCI). The research also defines heat stress exposure (HSE) to occur when UTCI crosses 32 degrees Celsius.

Here, we are in an exclusive email conversation with the co-authors of the paper—**Harvard Professor SV Subramanian** and **IIMB Assistant Professor Arpit Shah**.



Your study uses high-resolution hourly UTCI data to assess heat stress across Indian districts over four decades. What motivated you to take this granular, district-level approach, and what advantages does UTCI offer over traditional temperature metrics?

When we started this work, we were interested in figuring out 'when and where are people exposed to dangerous heat in their daily lives in India?'. This pushed us towards a district-level analysis using hourly Universal Thermal Climate Index (UTCI) data for multiple reasons. First, districts in India are where governance and implementation of policy actually happens. For instance, disaster management, health programmes, Heat Action Plans, and initiatives like the Aspirational Districts Programme are all implemented through the district governance structure. This makes our analysis highly actionable for administrators, as opposed to doing a coarser analysis at the state level. Second, using daily temperature averages, which the literature has largely done, smooths out fluctuations within the day. Using hourly data allows us to capture short, intense heat events within the day that are especially likely to impact outdoor workers, such as a construction worker in Delhi or a farmer in Gujarat or Bihar. Finally, we selected the UTCI because it approximates what the human body feels. UTCI combines air temperature, humidity, wind and solar radiation into a single metric of thermal stress. Prior work has shown that UTCI performs at least as well as the more established Wet Bulb Globe Temperature in predicting physiological strain, perceived heat, and labour loss. It's also particularly suited to outdoor workers, whose exposure is shaped not just by temperature but by direct sun, humidity, and wind.

The paper reports a 3.3 per cent rise in heat stress exposure (HSE) between 1981 and 2023. What do you see as the most striking or concerning aspects of this long-term trend?

On paper, 3.3 per cent might sound like a modest increase. But districts were already experiencing 5.4 hours/day above the UTCI heat-stress threshold (32°C) in the early period. 32°C represents a high heat stress threshold—exposure to heat beyond this limit can be considered stressful for the human body. By 2011–2023, this had risen to about 5.57 hours per day. That's 10 extra minutes of stressful heat every single day, averaged across 722 districts, over four decades.



Professor Arpit Shah



Professor SV Subramanian

We think this heat stress is reaching alarming levels in India. First, the data shows that the heat season is increasing across seasons. We find that heat stress exposure has increased most in January–March and October–December, by 6.5 per cent and 9.9 per cent, respectively, while April–June was already very high and stays high. The months that used to offer some respite are getting progressively hotter. This reduces the cool windows for people to recover from heat stress. Second, there is a lot of inequality that the average number does not highlight. Many districts that were already hot have seen high heat increases from high baseline levels. This heat is linked to excess mortality, crop losses, and reduced labour productivity. We're reaching a stage where people's ability to adapt and cope are getting



stretched, and qualitatively, this feels like a very high level of risk.

The research shows that night-time heat is rising faster than daytime heat. Why is this important, and how does it affect people's ability to recover from hot days?

We find a striking result in the paper. There is a mismatch between temperature trends and heat-stress exposure. On average, night-time temperatures in India are rising faster than daytime temperatures. This means the diurnal range (the difference between day and night temperatures) is shrinking. Globally, this has been linked to higher risks of cardiovascular disease and mortality. At the same time, we also examine the hours above the UTCI heat-stress threshold (32°C) for day and night. We find that daytime heat stress exposure (6 am–6 pm) increases by about 3.3 per cent, while night-time exposure remains largely stable because many places are still just below that threshold at night.

This is potentially a bad combination. Daytime hours are becoming more stressful, and nights are getting warmer even if they don't always cross the formal threshold of high heat stress. That means the body has less chance to cool down and recover at night after higher exposure to heat during the day.

Think about a construction worker sleeping in a poorly ventilated room in an informal settlement. If the night temperature keeps rising, the ability to cool down with a ceiling fan will get compromised over a period of time. The body no longer gets the same relief over a period of time; this chronic lack of rest can become dangerous from a health standpoint. This can lead to higher rates of heat-related illness and reduced work capacity.

Your findings show widening disparities: districts with high exposure in 1981 experienced the largest increases in HSE over time. Why are vulnerable districts becoming even more vulnerable?

While our data does show this trend, our focus and expertise going forward will largely be in managing and adapting to the increase. Someone with a climate science background would be best placed to answer why hotter districts are becoming even hotter as the reasons will likely depend on local weather patterns and other meteorological factors—we may not be best qualified to take a stab at this.

The study highlights strong spatial variations—larger increases in Northern and Eastern India and relatively lower increases in the South. What factors are driving these regional differences?

While our data does show this trend, our focus and expertise going forward will largely be in managing and adapting to the increase. Someone with a climate science background would be best placed to answer this question as the reasons will likely depend on local weather patterns and other meteorological factors—we may not be best qualified to take a stab at this.

Your study finds that heat stress events are happening more often and lasting longer. What kinds of challenges does this create for farmers, outdoor workers, and city residents?

In our analysis, we analyze individual heat events (that we define as a continuous period of time where UTCI exceeds the high stress threshold). We find that high heat stress events are becoming longer in duration and are occurring more frequently. In our analysis, the average number of continuous exposure events per district per year rises (from about 276 to 280), the interval between events shrinks (from 21.7 to 21.3 hours), and the average duration of each event lengthens (from 7.96 to 8.05 hours) between the early and late periods.

This would have multiple implications on the ground. For instance, farmers in India tend to shift work towards the cooler part of the day—they would typically do this by starting work early in the morning. However, longer and



more frequent heat events with lower gaps between consecutive events would reduce this flexibility. If a typical afternoon heat events starts earlier in the morning or stretches into the evening, many tasks would have to be compressed into shorter windows, or be done at times with higher heat stress. Over time, this can have health impacts on farmers.

Similar issues would apply to construction workers or delivery drivers or sanitation workers in cities. Many cities in India mandate construction work bans between noon and 4 pm. These intervals may have to be lengthened, but this would then impact the economics of construction and other industries. If not, workers would have to work in potentially unsafe conditions.

For cities in general, higher heat will strain power grids, water supply systems and health services. This will especially be true for informal settlements, which are already most vulnerable to heat because of poor housing conditions.

Your analysis of outdoor occupational exposure shows increasing risk and significant caste disparities. Could you elaborate on what the data reveals about social inequality and climate vulnerability?

In the last part of the paper, we link our district-level UTCI data to a large, nationally representative household survey (CPHS) that records where people work and how many hours they spend working. This lets us estimate, for each worker, how many of their work minutes are spent outdoors while UTCI exceeds 32°C.

We then look at this by caste group. We find that workers from Scheduled Castes (SC), Scheduled Tribes (ST) and Other Backward Classes (OBC) (these are historically marginalized groups in the Indian context) experience consistently higher outdoor heat exposure than workers in the 'Others' category. This is not because the weather is different for them. The results are driven by the fact that SC, ST and OBC workers are more likely to be doing jobs that require outdoor and manual work.



This reiterates the finding from our earlier Demography paper, which focused on the 2019 and 2022 heatwaves. There, we showed a similar picture and coined this as a form of 'thermal injustice'. Caste-based occupational segregation is effectively mapping onto who has to stand and work in the heat.

Our new study adds more details to that story. We show that the hours of dangerous heat are increasing across districts. Then we show that within that rising heat, some social groups spend more of their working day outdoors in those conditions.

For climate policy, this means you can't talk about adaptation in India without talking about caste and labour. Otherwise, we will end up with air-conditioned offices, while people who build those offices suffer outside in the heat.

Based on your findings, what simple, practical steps—at the community or government level—could help protect people from growing heat risks?

We think many of the solutions are known. The challenge is scaling them and targeting them better. At the district level, we believe that Heat Action Plans should move beyond air temperature thresholds and incorporate metrics such as HSE that consider factors like humidity and wind speed and also reflect how long people are actually exposed. With more research, we can work towards refining early-warning systems and tailoring advisories to specific occupational groups. Depending on the level of flexibility available for given occupations, one may have to think about planning staggered work hours when UTCI crosses critical thresholds.

Housing and urban design are an important policy consideration. Low-cost cool-roof interventions and better ventilation can reduce indoor temperatures in informal settlements by several degrees. This can really aid night-time recovery. Designing and scaling such measures could help urban heat equity.

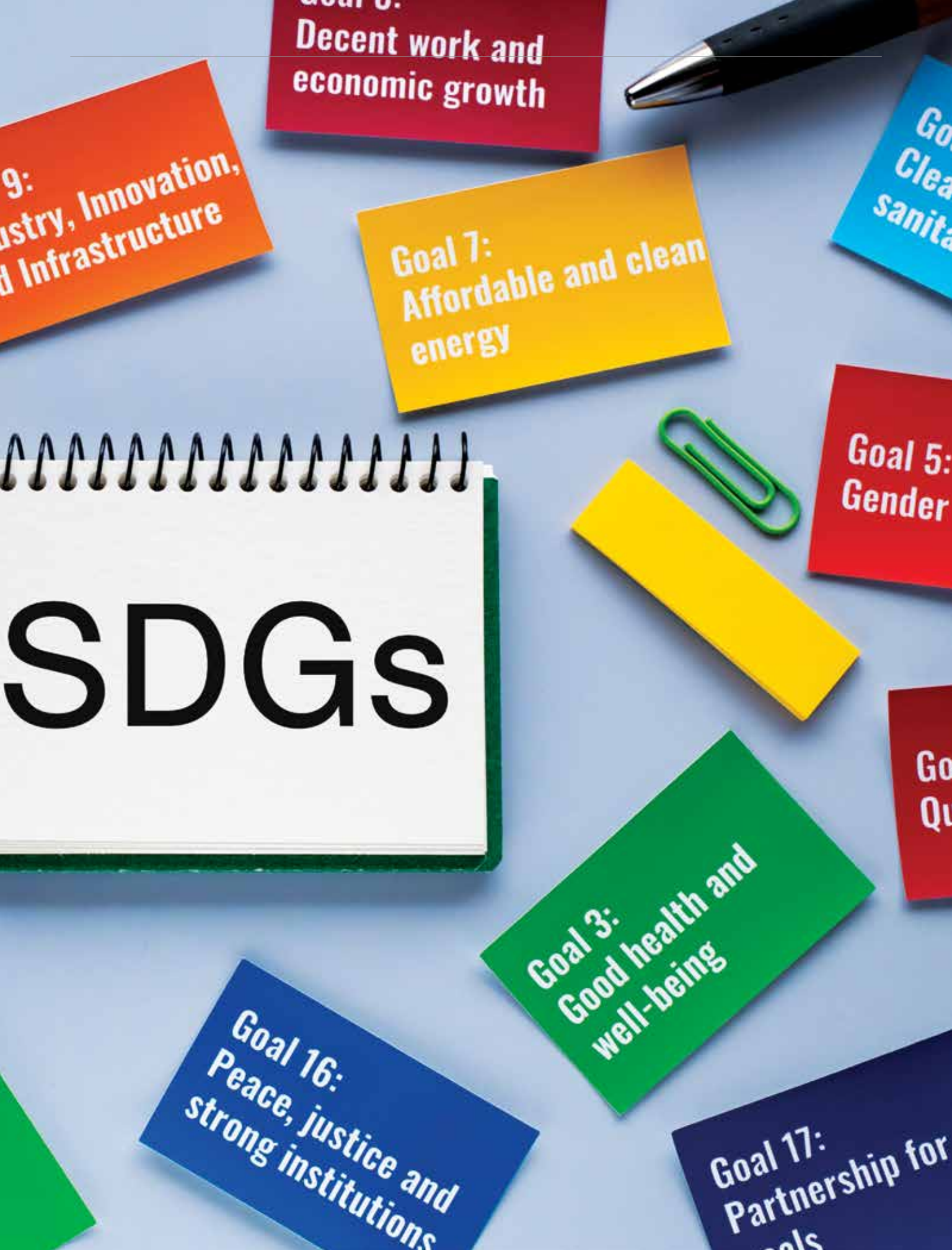
On the labour side, we need to think strongly about heat as an occupational safety consideration. Employers should provide shaded rest areas, drinking water, toilets and protect wages when work has to pause for safety. Social protection should extend to informal workers who currently bear the brunt of lost labour hours.

