








CREATING IMPACTS, TRANSFORMING LIVES

SUCCESS STORIES FROM TERI









THE ENERGY AND RESOURCES INSTITUTE
Creating Innovative Solutions for a Sustainable Future

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BREAKING NEW GROUNDS IN ACHIEVING SUSTAINABLE DEVELOPMENT

Dear friends

At the outset I must submit that during a long journey of 50 years, The Energy and Resources Institute (TERI) has steadfastly pursued the path of ecological sustainability. It has brought a confluence of ideas and perspectives on moving the needle on climate change. Through its journey marked by innovation and research, TERI has developed frameworks, and policies and co-created sustainable solutions. Most importantly, I believe colleagues in TERI have worked with the conviction that inducing change is possible.

This core belief and unwavering commitment to the cause of sustainability has provided TERI with the strength to gallantly trod unfamiliar paths and create solutions for the common good. Adhering to the philosophy of *'Vasudhaiva Kutumbakam'*, which means 'the whole universe is one family', TERI's dedicated team of researchers has delivered impactful projects and demonstrated cleaner technologies addressing newer challenges of food, water, energy security, and sustainable habitats that have resulted in greater adoption of climate resilience and mitigation strategies.

In these five decades, the institute's exemplary work in the fields of energy, resources, economy, environment, agriculture, and sustainable habitat has gained attention and enormous support from independent funding agencies, bilateral and multilateral donors, and government bodies, consequently led to its credibility and co-creation of innovative solutions.

Like all great endeavours and successes, TERI's initiatives, too, have grappled with countless obstacles and extraordinary resistance. But with an unflagging spirit to innovate, expanding into new research areas and exploring new channels of outreach, the Institute could imaginatively chart a pathway towards creating a unique space for itself in the sustainability space. It is this resilience which fostered the growth of TERI into a dependable voice on climate change, cognizant of its responsibility to offer noteworthy solutions for the advancement of sustainable development aspirations.

TERI's approach to fundamental research has always set it apart. In fact, the Institute has taken special pride in doing pilot-scale testing on its own. Efforts are being made to ensure that our research work benefits the target segments and the society at large. It is a matter of pride for me to share that different divisions in TERI have toiled to develop cutting-edge technologies and taken these scientific solutions to the field. Ultimately, that is what, I believe, success stories are all about.

Creating Impacts, Transforming Lives is a collection of our work and innovation spanning five decades. These stories bring together TERI's pioneering work in the expansive realm of sustainable development. They highlight the visionary approach of TERI leadership

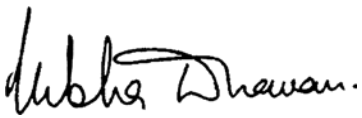
in establishing an institute which is dedicated to narrowing the gap between the haves and the have nots and enhancing their quality of life.

This rich collection of insightful stories fills me with pride and nostalgia. At the same time, it instills in me the courage to work more with my colleagues in carrying forward our legacy and taking it to newer heights.

In line with our forward-looking approach, TERI is committed to encouraging young researchers in developing solutions for the challenges the world is poised to face in the coming decades.

Looking ahead, TERI will continue to raise awareness about sustainability in our community, motivating new generations of scientists, and working to reduce environmental impact on our shared planet.

I hope, *Creating Impacts, Transforming Lives* will leave the readers inspired to take bold steps towards more sustainable practices no matter how small. That is what is needed in this battle against climate change—increasing numbers of people joining the cause to protect our planet, an encouraging sign of hope indeed.



Dr Vibha Dhawan
Director General
The Energy and Resources Institute (TERI)

CHAMPIONING THE GREEN ALTERNATIVE

Sustainable Development, an accepted development paradigm today, had few takers in the 1970s. Presented as a solution to the problems of environmental degradation, the concept grew in relevance as human bullishness towards economic and social development proliferated. Not many understood its deeper and lasting repercussions. The founders of The Energy and Resources Institute (TERI), however, were among those who did.

At a time when geopolitical tensions of the Cold War rippled through the world, JRD Tata and Darbari Seth laid the foundation of TERI to mainstream sustainability in India and the Global South. It all started when Seth, at the age of 54, became concerned about the unprecedented energy spent on desalination and in preparation of caustic soda in his factory located in Mithapur, Gujarat.

As the Chairman of Tata Chemicals, he decided to do something to address the problem of energy efficiency. He discussed the idea with JRD Tata. It resulted in TERI, which was established as Tata Energy Research Institute in Delhi in 1974.

In its fledgling days, TERI concentrated on documentation and information dissemination activities before entering the research domain towards the end of 1982. The institute quicky broadened its reach from the field of energy to environment, biotechnology, climate change, forestry, transport, habitat, and a whole range of sustainable development issues.

The rapid expansion of TERI during the 80s and 90s was largely due to the passionate and visionary leadership of Dr Rajendra Kumar Pachauri. A skilled administrator, he shepherded TERI in the backdrop of growing international discourse on climate change.