Finally, vulnerability targeting has to be improved. Our results suggest that caste, occupation, informality, etc., are determinants of heat risk and need to be considered in the planning process. ■

Transformations at a Defining Moment

Vision, Voices, and Values for Sustainable Development

This article examines the defining challenges confronting global sustainable development in 2026. Nearly a decade after the Paris Agreement and the 2030 Agenda, progress remains uneven, with climate impacts, inequality, and geopolitical tensions reinforcing a widening implementation gap. The authors argue that fragmented approaches to climate and development limit transformative potential, calling for integrated, inclusive, and equity-centred pathways. Highlighting the importance of aligning Nationally Determined Contributions with Sustainable Development Goals, the article positions the World Sustainable Development Summit 2026 as a critical platform to advance coherent, people-centred, and system-wide solutions in a decisive decade.


Decent work and economic growth
9:
ustry, Innovation,
d Infrastructure
Goal 7:
Affordable and clean energy
Goal 5:
Gender
SDGs
Goal 3:
Good health and well-being
Goal 16:
Peace, justice and strong institutions
Goal 17:
Partnership for



The year 2026 finds the global community at a moment of profound reckoning. Nearly a decade after the adoption of the Paris Agreement and the 2030 Agenda for Sustainable Development, the promise of a more resilient and equitable future remains unevenly realized. Scientific assessments, development indicators, and lived experience across regions converge on a single conclusion: the pace and direction of current efforts are no longer sufficient for the scale of challenges the world now faces.

The first Global Stocktake under the Paris Agreement offered an unambiguous signal. While climate ambition has expanded and participation has deepened, collective action remains inadequate to place the world on a pathway consistent with limiting global warming to 1.5°C.[1] Global greenhouse gas emissions continue to rise, and the remaining margin for delay has narrowed considerably. The United Nations Environment Programme's latest assessment similarly underscores that existing national commitments leave a substantial gap between current trajectories and the emissions reductions required within this decade.[2]

Yet the implications of this shortfall extend far beyond temperature thresholds. Climate change is no longer a distant environmental concern; it is a defining force shaping development outcomes. Recent global assessments show that climate-related hazards are intensifying risks to food security, reversing poverty



reduction gains, and deepening existing inequalities across countries and communities.[3,4] These pressures are increasingly reflected in global development trends, underscoring the growing interdependence between climate stability and sustainable development outcomes.

This convergence is increasingly evident in the slowing momentum of the 2030 Agenda itself. The *Sustainable Development Goals Report 2024* finds that fewer than one-fifth of global targets are currently on track, with progress across several goals stagnating or reversing under the combined pressures of climate impacts, economic disruption, conflict, and persistent inequality.[4] Rather than isolated setbacks, these reversals reflect deeper structural stresses including fiscal constraints, uneven recovery, and limited

1 United Nations Framework Convention on Climate Change (UNFCCC). (2023). *First global stocktake synthesis report.* Details available at https://unfccc.int

2 United Nations Environment Programme (UNEP). (2024). Emissions gap report 2024. Details available at https://www.unep.org/resources/emissions-gap-report

3 Intergovernmental Panel on Climate Change (IPCC). (2023). *Climate change 2023: Synthesis report.* Details available at https://www.ipcc.ch/report/ar6/syr/

4 United Nations. (2024). *The sustainable development goals report 2024.* Details available at https://unstats.un.org/sdgs/report/2024/



institutional capacity that are reducing governments' ability to sustain long-term development investments.

What is unfolding, therefore, is not a single or episodic crisis, but a complex interaction of multiple, reinforcing stresses, a 'polycrisis' in which environmental, economic, health, and geopolitical risks intersect and compound one another, narrowing policy space and amplifying vulnerability across systems.[5,6] In such a context, pressures rarely operate in isolation, economic volatility constrains fiscal responses, climate shocks strain institutional capacity, and geopolitical fragmentation disrupts cooperation and coordination. This interdependence helps explain why sector-specific or siloed interventions, even when well designed, often struggle to deliver durable outcomes, underscoring the need for more integrated and adaptive approaches to climate action and sustainable development.

This moment therefore calls for reflection as much as acceleration. It invites a reassessment of how climate goals and development aspirations are being pursued, and whether the frameworks that shaped earlier progress remain adequate for the complexities of the present decade. Incremental adjustments, while necessary, appear insufficient in the face of systemic risks that transcend sectors and borders.

It is within this global context that the World Sustainable Development Summit 2026 convenes.

5 Beltramo, T., et al. (2025). *Tracking SDG achievements in the age of polycrisis.* Retrieved from https://www.researchgate.net/publication/387993093_Tracking_SDG_Achievements_in_the_Age_of_Polycrisis

6 Kwamie, A., et al. (2024). Learning systems in polycrisis contexts. *BMJ Global Health, 9*(9), e014887. Details available at https://gh.bmj.com/content/9/9/e014887



Marking its Silver Jubilee, WSDS returns at a time when transformation is no longer a matter of aspiration, but of necessity. The Summit's theme *"Transformations: Vision, Voices, and Values for Sustainable Development,"* reflects a growing recognition that enduring progress will depend not only on technologies and targets, but on shared direction, inclusive participation, and the principles that guide collective choices.[7]

From Parallel Tracks to Integrated Pathways: Aligning Climate Commitments with Sustainable Development Goals

The international architecture for climate action and sustainable development is anchored in two closely linked, yet institutionally distinct, frameworks adopted in 2015. The 2030 Agenda for Sustainable Development articulates an integrated vision for economic, social, and environmental progress, while the Paris Agreement provides a collective mechanism for addressing climate change through nationally determined contributions. Together, they reflect a shared ambition to align development pathways with the planetary limits, even as their design, governance arrangements, and implementation logics differ.

Within the 2030 Agenda, climate action is explicitly positioned as integral to sustainable development rather than a discrete environmental concern. While Sustainable Development Goal 13 addresses climate change directly, its intent extends well beyond mitigation and adaptation as isolated objectives.

7 The Energy and Resources Institute (TERI). (n.d.). World Sustainable Development Summit 2026. Details available at https://wsds.teriin.org/2026/





Target 13.2 calls on countries to integrate climate considerations into national policies, strategies, and planning processes, recognizing climate change as a cross-cutting driver of development outcomes, underscoring the interdependence of climate stability and broader development outcomes.[8]

The Paris Agreement, adopted in the same year, takes a complementary but structurally different approach. Through Nationally Determined Contributions (NDCs), countries are afforded flexibility to define climate priorities in line with national circumstances. NDCs primarily stipulate mitigation targets, adaptation goals, and, in some cases, implementation needs related to finance, technology, and capacity building. While many NDCs acknowledge potential sustainable development benefits, the Agreement does not prescribe a common framework for explicitly linking climate commitments to SDG targets or indicators.

These differences become evident in national planning processes. Climate action is frequently articulated through NDCs and sector-specific climate policies, while development priorities are pursued through national development plans and SDG implementation frameworks. The two agendas often proceed in parallel, governed by distinct institutions, reporting cycles, and monitoring systems. Even where objectives overlap, limited coordination across ministries and different levels of government constrains opportunities for coherence and mutual reinforcement.

Analytical work examining the relationship between NDCs and the SDGs suggests that meaningful linkages do exist, particularly in areas such as renewable energy deployment, energy efficiency, land-use management, and institutional capacity building.[9] However, these linkages are uneven and frequently remain implicit. Development co-benefits are often acknowledged in principle, while planning, budgeting, and implementation continue to follow sectoral lines. As a result, interventions that could deliver multiple outcomes tend to be designed to meet narrow objectives.

This dynamic becomes particularly visible in sectors that lie at the intersection of climate mitigation and everyday development systems. Waste management and biomass energy, for example, are increasingly reflected within NDCs as opportunities to reduce methane emissions. Yet their significance extends far beyond emissions accounting. These sectors are embedded within complex local realities shaped by municipal governance structures, public health priorities, informal labour networks, and evolving value chains. When climate strategies frame waste primarily through a narrow mitigation lens, without integrating urban service delivery, financing mechanisms, or livelihood considerations, much of their broader development potential remains untapped. Evidence suggests that while emissions from waste management represent a relatively modest share of global greenhouse gas totals, interventions such as organic waste diversion, resource recovery, and decentralized bioenergy generation can deliver disproportionately larger benefits when aligned with broader planning process.[10]

8 United Nations General Assembly. (2015). *Transforming our world: The 2030 agenda for sustainable development.* Details available at https://sdgs.un.org/2030agenda

9 IDOS–SEI. (2023). *Aligning nationally determined contributions and sustainable development goals.* Details available at https://sdgs.un.org/sites/default/files/2021-04/Publication%20-%20Aligning%20Nationally%20Determined%20Contributions%20and%20Sustainable%20Development%20Goals.pdf

10 United Nations Environment Programme (UNEP). (2022). *Global waste management outlook 2022.* Details available at https://www.unep.org/resources/report/global-waste-management-outlook-2022



The questions of alignment are also inseparable from considerations of equity and inclusion. The sectors most relevant to climate-development integration including waste management, energy access, and urban services are often characterized by informal labour and unequal exposure to environmental risks. Where climate interventions fail to account for gender, livelihoods, and social differentiation, they risk reinforcing existing inequalities, even as they deliver emissions reductions. Conversely, evidence suggests that integrating gender-responsive and inclusive approaches into climate and development planning can strengthen implementation capacity and enhance the durability of outcomes.[11]

As climate risks intersect more directly with development realities, the costs of fragmentation become more visible. Sectors central to development including agriculture, water, infrastructure, and urban services are increasingly shaped by climate variability and shocks. Sustaining momentum towards the 1.5°C goal will therefore depend not only on strengthening climate ambition, but on how effectively climate priorities are integrated within development pathways, fiscal frameworks, and institutional processes.

It is this evolving reality that the World Sustainable Development Summit 2026 engages with directly. By convening discussions on climate action, sustainable development, and systems transformation within a single platform, WSDS creates space to move beyond parallel conversations towards integrated thinking. Bringing together policymakers, practitioners, researchers, businesses, and civil society, the Summit provides an opportunity to examine how global commitments translate into national and local pathways and how alignment across policies, institutions, and financing mechanisms can be strengthened in practice. In doing so, WSDS positions itself as a forum not only for dialogue, but for advancing more coherent, inclusive, and development-aligned climate action in a decisive decade.

The global development landscape in 2025 reflects a period of significant strain and transition. With just five years remaining to achieve the 2030 Agenda, progress across the Sustainable Development Goals has become increasingly uneven, shaped by climate impacts, economic uncertainty, and evolving geopolitical dynamics. Armed conflicts, rising inequality, and extreme weather events continue to influence outcomes across poverty reduction (SDG 1), food security (SDG 2), health (SDG 3), education (SDG 4), and access to water and sanitation (SDG 6). Conflicts in Ukraine, Sudan, and parts of the Middle East have disrupted livelihoods and strained humanitarian systems, while droughts, floods, and fiscal pressures



11 United Nations Development Programme (UNDP). (2023). Gender equality and climate action guidance. Details available at https://www.undp.org



test resilience in vulnerable economies.[12,13] Rather than isolated setbacks, these intersecting pressures highlight the need for development pathways that are more integrated, adaptive, and responsive to a rapidly changing global context.

Responding to this reality requires a reorientation in how climate action and development are pursued together. National planning systems must increasingly bridge the long-standing divide between climate commitments and broader development strategies, embedding mitigation and adaptation within decisions on infrastructure, public investment, and service delivery. Progress will depend not only on ambition but on enabling conditions such as access to climate finance, stronger institutional coordination, and data systems capable of capturing cross-sectoral impacts.

Equally important is the social grounding of transformation. Transition pathways must promote equity, inclusion, and fairness so that changes in energy systems, land use, and urban development expand opportunities rather than deepen existing inequalities. Inclusion, in this sense, extends beyond representation to meaningful participation in shaping decisions that affect livelihoods, communities, and local economies.

It is within this demanding yet critical context that the World Sustainable Development Summit 2026 assumes particular significance. Built on 25 years of sustained global dialogue on sustainable development, the Summit has evolved into a leading multi-stakeholder platform where governments, industry, academia, and civil society come together to explore pathways towards shared progress. Over the years, WSDS has convened a wide spectrum of global voices from policymakers and scientific leaders to business innovators and youth advocates reinforcing its role as a forum where diverse perspectives intersect to shape collective solutions and advance the spirit of SDG 17: Partnerships for the Goals.

The Summit's emphasis on vision is expected to deepen conversations around aligning long-term climate ambition with inclusive development pathways, recognizing that decisions made today will shape resilience, equity, and environmental stability for decades to come. At a time when countries are navigating overlapping pressures from climate risks and fiscal constraints to geopolitical uncertainty, such alignment becomes critical to ensuring that transformation is not only ambitious but also grounded in practical realities. By creating space for dialogue on integrated approaches across energy systems, urban transitions, nature-based solutions, and circular economies, WSDS 2026 seeks to bridge the gap between global commitments and on-the-ground implementation.

Another defining element of the Summit's approach is its focus on voices. By convening policymakers, scientists, business leaders, youth representatives, and civil society actors from diverse regions, WSDS aims to foster conversations that reflect both technical expertise and lived experience. This diversity of engagement reinforces the understanding that sustainable development challenges cannot be addressed through isolated institutional efforts alone; they require collaboration across disciplines, geographies, and generations. In doing so, the Summit reflects a growing recognition that inclusive dialogue strengthens the legitimacy and durability of policy pathways.

Grounded in shared values of equity, responsibility, and trust, WSDS 2026 also highlights the importance of placing people at the heart of this transformation. As countries pursue pathways towards net-zero emissions and resilient development, questions of fairness and justice, participation, and intergenerational responsibility remain central. Through thematic tracks, leadership dialogues, and multi-stakeholder engagements shaped by decades of convening experience, the Summit aspires to create a practical arena where ideas evolve into partnerships and commitments move closer to action. ■

Article contributed by Mr Souvik Bhattacharjya, Senior Fellow & Director at Resource Efficiency & Governance division, TERI and Dr Vibha Dhawan, Director General, TERI.

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WORLD SUSTAINABLE DEVELOPMENT SUMMIT 2026

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Clearing the Air

India's Multi-Sector Battle against Pollution

In this article, **Arvind Kumar** highlights that air pollution remains a severe winter crisis in northern India, driven by $PM_{2.5}$ from vehicles, industry, construction, biomass burning, and agriculture. Its impacts are worsened by weather patterns and transboundary movement. With serious health and economic costs, urgent action is needed. Effective control requires robust data, strong regulatory institutions, cross-jurisdictional coordination, cleaner technologies across sectors, and sustained political commitment. Initiatives such as NCAP, GRAP, and renewable energy expansion show progress, but integrated, long-term, airshed-based management is essential.

Every winter reminds us of the persistent air pollution problem, in the form of smog enveloping cities across northern India in particular. Indeed, $PM_{2.5}$ levels quite often exceed health safety thresholds in most cities of the developing world. Air pollution is especially severe in some of the world's fastest-growing urban regions, where the combination of more people, more vehicles, energy derived from fossil fuels, construction, improper management of wastes, and other factors have driven air pollution.

Sources of Air Pollution

Air pollution takes many forms. One of the most damaging pollutants is $PM_{2.5}$, which is very fine particulate matter (PM) that is less than or equal to 2.5 microns in diameter, or about one-thirtieth the width of a human hair. Reported in micrograms per cubic metre ($\mu g/m^3$) serves as the standard air quality metric monitored globally due to its significant adverse effects on human health.

A wide range of economic activities are responsible for $PM_{2.5}$ emissions.



They can be either directly emitted (primary PM) or chemically formed in the atmosphere from precursor emissions such as sulphur dioxide (SO_2), nitrogen oxides, and ammonia (secondary PM). Primary $PM_{2.5}$ originates from a wide range of sources, including fossil fuel combustion, open-fire cooking, industrial processes, the burning of agricultural residues, waste, and road and construction dust. In some regions, natural sources such as windblown desert dust also contribute significantly to $PM_{2.5}$. Secondary $PM_{2.5}$, which makes up about one-third of total $PM_{2.5}$, is the result of chemical transformation of gases such as nitrogen oxides, SO_2, and volatile organic compounds (VOCs) emitted when fuel burns or solvents evaporate. Ammonia, which is emitted by agricultural sources such as nitrogen fertilizer and when livestock manure is stored and used, combines with nitrogen oxides and sulphur dioxide to form ammonium nitrate and ammonium sulphate $PM_{2.5}$ particles.

Air pollution is also a highly dynamic phenomenon in space and time, influenced by weather systems and topography, with relatively localized transportation of pollutants within a catchment area known as 'airshed'. Furthermore, long range transportation of air pollution even transcends

international borders and raises issues of transboundary air pollution, which is a key challenge due to inherent geopolitical and socio-economic complexities.

Air Pollution in Delhi-National Capital Region (NCR)

Various technical studies have shown that there are multiple sources including high level of anthropogenic activities, arising from various sectors, viz., vehicular pollution, industrial pollution, dust from construction, biomass and municipal solid waste burning, and secondary inorganic aerosols which require a multi-source strategy for pollution management. Stubble burning during winter season has also been identified as an episodic event, which aggravates the air quality index in Delhi and NCR region.

World Health Organization Air Quality Guidelines

The World Health Organization (WHO) recommends avoiding average $PM_{2.5}$ concentrations above 5 micrograms per cubic metre (µg/m^3), with interim targets of 35 µg/m^3, 25 µg/m^3, 15 µg/m^3 and 10 µg/m^3 on the way to achieving the 5 µg/m^3 guideline.



This report shows that halving the number of people exposed to $PM_{2.5}$ concentrations above 25 µg/m^3 globally by 2040 is feasible and affordable. Because air pollution stems largely from anthropogenic sources, effective policies can reduce it. Only 12 countries, regions, and territories across the world recorded $PM_{2.5}$ concentrations below the WHO annual $PM_{2.5}$ guideline of 5.0 µg/m^3, most of which were in the Latin America and Caribbean or Oceania region.

Socio-Economic Costs of Air Pollution

Globally, air pollution is a silent killer. Air pollution is a major cause of disease and death. According to the World Bank's publication "Accelerating Access to Clean Air for a Livable Planet", ambient (outdoor) air pollution kills roughly 5.7 million people globally each year. Its economic costs are estimated at nearly 5 per cent of global gross domestic product (GDP), accruing not only from poor health outcomes and the death burden, but also from productivity loss and cognitive impacts, which can span generations. Air pollution is not just a health risk; it is also an economic burden. By causing illness and premature death, pollution reduces quality of life. By causing a loss of productive labour, pollution also reduces output and incomes. Ninety-nine per cent of the global population is exposed to pollution exceeding WHO guideline values, but the burden is highest in low- and middle-income countries, where low incomes and limited access to healthcare compound impacts and exacerbate existing inequalities across and within national boundaries. The poor are more likely to live and work in polluted environments, but they are less able to avoid exposure or self-protect.



What Needs to be Done to Combat Air Pollution

Policy decisions, investments, and technologies have a role to play in bending, flattening or shifting the

Environmental Kuznets Curve—the notion that pollution first worsens and then improves at higher levels of income as a country develops. There is no silver bullet, and air pollution will only be tackled through sustained commitment. Information, incentives, and institutions are the three prongs of an effective air pollution management strategy for any country.

Data on air pollution concentrations and its health implications, on sources of pollution, on violations of regulations, etc., are critical to the design and implementation of air quality programmes. Expanding air quality monitoring networks, supporting public disclosure of information on air quality levels are vital.

A strong regulatory mechanism is a must to ensure that states and cities are incentivized to implement policies and programmes to reduce air pollution. Be it carrot- or stick based, a mechanism to incentivize implementation of air quality management plans is needed. The multi-jurisdictional nature of air pollution requires an institutional set-up that reaches across individual jurisdictions-central-state-city governments. Because air pollution travels across administrative boundaries, and pollution sources are located both inside and outside any given city, an airshed-based management approach that cuts across jurisdictions is essential to achieving results. This calls for strong cross-jurisdictional coordination on air pollution control.

To be effective and sustainable in the long term, policies will need to be embedded in national and state policy frameworks, and appropriately funded. For instance, some significant sources of air pollution in India—residential biomass burning, agricultural emissions, and dust—do not fall under the direct purview of pollution boards. Programmes such as the Pradhan Mantri Ujjwala Yojana that has expanded access to clean cooking fuels, most notably Liquefied Petroleum Gas (LPG), thereby reducing the reliance on residential biomass burning, is essential to strengthen efforts to reduce air pollution. Such a programme goes well beyond the mandate of a pollution control board and gets to the heart of how development programmes are designed. Similarly, reducing emissions from power generation and small- and medium enterprises will entail increasing the use of natural gas and renewable energy and goes well beyond the provisions of the Indian Air Act to prescribe and enforce emission standards for power plants and industry. Effective air quality management depends less on new policies than on stronger institutions, coordination, and accountability.

No single sector or short-term intervention can deliver clean air—only sustained, parallel action across all major sources of pollution will yield the results. Reducing air pollution requires accelerating the adoption of cleaner technologies and practices across five key sectors: cooking, transport, agriculture, industries, and waste management. Priority actions include facilitating access to cleaner industrial boilers, furnaces and kilns, electric vehicles, improved household cookstoves, mechanized agricultural residue removal, and improved livestock manure management. These transitions can be supported by investments in critical infrastructure—such as electric vehicle charging networks, efficient public transport, and expanded waste collection services—but also incentives to overcome barriers to adoption. Governments can also mandate cleaner technologies; for instance, through brick kiln modernization, vehicle scrappage programmes, or recycling at construction and demolition sites.