Sweeping narratives targeted the Global South for the rising greenhouse gas emissions. Its countries felt pressured to take obligations under the world climate regime. What they needed was a robust climate change policy to mitigate and adapt to its effects, without crushing their developmental aspirations. Understanding its role in supporting the interest of these countries, TERI emerged as a leading advocacy group, strengthening the voice of the Global South in raising the ambition for meaningful climate action.

In due course, the institute conjured up a slew of achievements by establishing varied partnerships and collaborations with governments, multilateral organizations, philanthropic entities, and corporations. From providing solutions to rural energy problems to addressing global climate change issues to enhancing forest conservation efforts among local communities and promoting energy efficiency in the Indian industry, TERI was in forefront in providing innovative green alternatives.

Dr Pachauri's election as the Chairman of the Intergovernmental Panel on Climate Change (IPCC) brought international attention to the pathbreaking work of TERI. It was under his leadership, the IPCC was awarded the Nobel Peace Prize in 2007 and delivered the *Fifth Assessment Report*, the scientific foundation of the Paris Agreement.

The untiring efforts of Dr Pachauri and TERI researchers spawned a spate of successful offerings which brought a perceptible change in the lives of people. It established an enduring legacy of this premier institute which is relentlessly nudging the world towards a sustainable future.

This ingenuity and resolve of TERI researchers in developing innovative solutions became an inspiration to compile *Creating Impacts, Transforming Lives*. Designed in a coffee-table format, the publication is an attempt to bring vividness to their remarkable initiatives.

From illustrating life-changing initiatives such as Lighting a Billion Lives to groundbreaking technologies of Oil Zapper and TADOX to TERI's contribution in framing India's National Action Plan on Climate Change (NCAP), and conceptualizing Clean Developing Mechanism (CDM) to developing the green-housing rating system in GRIHA, to tracking over two-decade long journey of institute's flagship event, the World Sustainable Development Summit (WSDS), the book brings together an exhaustive range of TERI's work, cutting across various disciplines.

As the institute gears up for its 50th anniversary, a lot has changed since it took its first step in the realm of sustainable development. Climate change is no longer a debatable topic; it is a grim reality that has seeped into our everyday lives. Since its origins in Brundtland Commission report, sustainable development has graduated to a clear-cut framework. Today, it is being aggressively pursued and integrated in our national policies.

The concept, though, remains a utopian dream for many. However, as these collection of stories elucidates, sustainable development has the potential to break through the theoretical trappings.

For TERI, the task in the coming years is well outlined and arduous, too. As it begins its journey from 50 years onwards, the institute will be extending its reach in resolving challenges to sustainable development.

We hope while traversing the rocky terrain of sustainable development, *Creating Impacts, Transforming Lives*, will become the guiding light in inspiring actions for a cleaner and greener tomorrow.

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Sustainable Agriculture

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TRANSFORMING KAMRUP THROUGH WATERSHED MANAGEMENT

Watershed development in India has played an important part in improving agricultural production and alleviating poverty in rainfed regions. It meets several Sustainable Development Goals (SDGs) like improvement in agricultural output, food security, elevation in status of women, better health outcomes, and sustainable economic development through community participation.

Currently, as per a report rainfed agriculture accounts for 55% of the net sown area (139.42 Mha), and 61% of India's farmer population. It accounts for around 40% of the total food grain production; supports two-thirds of livestock and 40% of the human population. It impacts the livelihoods of 80% of small and marginal farmers.

The same report states that crop diversity in rainfed regions is striking with almost 34 major crops grown annually compared to 4 to 5 major ones in irrigated areas. However, India's rainfed regions are characterized by complex climatic challenges, unreliable rainfall, and dry spells at critical growth stages, leading to water scarcity for rainfed crop production.

A watershed is a catchment area through which streams, tributaries, and rainfall drain out to a common point. An effective management of water, land resources, soil, and biodiversity surrounding the catchment area brings enormous agricultural and economic benefits in rainfed areas.

Integrated watershed management provides a solution in enhancement of crop productivity through various soil- and water-conservation methods including check dams, while boosting groundwater and allowing other economic activities in the vicinity.

Bringing the people of Kamrup together

Success of any watershed project and its sustainability depends on people's participation.

Assam's Kamrup district went through a transformation after TERI implemented a watershed management project, addressing the issues of sustainable socio-economic development of the community in the watershed area and peripheral villages.

The project sponsored by CAPART (Council for Advancement of People's Action and Rural Technology), Ministry of Rural Development, Government of India covered six revenue villages in Dimoria Block, Kamrup district of Assam. The project started in 2004 and aimed to develop an area of approximately 1500 hectares.

The main objectives were to promote economic development of the community that were directly or indirectly dependent on the watershed through effective utilization of the natural resources like land, water, grass, forests, etc. The project was aimed to generate employment and boost the economy of the villages through sustained community action in the watershed region. The focus was on soil and water conservation through different methods along with biomass conservation approaches. Capacity building and community mobilization were also needed considering the sustainability aspect.

Under the project, water-harvesting structures like farm ponds, diversion weirs, check dams, concrete irrigation canals and earthen canals were developed to facilitate conservation and utilization of water for agricultural purposes.