Air Pollution is a Multi-Sectoral and Multi-Jurisdictional Challenge

The air pollution challenge in India is inherently multi-sectoral and multi-jurisdictional, requiring an "airshed" approach. An airshed can be defined as a region that shares a common flow of air, which may become uniformly polluted and stagnant. Air quality within an airshed will largely depend on pollution sources within it. Because the formation of secondary particles and the transporting of primary and secondary particles take place over large geographic areas, airsheds can extend over several hundred kilometres, well beyond the boundaries of cities. India, therefore, needs to look beyond its cities and take action at the sub-national level for effective air pollution control strategies and apply new set of tools for airshed-based management. Standardizing tools across India is important and so control strategies and relevant data sets can be linked.

Government Initiatives to Control Air Pollution

India has taken many significant steps in responding to air pollution.



The Government of India (GoI) has strengthened vehicular and industrial emission standards in recent years. A strong emphasis on expanding renewable energy, promoting electric vehicles, and supplying LPG cooking fuel to millions of households are some examples of the actions India is taking to combat air pollution.

The GoI's National Clean Air Programme (NCAP) is a step in acknowledging and resolving the problem of deteriorating ambient air quality. The NCAP has set a time-bound goal for improving air quality across the country, with a focus on around 132 "non-attainment" cities where air pollution standards are not being met. Recognizing the need for concerted cross-jurisdiction and airshed level action and coordination, India's Parliament approved a law in August 2021 to establish the Commission of Air Quality Management in the National Capital Region and Adjoining Areas.

The 15th Finance Commission has provided INR 12,139 crore for the award period [2021–22 to 2025–26] for augmenting measures to improve air quality in 42 cities/urban agglomerations with million plus population. This is in addition to INR 4,400 crore recommended for the year 2020–21.

The India National Air Quality Index programme, initiated in 2015, is an important step towards supporting action. Additionally, apart from better monitoring data, it is important to improve data to inform air quality action plans, which, in turn, require data on pollution sources and cost effectiveness of different policy interventions.

Besides, Graded Response Action Plan (GRAP) has been put in place which provides set of emergency response actions, depending on severity of air pollution levels, to be implemented by identified agencies for minimizing air pollution, a situation that generally persists in the Delhi-NCR during the peak winter months.



Many cities in low- and middle-income countries control air pollution in part through interventions and environmental policies that aim to reduce pollutant emissions during acute air pollution periods. These policies impose additional temporary restrictions on pollutant emissions with the objective of reducing ambient concentrations of air pollutants in the short term. While these policies could reduce concentrations of air pollution, they could have significant economic costs. Data on emissions and sources of pollution allow policymakers to frame policy interventions, to set measurable targets and to identify strategies to meet targets in a cost-effective manner, and to monitor progress.

Good Examples of Air Pollution Management

Over the decade, China, Japan, and the Republic of Korea have made significant strides in reducing air pollution through strong legal and policy frameworks. However, they all face challenges in meeting the new WHO air quality guidelines. China's experience could serve as an example for developing countries currently grappling with some of the world's highest pollution levels. China's success in curbing air pollution is attributed to a multi-pronged and time bound approach implemented systematically across various jurisdictions and sectors/activities.

Way Forward

Air pollution challenge is both multi-sectoral and multi-jurisdictional. It is today a major health risk and a drag on economies. But it is a challenge that can nevertheless be tackled with sustained political commitment, policy innovations, and fit-for-purpose institutional arrangements.

To effectively address air pollution, a comprehensive and integrated approach to air quality management (AQM) is needed. This approach encompasses planning, implementing, evaluating, and adjusting abatement strategies and measures for continual improvements. This approach should also take into account existing policy and operational constraints that could foreclose or limit the implementation of certain air pollution reduction interventions. ■

Arvind Kumar, Former Senior Economic Adviser, Government of India.

The Hidden Side of Himachal's Apple Blossom

In this article, **Dr Muskaan Negi** examines the widespread practice of burning apple-pruning residue in Himachal Pradesh and its environmental and health consequences. While burning is a convenient and low-cost method for farmers, it releases harmful pollutants such as $PM_{2.5}$, black carbon, and toxic gases that degrade air quality, especially in mountain valleys prone to temperature inversions. These emissions raise AQI levels and pose serious respiratory and cardiovascular risks. The article advocates practical, community-based solutions—such as mulching, composting, shared chipping facilities, supportive policies, and local biomass markets—to reduce pollution while improving soil health and farmer livelihoods.

Every winter, after the harvest is done and the orchards lie bare, thousands of apple growers across Himachal Pradesh face the same question, what to do with the trunks, branches and twigs left from pruning? For many, the simplest answer has been to pile it up and burn it. It's cheap, fast, and feels like a clean reset for the next season. But that smoke carries a cost for farmers, for neighbours, and for the mountain air we all breathe.

Why Farmers Burn Apple-Pruning Residue

Apple pruning is a vital orchard practice that improves light penetration, reduces pest and disease incidence, helps maintain tree structure, and ultimately enhances fruit yield and quality. However, it also generates large quantities of woody residue in the form of branches, twigs, and leaves, which can be difficult to manage. For many farmers, burning this pruning waste becomes the most convenient option due to several practical reasons. Burning involves minimal immediate cost, as it does not require specialized equipment, additional labour for collection, or expenses related to transportation. It also allows for quick and efficient clearing of orchards, which is especially important before the onset of new vegetative growth. In many apple-growing regions, particularly in hilly areas, there is a lack of accessible alternatives such as chipping services, composting units, or established markets for woody biomass. Moreover, pruning and residue disposal usually take place during colder months, when natural decomposition is slow and storing bulky biomass becomes impractical. Together, these economic, logistical, and seasonal factors make burning an attractive short-term solution for farmers, despite the significant environmental and health trade-offs associated with smoke emissions, air pollution, and loss of valuable organic matter.



What Burning Releases into the Air

When pruning waste is burned, it does not simply disappear; instead, it releases a complex and harmful mixture of air pollutants into the atmosphere. This includes particulate matter such as $PM_{2.5}$ and PM_{10}, microscopic particles that remain suspended in the air for long periods and can penetrate deep into the lungs, with $PM_{2.5}$ posing particularly serious risks to respiratory and cardiovascular health. Burning also emits black carbon, or soot, which contributes to local and regional warming and, when it settles on snow and ice in mountainous regions, accelerates melting. Carbon monoxide is another byproduct, which at elevated concentrations reduces the blood's ability to carry oxygen, leading to headaches, dizziness, and more severe health effects. In addition, the smoke contains volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs), many of which are toxic and some known to be carcinogenic. Smaller quantities of nitrogen oxides and sulphur compounds are also released, which act as precursors to secondary pollutants such as ground-level ozone and additional fine particulates. In hilly and mountainous areas, valley topography and frequent



temperature inversions—where cold air becomes trapped beneath warmer air layers—often prevent smoke from dispersing. As a result, pollutants accumulate near the ground, significantly degrading air quality in nearby towns and villages.



Impacts on Air Quality Index (AQI) and Health

The Air Quality Index (AQI) serves as a simplified indicator of overall air pollution levels, and during agricultural burning events, fine particulate matter ($PM_{2.5}$) is typically the dominant pollutant driving AQI spikes. Even short but repeated episodes of pruning-waste burning can rapidly shift local air quality from "Good" to "Unhealthy" or worse. Such exposure has immediate health impacts, including irritation of the eyes, nose, and throat, coughing, breathlessness, and the aggravation of asthma and chronic bronchitis. Over the long term, sustained exposure to elevated $PM_{2.5}$ levels increases the risk of cardiovascular disease, reduces lung function, and is associated with higher overall mortality. Vulnerable populations, particularly children, elderly individuals, pregnant women, and people with pre-existing respiratory or heart conditions are disproportionately affected. In Himachal Pradesh, where many villages and small towns are located downslope from apple orchards, smoke from burning residues often drifts directly into residential areas, raising AQI levels for several hours or even days. Beyond human health, burning pruning residue also has serious environmental and agricultural consequences. It leads to the loss of valuable organic matter and nutrients, as wood and leaves that could otherwise replenish soil carbon, nitrogen, and other elements through composting or mulching are destroyed. Repeated burning can degrade soil structure, reduce microbial activity, and gradually diminish soil fertility. Although burning may eliminate some pests or diseased material, it is a crude and non-selective method that can also harm beneficial organisms essential for soil and ecosystem health. Additionally, open burning releases carbon dioxide

and black carbon, contributing to greenhouse gas emissions and localized climate warming. Reduced visibility caused by smoke further poses safety risks on narrow mountain roads, increasing the likelihood of traffic accidents.

Enabling Policies and Local Governance Models to Curb Pruning-Waste Burning

Reducing the persistent practice of open burning of apple-pruning residue requires policy and programmatic measures that are practical, locally driven, and supportive rather than punitive. Municipal and cooperative models can play a central role by organizing village-level collection, shared chipping or composting facilities, and community equipment rental systems, making residue management affordable for small and marginal growers while distributing costs and benefits across communities. Targeted subsidies or microgrants for chippers, shredders, and small composting units can further lower entry barriers, especially when combined with strong extension services



that provide regular field demonstrations and hands-on training in composting, mulching, and biochar production. Instead of imposing blanket bans, seasonal or partial burn restrictions paired with viable alternatives such as organized residue collection or chipping support during peak pruning periods are more likely to gain farmer acceptance and compliance. Where burning is unavoidable for phytosanitary reasons, it should be strictly limited to diseased wood, carried out in a controlled and isolated on-farm setting, properly permitted, and timed to minimize smoke impacts, following guidance from local authorities. Creating and supporting local markets for biomass-based products, such as briquettes or small-scale heating solutions for farms and rural institutions, can further incentivize change by converting waste into income or energy savings. Finally, improved AQI monitoring and local advisory systems, using simple village-level sensors and alerts, can help farmers plan cleaner management windows and avoid burning during temperature inversions or poor dispersion conditions, thereby protecting both public health and the fragile mountain environment.

Immediate, Low-Effort Actions for Growers

At the farm level, several simple and affordable steps can be adopted right away. Larger branches can be shredded using hand-operated or shared chippers and applied as mulch beneath trees to conserve moisture and enhance soil health. Small compost pits can be started on-farm by mixing pruning residues with green waste, dung, or kitchen scraps, gradually producing valuable organic manure. Neighbouring growers can coordinate to aggregate pruning material, making a single chipping or transport run more efficient and cost-effective. Where burning is still practiced, it should at least be avoided on still, cold days or during known inversion periods,

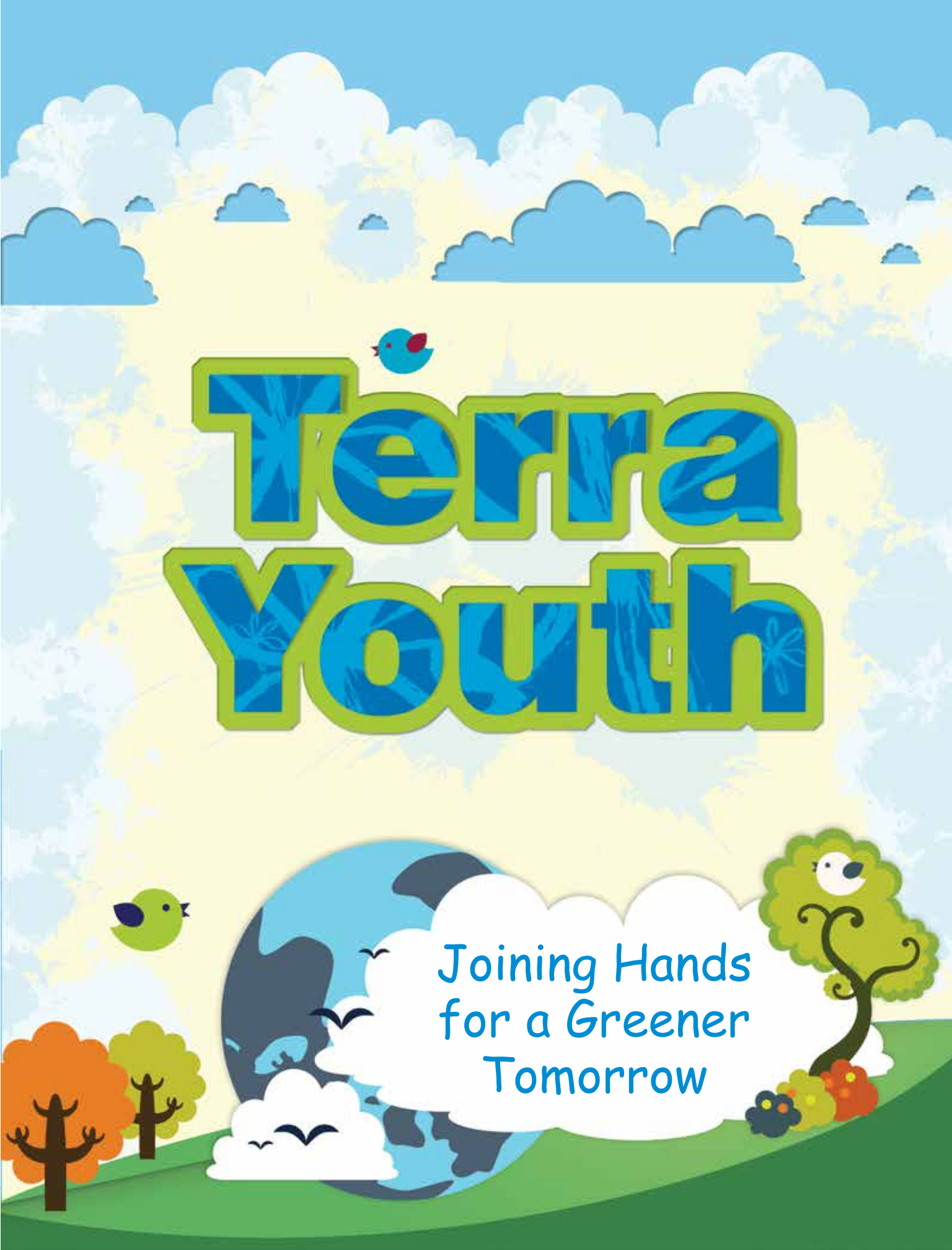


when smoke tends to linger and severely degrade local air quality. Farmers can also seek support from local extension agencies, NGOs, or CSR-backed projects for training, technical guidance, and access to shared equipment.

A Closing Thought

Pruning in apple orchards is indispensable, but the way pruning residue is managed does not have to harm the environment. Moving away from the long-standing practice of open burning towards reuse and recycling of wood and leaves can safeguard the clean mountain air that defines Himachal Pradesh, while simultaneously improving orchard soils and opening up new livelihood opportunities. Small, achievable changes such as a community chipper, a simple compost pit, or a village-level briquette initiative can collectively make a substantial difference. For a region that supplies apples to the world, preserving fresh air and healthy ecosystems is a harvest that benefits everyone. ■

Dr Muskaan Negi, Research Scholar, Dr YSP UHF, Nauni Solan, Himachal Pradesh.


Terra Youth
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All That Makes Up the Whole

A Holistic Approach to Environment Conservation and Sustainable Development

When the linkages and network in an ecosystem and habitat make up a whole that is complex, analysis and policy-making cannot be linear and simplistic. All life forms including *Homo sapiens* are connected and are influenced by various natural and anthropogenic factors. Human activities as part of economic growth and development also need to take a holistic approach safeguarding our natural environment and surroundings and the life forms therein.

In this article, **N Kalyani** lets us take a look at the interconnectedness and complex linkages that exist whether in the natural world or in human activities that influence and are influenced by the environment, and argues for a holistic approach to environment conservation and sustainable development.

"Piecemeal" and "standalone" are not tenable or practical concepts in real life in general, and, in particular, in the context of nature and environment. Likewise, *ceteris paribus* (all else remaining the same) is not a real-life situation or condition; it may be a theoretical, man-made and laboratory-controlled condition. In real life there is nothing static; everything is in a state of flux, there is constant evolution, adaptation, and the quest for equilibrium, optimality and sustainability in growth and development.



Photo by Amee Fairbank-Brown on Unsplash

When we come to the issues of studying and conserving and protecting nature and the environment we find there is nothing static, no water-tight compartments. Instead, we observe networks, inter-relationship, inter-dependence, and inter-connectedness. And these are complex in nature and cannot be viewed or analysed in isolation. For instance, many species share symbiotic relationships, and food chains themselves are intricate and interdependent. Flora and fauna within habitats are closely interconnected. Moreover, natural cycles both influence and are influenced by multiple factors, including weather, climate, and landscape.

Such being the case of the web of life on planet Earth revealing a highly intricate and complex scenario the role of every element, big and small, becomes important. For, after all, life on Earth did not start yesterday or the day before; it has millennia behind it. Therefore, it is not



only the seemingly sitting-at-the-top-of-the-evolution-pyramid *Homo sapiens* who is important. Or the mammoth elephant or the flagship tiger that alone are important by themselves. In the complex whole everything is significant.

This is a subject of great significance. Just as specialization and over-specialization in the human race and civilization in work, life and livelihood has cost us heavy, so too a lack of understanding and appreciation of the inter-connectedness in nature and environment has caused much harm, often irreparable.

We know, for instance, that doing away with bees only means doing away with the great pollinators so that plants, trees, crops, nothing can grow in their natural cycle of coming into fruition. There can be no vegetation, no green cover, no agriculture. And then if an orchard, for instance, has to have trees bearing fruit, bees have to be brought in as a consignment hoping they will do the job of pollination.

The realization then comes that the seemingly unattractive black bees have been playing a major role in pollination and thus in germination and thriving of every form of vegetation. Likewise, if we take the case of the cute little house sparrow we discover that the trend in the last decade and a half has been one of falling populations. A bird that has been part of human habitations for many thousands of years has now become a rarity to spot in most human habitations whether rural or urban. The house sparrow is, in fact, an indicator species in urban settings. In other words, if the population of the house sparrow is declining in an urban setting it is indicative of such changes in the habitat, environment and surroundings that are harmful to life—life forms—and vegetation. The little birds that were forever chirruping on our verandas and in our balconies in our homes often taking the liberty to dash into our bedrooms and living rooms have dwindled in their numbers, and various factors are being studied to understand the causes. From vehicular pollution to mobile tower-generated electromagnetic radiation to modern architecture of buildings and homes to increased use of chemical-based insecticides and pesticides in our gardens and agricultural fields.

We see here thus the complex interplay of factors and scenarios that influence and are influenced by various other factors and various other scenarios.

If wildlife species have got extinct, species of trees, plants and herbs have also got lost. Many traditional crops have also disappeared from the culinary scene. Of course, today millets have begun to catch on winning the fancy of the people, and, in fact, even becoming quite a rage. But this was not the case a few years ago when one hardly heard of



Photo by Camerauthor Photos on Unsplash

ragi in cosmopolitan fast-paced cities. Millets are not only healthy for human consumption, but also environment-friendly given that the hardy millets are amenable to growing in dry weather conditions making them even drought-resistant.

Ecosystems being dynamic there is interaction and mingling of everything with everything else. Known examples are innumerable. For instance, if we go back into the past, we know that DDT (dichloro-diphenyl-trichloroethane), the extensively used insecticide, was found, through the food chain, in human mother's milk, and was thus passed into babies' bodies, impacting their health from infancy.

Not long ago the issue of the consequences of the chemical named diclofenac used as a veterinary drug came up. Vultures that consumed carcasses of cattle that had been treated with diclofenac eventually died. This led to large numbers of deaths of vultures nearly threatening their extinction. Of course, incidentally, the chemical diclofenac is also used as an analgesic for humans.

In present times, plastic has assumed mammoth proportions as a pollutant. The issue of plastic reaching water bodies and eventually oceans, has become a multi-dimensional menace, affecting, as it does, the water and both aquatic and terrestrial life forms. Recently, the issue of microplastics in the human body has come to light, with the presence of microplastics affecting the human brain and cardiac health, besides other consequences.

What is seen as economic growth and urbanization and city development should also take a holistic approach vis-à-vis the plans and execution. All factors need to be taken into consideration with a view to protect and safeguard life forms and vegetation in their habitats. This includes thus the floral and faunal wealth and pristine habitat and landscape of any place. So whether it is laying a railway line, developing land for real estate, and all the varied construction activities, the impact on the habitat and its inhabitants needs to be assessed 360 degrees.

All these cases and scenarios in nature and the environment, in our surroundings, near and far, and in our human lives, reveal the interplay of so many factors both natural and anthropogenic. Any analysis and research and thereupon policy needs to factor in all factors and determinants for an ecologically sound and sustainable as also a holistically meaningful understanding and solution set. In other words, a holistic approach is what is called for. ■

N Kalyani is a freelance writer, and writes on environment, nature, and wildlife. She is the author of Mysteries and Musings (2011), a collection of her poems, and of Make it Big (2023), a motivational book. She loves nature and is a meditation enthusiast.

How Somaiya Vidyavihar is Shaping a Generation

That Protects the Coast, Not Just Studies It

Education at Somaiya Vidyavihar prepares students for more than just their careers. It shapes individuals who are conscious of their impact on the world, guided by responsibility, empathy, and purpose. Driven by this philosophy, the institution is cultivating a culture where science becomes a force for environmental stewardship, and students grow into thoughtful custodians of the future. This belief took form through One-Day International Conference in Biological Sciences on "Coast, Community & Conservation that brought together scientific inquiry, sustainability, and social accountability. It was designed to ignite a deeper understanding that conservation is not an academic chapter, but a lifelong commitment to protecting what sustains us. Aligned with the United Nations Sustainable Development Goals, particularly SDG 13 (Climate Action) and SDG 14 (Life Below Water), the conference created a vital connection between global environmental priorities and the realities of India's coastline. Sponsored by the Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra (Mangrove Foundation), the conference brought together 127 participants from 27 institutions and three countries, including students, research scholars, academicians, scientists, and conservation professionals.

Students were encouraged to see Mumbai's coastline as a living, breathing laboratory. Mangroves, wetlands, creeks, and intertidal zones were presented not merely as ecosystems, but as shared responsibilities that demand awareness, respect, and action.

Dr Pradnya Prabhu, Principal of K J Somaiya College of Science and Commerce, highlighted the role of education, awareness, and collaboration in driving conservation efforts. She emphasized that students today are not just learners but future leaders shaping sustainable coastal practices, and that meaningful conservation combines scientific understanding with community engagement and responsibility. The conference opened with a keynote address by Dr Sreenath K R, Director General, Fishery Survey of India, who reframed the way we look at India's coastline and its communities.

The conference challenged complacency and encouraged evidence-led conservation.

Dr Deepak Apte, Director, Advanced Research Centre, DES Pune University, dismantled long-standing myths surrounding coastal ecosystems and reinforced the need for science-driven policy and practice. Adding a global lens, Dr Bhavani Narayanaswamy highlighted the far-reaching consequences of plastic pollution and its cascading impact on marine life and food systems.

Its academic depth was reflected in 30 oral and 53 poster presentations that explored oceanography, wetlands and mangroves, biodiversity conservation, pollution and bioremediation, sustainable fisheries and aquaculture, community-led marine conservation, climate change, environmental toxicology, and entrepreneurship in biosciences. The work presented by students and young researchers was marked by intellectual rigour and real-world relevance, demonstrating how education at Somaiya Vidyavihar transforms curiosity into responsibility.

Through this programme, Somaiya Vidyavihar reaffirmed its commitment to education that responds to environmental challenges with depth, integrity, and intent. By uniting research, policy awareness, and community engagement, the institution continues to shape a generation for whom protecting nature is not a duty imposed but a value deeply lived. ■



Team Zoology and the students

When Students Take Energy Conservation Home

In this article, **Dr L Ramesh** highlights how #ENSAV9MANTRAS is turning everyday household habits into climate action.

Why Household Energy Use Matters

India's energy demand is rising rapidly, driven not only by industrial growth but also by everyday household consumption. While national conversations often focus on renewable capacity and large infrastructure, a significant share of electricity savings lies hidden in homes—in how appliances are used, maintained, and switched off. Behavioural change at the household level remains one of the most cost-effective yet underutilized tools for energy conservation.

This is where #ENSAV9MANTRAS (simple 9 mantras can save one unit per day at home), researched, founded, and formulated by Dr L Ramesh and Dr J Balamurugan, emerges as a powerful student-led energy conservation initiative—demonstrating that meaningful climate action can begin with simple daily habits, driven by community engagement rather than policy mandates alone.

Students as Energy Messengers

ENSAV9MANTRAS was built on a simple insight—students are trusted voices within families and neighbourhoods. When young people explain energy-saving practices to parents, relatives, and neighbours, the message carries credibility and emotional connection.

Under the IGEN ENERGY99 Challenge, trained students committed to engaging 99 households each, introducing nine practical energy-saving actions that require minimal or no financial investment. These actions focused on routine electricity use, appliance care, and the often-overlooked link between water use and energy consumption.

From Awareness to Action

Unlike conventional awareness campaigns that stop at information sharing, ENSAV9MANTRAS emphasized demonstration and follow-up. Students visited homes, explained why certain practices waste electricity, and showed



how small changes—such as switching off standby power or improving ventilation around appliances—could reduce energy bills.

Communication materials were kept simple and local-language friendly. Visual aids, household conversations, and peer examples proved far more effective than posters alone.

What Changed Inside Homes

Between 2022 and 2024, the initiative reached more than 33,000 households across urban and semi-urban communities. Surveys and electricity bill comparisons revealed that over 75 per cent of households adopted at least six of the nine recommended practices.

On average, participating households recorded annual savings of up to 3,650 units of electricity, translating into significant cost reductions. The associated environmental benefits included lower carbon emissions (around 4.7 tonnes of CO_2 annually per household) and reduced water consumption, underscoring the strong water–energy linkage.

These results reinforce a key insight: behaviour-led interventions can deliver substantial energy savings without requiring new infrastructure or capital investment.





Co-benefits beyond Electricity

Households reported additional benefits such as lower appliance repair costs, longer equipment lifespan, and increased awareness of resource use. In several neighbourhoods, women emerged as informal energy champions, sharing conservation practices with neighbours and monitoring household routines.

For students, the initiative functioned as experiential learning. Participants developed leadership, communication, and problem-solving skills while gaining a grounded understanding of sustainability as a daily practice rather than an abstract concept.

Why Personal Engagement Works

Digital campaigns supported the outreach, but the strongest results came from face-to-face interaction. Personal conversations built trust and accountability, while recognition of participating households created positive social reinforcement. Energy conservation gradually evolved into a shared community norm rather than an externally imposed requirement.

Linking Local Action to Global Goals

ENSAV9MANTRAS directly contributes to SDG 7 (Affordable and Clean Energy), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). Its measurable outcomes and replicable design led to its recognition by the United Nations Department of Economic and Social Affairs (UN DESA) as SDG Action #48555.

A Scalable Model for India

The initiative demonstrates how educational institutions can become hubs of community energy action. Integrating behaviour-based energy modules into school and college programmes, supported by local governments and utilities, could significantly reduce household electricity demand nationwide.

As India works towards a low-carbon future, ENSAV9MANTRAS highlights a simple but powerful truth: energy transition is not only about how energy is generated, but also about how it is used every day. ■

Dr L Ramesh is President of The Institution of Green Engineers (IGEN) and Professor at Dr MGR Educational and Research Institute that works on community-led energy efficiency and SDG-aligned climate action initiatives across India.



World's Largest Sand Island Lakes Dried up during Rainy Era

K'gari, the largest sand island on Earth, is famous for its clear freshwater lakes. New research from the University of Adelaide suggests those iconic waters may be more vulnerable than previously thought. By analysing ancient sediment layers from lakes on K'gari, located off Queensland's south eastern coast, scientists uncovered signs of a major drying period about 7500 years ago during the middle Holocene. "Our research shows that about 7500 years ago, at a time of higher rainfall and long after the end of the last Ice Age, some of K'gari's deepest lakes dried out," says lead researcher Associate Professor John Tibby, from the University of Adelaide. Drying episodes are not unusual in Australia, Associate Professor Tibby explains. However, this particular event stands out because it occurred during a period that was generally wetter than today. "There are many Australian lakes that dried during the Millenium Drought when there was not enough rainfall to sustain them," says Associate Professor Tibby, whose study was published in *Quaternary Science*.

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

What You Eat Could Decide the Planet's Future

What we put on our plates may matter more for the climate than we realize. Researchers found that most people, especially in wealthy countries, are exceeding a "food emissions budget" needed to keep global warming below 2°C. Beef alone accounts for nearly half of food-related emissions in Canada. Small changes—less waste, smaller portions, and fewer steaks—could add up to a big climate win. Food is now one of the biggest drivers of climate change, and most people are eating beyond what the planet can handle. Cutting food waste and reducing beef consumption could make a powerful difference—starting today. A recent study from the University of British Columbia suggests moderation should not be a seasonal goal but a long-term one. The research found that 44 per cent of the global population would need to change their eating habits to keep global warming below 2 °C. The study was led by Dr Juan Diego Martinez while he was a doctoral student at UBC's Institute for Resources, Environment and Sustainability. He explains what the research uncovered and outlines practical diet changes that could make a real difference.

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



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POLLUTION SOLUTIONS
FOR A CLEANER, GREENER EARTH

Urmi A Goswami

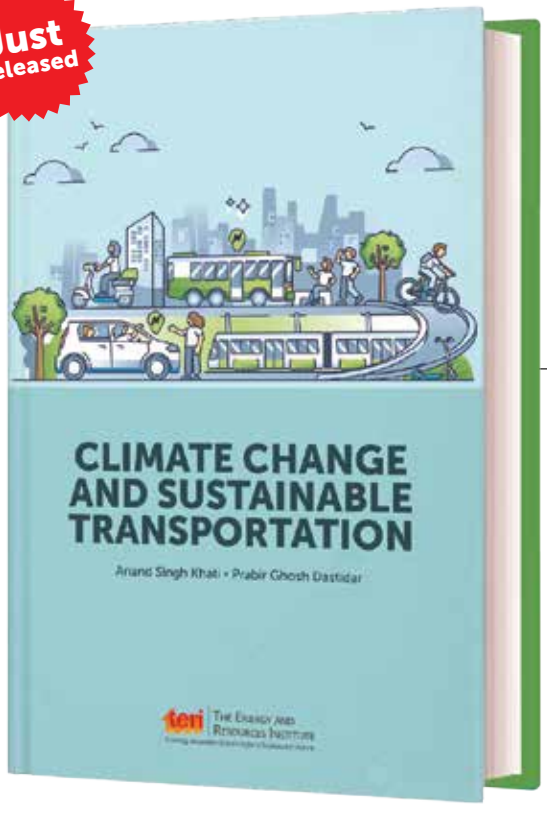
We are living in a fast changing world. Pollution of natural resources, such as air, water, and land is one of the biggest banes of our times. Under such precarious circumstances, it is needed that the young generation is not only made aware about the different kinds of pollution but also about the solutions.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

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Healing Herb to Hidden Hazard

The Fragile Knowledge of Kashmir's Wild Herbs

Forests are more than ecosystems—they are living pharmacies and pantries. Communities have long depended on wild herbs and mushrooms for food, medicine, and income. Yet, recent cases of accidental poisoning in Jammu & Kashmir reveal the risks that emerge when indigenous knowledge systems weaken and ecological patterns shift. A centuries-old tradition of forest foraging is increasingly threatened by misidentified herbal plants, **Khursheed Ahmad Shah** writes.

Himalayan forests have shaped life in Jammu and Kashmir for generations. They provide fuel, food, and medicine for communities that rely on them throughout the year. Under the Forest Rights Act, 2006,[1] Scheduled Tribes and other traditional forest dwellers are legally entitled to access forest resources for their livelihood needs and to manage them sustainably.

Forests as the Backbone of Daily Life

From spring to autumn, women rise early, carrying willow baskets on their heads and grass ropes in hand. They walk narrow forest paths to collect dry branches of fuelwood for the *daan* or *dambur*, the traditional stove that fuels cooking and warms homes. Without this fuelwood, daily life would come to a standstill—particularly during winter and *Chill-e-Kalan*, the forty-day period when roads freeze, water pipes burst, and power cuts can last for days.

During these months, rural families eat simple meals of pulses such as rajma and chickpeas, dried vegetables, and forest herbs. Preparing these foods requires time, but the *dambur* and collected firewood allow households to cook without relying on gas or modern fuels.



Bergenia ciliata (Haw.) Sternb. Photo courtesy Akhtar H Malik

Spring also marks the season for gathering wild herbs, leafy greens, and mushrooms like Shajkan, Kanpopar, and Gucchi. These plants are sun-dried, tied in cloth, and stored beneath tin roofs. Families use them throughout the year, especially during months when temperatures reach sub-zero, to treat common illnesses such as colds, coughs, stomach problems, and minor infections. Knowledge of which plants are safe is passed down from mother to daughter, refined through years of practice rather than written manuals. This oral tradition remains central to food security among forest-dependent communities.

1 Details available at https://tribal.nic.in/FRA/data/FRARulesBook.pdf

When Tradition Turns Dangerous

In the border village of Inderdaji Nowgam in Handwara tehsil, about 45 km from the district headquarters in Kupwara and 120 km from Srinagar, these risks become real. Rafeeqa Begum, a local, followed local tradition by collecting herbs and mushrooms in July with a group of women. They dried the plants and stored them for winters.

On December 23, Rafeeqa cooked one of the stored herbs for dinner. Minutes later, she and ten members of her family collapsed.[2] Relatives rushed them to a health centre in Nowgam Mawer, from where doctors referred them to the Government Medical College in Handwara. Medical staff later confirmed that the poisoning had been caused by a toxic herb.

"Most of the time, we go to the forests to collect *jadi-buti* for the winter months. These herbs help us stay warm during the harsh winters," stated Ishfaq Khan from Kupwara. "Sometimes, we end up collecting the wrong plants, mistaking them for the original ones, as many herbs have similar structures," he added. Similar incidents across multiple districts of Kashmir highlight the hidden risks of dependence on forest plants.

Forests that Heal and Sustain Livelihoods

These highland forests support a wide range of medicinal plants. Among them are *Aconitum heterophyllum* (Patrees), *Trillium govanianum* (Tripater), *Polygonatum verticillatum* (Mehmak), and *Podophyllum hexandrum* (Wanwugun).

For many communities living close to forests, seasonal foraging remains closely tied to household survival. Wild greens and mushrooms such as *Taraxacum officinale* (Handh), *Malva*



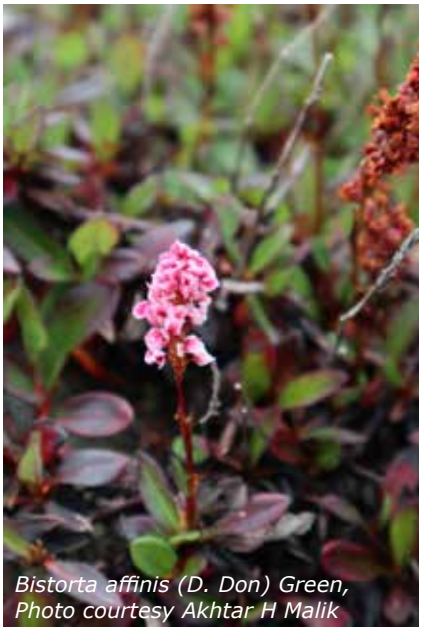
Atropa acuminata Royle. Photo courtesy Akhtar H Malik

neglecta (Suchal), *Morchella esculenta* (Gucchi) and *Geopora sumneriana* (Kanpoper) are collected during specific seasons and sold to contractors. "Most families depend on morels and Sajkan or Kanpoper for seasonal income," said Mansoor Rahim Ganaie, a forester who has been documenting North Kashmir's flora for over a decade.

Mr Ganaie cautioned that the line between medicine and poison in the wild is often thin. Medicinal plants can become harmful if consumed in excess or without proper knowledge. Some species closely resemble edible vegetables but are highly toxic. He recalled an incident from the Rafiabad range in Baramulla district, where an elderly man unknowingly collected *Atropa acuminata* (Maitbrand). Despite being warned, the man consumed it and fell sick the following day.

Ethno-botanical research reinforces this risk. A study documenting wild edible plants[3] among indigenous communities recorded 55 species across 45 genera and 31 families, noting that while these plants are essential for food and health security, several species are toxic if misidentified or prepared incorrectly.

"The forest carries risks. Many edible and medicinal plants grow close together



Bistorta affinis (D. Don) Green, Photo courtesy Akhtar H Malik

2 Details available at https://voicetvnews.com/2025/11/24/11-family-members-fall-ill-after-consuming-wild-herbs-in-mawer-qalamabad-village/

3 Details available at https://www.researchgate.net/publication/385044146_Wild_edible_plants_sustaining_food_security_among_indigenous_communities_in_Kashmir_Himalayas_India


Delphinium brunonianum Royle

as friends, and subtle differences in leaves, stems or roots can mean the difference between nourishment and danger," said Dr Akhtar H Malik, Scientist & Curator of KASH-Herbarium at the University of Kashmir.

He added that districts such as Kupwara, Baramulla, Kulgam, Anantnag, Budgam, Pulwama, Shopian, and Bandipora have reported cases of accidental poisoning. Shifting climate patterns further complicate identification, as plants flower at unusual times or appear in new locations.

A Deadly Forest Berry

Masuri berry (*Coriaria nepalensis*) grows wild in the Himalayan foothills. Flowering in spring and bearing bright red, mulberry-like fruits in summer, the shrub often lures people and animals into mistaking it for something harmless.

Dr Malik recalled a tragic incident from Char-e-Sharief in Budgam district, where three boys grazing sheep during summer vacations, consumed the berries. Soon after, they lost consciousness and slipped into a coma. They were taken to multiple hospitals as their condition worsened. One of the boys could not survive.

Such plants pose a serious but often overlooked risk, not just to humans but also to livestock. Newborn cattle and sheep are especially vulnerable. Ganaie states, "Certain plants, including *Stipa sibirica* (Draham Gassa) and *Aconitum chasmanthium* (Mohund), can cause poisoning and miscarriage in cattle, sheep and goats. Mohund is particularly common in the Bungus Valley, where grazing animals instinctively avoid it."

When Livestock Pay the Price

Dr Malik noted that around five years ago, his department investigated reports of sudden cattle deaths soon after forest grazing. Plant samples collected from the affected areas, confirmed the presence of poisonous grass. "Most cases of grass poisoning involved newborn animals unfamiliar with their surroundings and cannot differentiate between edible and toxic plants," he explained.

At the same time, Dr Malik cautioned against treating forests solely as threats. Many species also hold important ethno-veterinary and medicinal value. "This indigenous knowledge, passed down through generations, forms the basis of ethno-medicine," he added, underscoring the need to clearly distinguish between toxic plants and those that offer therapeutic benefits.

Toxicological Awareness and Food Practices

Traditional culinary practices around wild herbs are deeply rooted in inherited knowledge, especially in rural Kashmir where foraging remains common. "We use indigenous knowledge passed down from our grandparents," said Dr Naila Irshad, Associate Professor and Nutrition Expert at the University of Kashmir.

She highlighted Dandelion (*Taraxacum officinale*), locally known as Handh, a calcium-rich herb widely used, particularly during the postpartum period. She stressed that its safety depends on preparation. "The herb is washed and blanched thoroughly for two to three minutes to remove any residual toxicity," she added.


Rheum webbianum Royle

Without such knowledge, risks multiply. Herbs resembling edible varieties are often consumed despite being toxic or nutritionally insignificant. "Nutritional science focuses on documented edible foods. Shrubs, herbs or mushrooms outside scientific or traditional knowledge can be dangerous," Dr Irshad warned.

The Collapse of Knowledge Systems

What sustains health in the presence of traditional knowledge can become dangerous in its absence, exposing communities to serious toxicological risks. Dr Rouf Hamza Boda, Senior Lecturer in Botany said that when herbs that have been used for generations begin to cause harm, the real issue is not tradition but the erosion of indigenous knowledge systems. "Earlier, this knowledge was carefully transferred from elders to youth. Today, guesswork has replaced experience," he added. Improper boiling, drying, or storage can destroy medicinal value or introduce fungal toxins.

Environmental pressures compound the problem. Deforestation and forest fires are reducing minor forest produce, including medicinal herbs and wild mushrooms, even as forests continue to offer mental and ecological healing benefits.

Tradition, Trust, and Toxicity

Herbal poisoning cases are rising, particularly in forest-dependent and tribal areas. Mohammad Tabraiz, a Scholar, explained that poisoning often occurs when herbs, shrubs, or wild mushrooms, are consumed without proper detoxification. "Many plants contain potent bioactive compounds. Small errors in handling can turn remedies into hazards," he said, detailing gastrointestinal, neurological, cardiac, liver, and kidney impacts.

Tabraiz stressed that herbal poisoning should be treated as a medical emergency, with immediate cessation of the substance, early decontamination when necessary, and close monitoring in a medical facility.



Trillium govanianum Wall ex D Don



Inula racemosa Hook. f.

The Need for Regulation and Verification

Risks increase when herbs are adulterated or substituted. Dr Malik noted that plants such as *Saussurea lappa*, widely used in Unani medicine for arthritis and rheumatic pain, lose therapeutic value when mixed with inferior or incorrect species.

"We currently lack widespread and advanced methods to authenticate medicinal plants," he said. While DNA barcoding offers scientific verification, regulation remains essential. He called for stronger government oversight, monitoring of herbal and Ayurveda shops along with enforcement of quality standards.

Only through scientific verification, regulation, and vigilance can traditional medicine remain safe, effective, and trustworthy. ■

Khursheed Ahmad Shah is a freelance journalist based in Srinagar, Kashmir.

Pashu Sakhi

Listening to Hooves and Heartbeats in Every Village

The Pashu Sakhi model strengthens rural livestock healthcare by training local women as para-veterinarians, addressing India's shortage of veterinary services. Supported by WOTR, the initiative improves animal health, farmer incomes, and women's leadership. In Rajasthan's Baran district, trained Pashu Sakhis are enhancing disease prevention, productivity, and community resilience.

Livestock forms the backbone of India's rural economy. For more than two-thirds of rural households, animals are a primary source of income, nutrition, and security. The sector provides about 16 per cent of income to small and marginal farmers. It also supports the livelihoods of over 20 million people, with women playing a central role in daily animal care and management. And while this livestock might have multiple caretakers, professional medical care isn't widely or easily accessible.

With approximately one veterinarian for every 4616 animals, millions of farmers struggle to obtain timely and affordable healthcare for their livestock. Delayed treatment, poor preventive care, and limited technical guidance often lead to avoidable losses, reduced productivity, and financial vulnerability. Addressing this critical gap requires community-driven, sustainable solutions. This is where the Pashu Sakhi model,[1] strengthened and scaled by the Watershed Organisation Trust (WOTR), has made a transformative difference.

The Pashu Sakhi model emerged in the early 2000s as a grassroots response to India's shortage of veterinary services. Pashu Sakhis are trained women from local communities who serve as para-veterinarians, providing doorstep livestock care in villages. By decentralizing animal healthcare, the model places knowledge, skills, and services directly in the hands of rural households.

As the vital "last-mile" link between farmers and formal veterinary systems, Pashu Sakhis deliver essential services such as vaccination, deworming, basic treatment, first aid, nutrition advice, disease surveillance, and livestock management counselling. Their presence reduces farmers' dependence on distant veterinary centres, lowers travel costs, and ensures timely interventions—particularly for small ruminants such as goats and sheep that are often neglected by mainstream services.

Much like Anganwadi workers and Auxiliary Nurse Midwives in human health, Pashu Sakhis strengthen animal health systems at the grassroots level. What makes them unique, however, is their entrepreneurial dimension. Alongside veterinary service delivery, they supply medical inputs like mineral mixtures and dewormers, promote improved livestock practices such as better feeding and disease prevention, and develop small enterprises focused on input distribution and farmer training. This integrated role makes the model financially viable, community-owned, and sustainable over time.

WOTR's Integrated Approach

WOTR is playing a vital role in strengthening and institutionalizing the Pashu Sakhi movement in the regions where it works. By combining technical excellence, community participation, and long-term mentoring, WOTR has transformed the model into a robust system for rural livestock development.

Under WOTR's approach, Pashu Sakhis function as extension workers, healthcare providers, and enterprise promoters. They disseminate knowledge on improved feeding, housing, and disease prevention practices, provide doorstep healthcare and counselling, and demonstrate best practices through their own livestock units. This integrated role ensures that learning is practical, locally relevant, and easily adopted by farmers.

WOTR has also embedded strong monitoring and learning systems within the programme. Pashu Sakhis regularly visit goat and cattle sheds, assess animal health, maintain registers, and share data for analysis. These records help track disease patterns, monitor morbidity levels, and guide timely interventions.

Through this sustained support, WOTR has nurtured a cadre of trusted community professionals who serve as the backbone of village-level livestock systems.

The Process of Enabling Women as Livestock Leaders

For the Pashu Sakhi programme, women are carefully identified from village communities based on basic

1 Details available at https://wotr.org/blog/pashu-sakhi-the-women-bringing-veterinary-care-to-every-doorstep/

literacy, leadership potential, and commitment to service. Selected women undergo intensive capacity-building programmes that cover feed and fodder management, shed maintenance, disease diagnosis and treatment, vaccination protocols, breed improvement, and record-keeping. These residential trainings are supplemented by regular refresher courses, ensuring continuous learning and adaptation to emerging challenges.

By investing in women's technical and leadership capacities, WOTR strengthens livestock systems while also enhancing women's social status, decision-making power, and income opportunities. Pashu Sakhis emerge not only as service providers but also as respected community leaders and entrepreneurs.

Strengthening Pashu Sakhis in Baran, Rajasthan

A powerful example of WOTR's impact can be seen in Baran district of Rajasthan. Designed to strengthen the Pashu Sakhi cadre, the initiative here covers eight blocks of the district and has directly engaged 44 women as frontline livestock service providers. Baran faces multiple challenges, including frequent disease outbreaks like the lumpy skin disease (LSD), limited veterinary infrastructure, poor nutrition and management practices, and high economic vulnerability among tribal households. Although women play a central role in animal rearing, most lack access to formal technical training. The Pashu Sakhi intervention was designed to address these gaps and build long-term community resilience.

To strengthen local capacities, WOTR recently organized two four-day residential training programmes. Forty-four women were selected based on their experience and interest. The training was delivered by experienced livestock experts and focused on balanced feeding, fodder management, hygienic shed design, vaccination schedules, parasite control, and emergency care.

A strong emphasis was placed on hands-on learning. Participants practiced feeding systems, medicine administration, and preventive healthcare methods. They were trained to manage common diseases such as peste des petits ruminants (PPR or plague of small ruminants), foot and mouth diseases (FMD), goat pox, and foot rot, and introduced to the diagnosis and treatment of bacterial, viral, and fungal infections. Field orientation and exposure visits further strengthened practical understanding and community engagement.





As a result, all 44 Pashu Sakhis now possess improved technical skills in small and large animal management, biosecurity, and disease prevention. Villages are witnessing better early disease detection, improved feed utilization, and reduced wastage. Farmers are increasingly confident in adopting improved practices, supported by locally available and trusted service providers.

The programme is expected to impact nearly 30,000 animals and their owning households. Goats, sheep, cows, buffaloes, and backyard poultry have all benefited from improved healthcare and management practices.

Building Resilient Rural Futures

Today, many Pashu Sakhis, across India, are caregivers, educators, entrepreneurs, and leaders. They ensure that livestock, often the primary asset of rural families, receive timely, affordable, and effective care. In doing so, they protect livelihoods, enhance food security, and promote inclusive growth.

As India continues to depend on livestock for rural prosperity, WOTR's community-led Pashu Sakhi model offers a powerful pathway forward, where empowered women, healthy animals, and resilient communities grow together. ■

Article source and all images courtesy of: https://wotr.org. To help rural communities tackle climate change, write to: info@wotr.org

Drawing the Green Line

The Revamping of Indian Climate Finance Taxonomy

India's first Climate Finance Taxonomy promises to steer billions of dollars towards climate action. Designed as a guiding framework for investors and policymakers, the draft released in May 2025 laid down ambitious objectives. Yet, beneath the promise lie ambiguities that risk blurring the line between genuine climate action and greenwashing, write **Yukta Anand** and **Prof. Asheesh Pandey**.

In response to worsening climate risks and environmental degradation, the Department of Economic Affairs (DEA), under the Ministry of Finance, Government of India, came up with the draft of nation's first Climate Finance Taxonomy in May, 2025. A climate finance taxonomy refers to any document prepared to assist investors and policymakers in identifying and directing funds towards projects, initiatives and sectors that not only require capital but also align with a nation's environmental goals.

The European Union, China, the UK, and South Africa are among other governments to have introduced climate/sustainable finance taxonomies. India's draft taxonomy aims to support the country's 2030 and 2070 net-zero goals by facilitating a green finance corpus of around $250 billion annually. The document was also opened to the public for consultation and feedback until June 25, 2025.

A Living Framework for Climate Finance

The draft is intended to be a 'living document', implying that it is designed to evolve over time, remain adaptive to global developments and respond





to feedback received from various stakeholders. It relies on three key pillars—mitigation, adaptation, and transition of hard-to-abate sectors.

These pillars are sub-divided across multiple sectors and industries—power, agriculture, water, and food security, among others. Hard-to-abate sectors such as steel, iron, and cement receive specific attention due to their high emission intensity and limited decarbonization alternatives. The framework adopts a two-pronged methodology—qualitative, which outlines objectives and standards to classify an activity as climate-relevant, and quantitative, which translates these standards into measurable thresholds.

All projects and activities are classified into one of the two baskets—transition supportive and climate supportive. Climate-supportive activities are further divided into two tiers:

Tier 1: Activities that aim for complete avoidance of emissions or achieve significant reduction in emission intensity beyond a specified limit.

Tier 2: Measures that improve energy efficiency, especially in sectors where absolute avoidance of emissions is currently unfeasible.

Transition-supportive measures, on the other hand, aim at those activities or projects which enhance energy efficiency in the sectors where complete decarbonization is currently unfeasible.

Importance of the Taxonomy

The taxonomy lays down four objectives—supporting climate mitigation, strengthening adaptive capacity, enabling the transition of hard-to-abate sectors, and preventing greenwashing. Based on the premises of impact and credibility, the framework seeks to attract sufficient capital and gauge investment and innovation to help India progress towards its net-zero targets.

The taxonomy offers valuable insights for multiple stakeholders. For businesses, particularly those in construction, technology, and renewable energy, it opens up new avenues to access green finance at potentially lower costs. Meanwhile, the investors are provided with a much-needed framework to assess risk and align their portfolios with environmental objectives, enabling them to scrutinize projects seeking green funding. Similarly, international and domestic banks, along with other financial institutions, gain a screening mechanism to guide lending decisions. Regulators and government authorities can also use the taxonomy to harmonize green finance policies and regulations, creating a shared reference point across institutions.

Why the Taxonomy is Losing Momentum: Public feedback

Despite its intent, the draft taxonomy has drawn criticism on several

parameters. There exist multiple language overlaps in defining the criteria for different activities. The criteria for transition-supportive activities closely resemble those for Tier-2 climate-supportive activities, calling for further differentiation.

The framework mentions finance requirements mainly for allied projects and sectors, ignoring the financial needs of existing and emerging climate-friendly technologies required to attain the 2070 Net-Zero Vision. Moreover, the document disproportionately focuses on agriculture, leaving out key sectors such as energy generation, manufacturing, and transport, which require greater focus. Another major gap is the absence of a clearly defined governance mechanism to regulate the framework, creating a major loophole. Further, social dimensions—communities, livelihoods, and equity concerns that may be impacted by the proposed activities—are largely excluded.

Concerns of Global Investors

Principles for Responsible Investment (PRI), a UN-supported initiative, has flagged uncertainty in the draft's hybrid (quantitative and qualitative) approach which can reduce its objectivity and standardization. PRI recommends a clearer distinction between the two major activity categories and stresses that the metrics and objectives must be science and evidence-based.

Overall, the draft appears to follow a largely theoretical and borrowed approach, rather than one curated especially for India and its specific developmental, economic, and environmental realities.

Revamping the Taxonomy

The framework, mostly built on international taxonomies, should undergo a reconditioning to allow for clearer objectives that are not only science-based but also reflect the true scenario of India's economic situation. It should not be limited only to sector or projects but should also encompass climate-friendly technologies.

Rather than focusing largely on agriculture, the taxonomy should prioritize sectors where transition is the need of the hour. The draft could also look to inculcate extractive industries, enabling India to focus on low-carbon economic pathways, reducing exposure to price spikes globally.

The DEA should ensure that these metrics are periodically updated to provide for any global advancements in technology and allied fields through an internally benchmarked screening mechanism. Greater alignment is needed with existing as well as upcoming regulatory green finance frameworks coming from RBI and SEBI. They should also be in sync with the country's upcoming Carbon Credit Trading Scheme (CCTS). Lastly, the taxonomy must explicitly recognize the social relevance and impacts particularly in a diverse country such as India. Lessons could be drawn from South Africa and Indonesia, which have recognized investments to be made in rehabilitation and land repurposing.



Conclusion

The taxonomy, though marked by several gaps, represents a significant first step in mobilizing large-scale sustainable finance in India. It offers a promising foundation for supporting the country's net-zero ambitions. However, its success will depend on how effectively it reflects India's ground realities, clarifies its objectives and metrics along with its governance and scrutiny. With these measures in place, the taxonomy can emerge as a bedrock for the nation's green finance market and a blueprint for other emerging economies. ■

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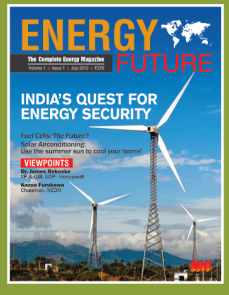
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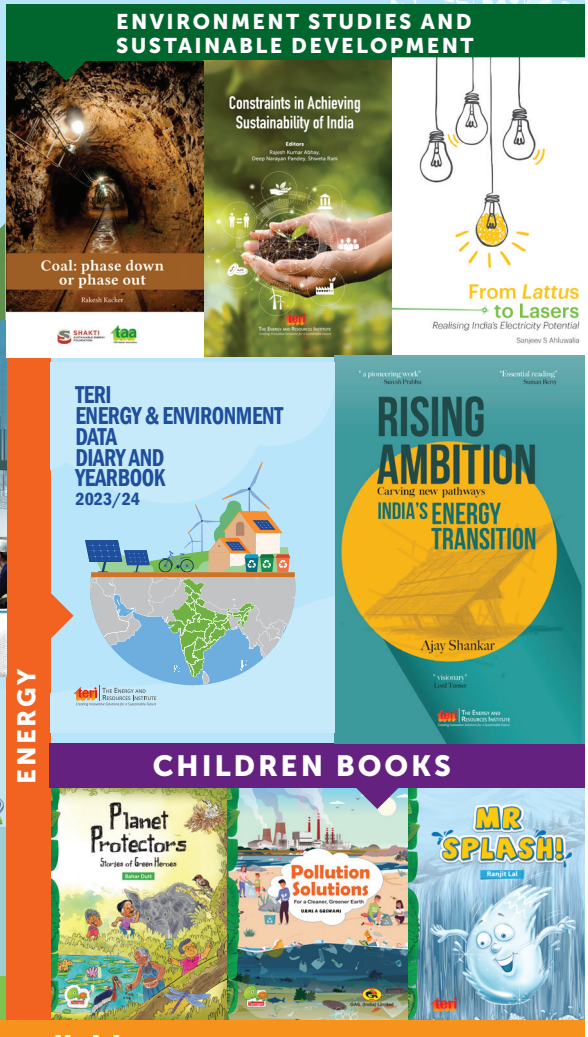
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