Building check dams

Soil erosion due to rainwater runoff was severe in the area and impacted water-conservation and management efforts within the watershed area. All land-based productive activities largely depend on terrain of the area, soil type, available biomass, and water and require an integrated management approach. Therefore, it was important to tackle environmental degradation effectively for the holistic development of the watershed by adopting a systematic approach for resource conservation and management along with strategy to address the issues of human development.

Water flowing through the natural perennial stream flowed down towards the tail end of the watershed. In spite of having water in the stream, upper and middle reaches of the watershed got less water for crop cultivation and as a result crop productivity was less. Moreover, double cropping was not possible due to lack of mechanism to regulate water.

Under the community-based integrated watershed conservation and management programme location, specific check dams were built to regulate water which resulted in recharging of groundwater level. The check dam regulates the amount of rainwater flowing into the crop fields, allowing crops to receive optimum level of water necessary for growth as well as recharge groundwater to facilitate double cropping.

Holistic development

This resulted in an increase in both surface and groundwater and second crop area increased by 20-25% over the baseline situation and year-round access to drinking water due to increase in groundwater table. There was an improvement in soil moisture regime, which enabled sowing of crops for at least two seasons.

Apart from these open wells, vermicomposting units, mixed horticultural gardens, kitchen gardens, crop demonstrations were also undertaken. The project covered a total of 1402 direct beneficiaries of which 954 were male and 448 were female and generated 13,423 man-days amounting to direct benefit of Rs 16.54 lakh due to execution of various activities of the project.

The efforts bore fruits in many ways. It helped communities acquire skills in soil and water conservation. There was an increase in biomass and horticultural tree species plantation on individual land within the watershed. Besides the environmental benefits, it brought village communities together in taking responsibility for their natural resources. Women played a key role in the decision-making process.

Overall, the projects stand out as a fine example of sustainable development in rainfed areas deriving holistic development and economic benefits for farming communities.

LAB-TO-LAND TISSUE CULTURE TECHNOLOGY BORE FRUITS FOR NORTHEAST STATES

Plant diseases cause significant losses in yield and income. Plants are constantly faced with biotic or abiotic stress, which impacts their growth and development. Conventional propagation methods impact quality and make plants vulnerable to fungal infections and pest infestation. In that respect, tissue. culture technology is a viable option that can enhance agricultural productivity and food security.

Micropropagation is a technique of producing identical plants by culturing plant tissues or organs under sterile conditions which is a more effective way of producing high-quality planting material of various species within a short period of time. This is done by selecting elite genotypes from the natural population of a species and culturing them under germ-free conditions to produce millions of identical plants.

The benefits have been multifaceted—greater output, economy of time and space, freedom from seasonal constraints, clone uniformity, and disease-free nature of the regenerants.

Introducing tissue culture technology

The Department of Biotechnology (DBT), Government of India, launched a mission in January 2008 for Northeast states, making available quality planting material in the region, which produced great results.

The 'DBT Mission for Quality Planting Material Production and its Utilization in the North East India' was undertaken by TERI's Northeastern Regional Centre. The programme was executed in eight northeastern states with one partner institute in the eight states—Manipur-IBSD, Imphal; Assam-TERI, Guwahati; Mizoram-Mizoram University; Meghalaya-North-eastern Hill University, Shillong; Arunachal Pradesh-Rajiv Gandhi University; Sikkim-NRC for Orchids and Sikkim Council of Science and Technology; Nagaland-Nagaland University; and Tripura-Tripura Biotechnology Council each for implementation of the programme. TERI's Northeastern Regional Centre was the Project Monitoring Unit for DBT.

The project envisaged availability of quality planting material produced either by tissue culture (TC) or other vegetative means from the selected quality mother stock of a variety of horticultural crops such as banana, black pepper, cashew nut, citrus, edible bamboo, kiwi, large cardamom, orchids, strawberry, etc.

Under the project, 95 polyhouses and shade areas were developed. About 1.773 million superior quality planting material of banana (Malbhog, Amrit Sagar, Sabri, Meitei Hei, Mizoram Cavendish and Grand Naine), black pepper, cashew nuts, citrus (Khasi & Sikkim Mandarin), Cymbidium, edible bamboo (Dendrocalamus asper), large cardamom, strawberry, etc. were produced and planted across the region.

The efficacy of the technology was demonstrated in an area of 1147.881 hectares for 10 different horticultural crops covering 2376 direct beneficiaries.

As a part of capacity-building initiatives, 107 capacity-building programmes were conducted on different aspects of plant propagation, crop production and management covering 4718 beneficiaries.

Demonstration plots at farmers' fields helped in refining the strategy for transfer of technologies from lab-to-land which created a positive impact among the farming community. Seeing the benefits of the project, farmers in other areas were also encouraged to use the technology.

Earlier, the availability of quality planting material was a challenge for the farmers involved in banana cultivation. Farmers depended on conventional suckers from various places. This imposed certain restrictions. Besides, farmers had to face the risk of ending up with infected suckers that resulted in yield losses. Such constraints were overcome by planting tissue culture quality planting materials.

The main objective of the project was to cultivate bananas with quality planting material and demonstrate the benefit of tissue culture plants. This would also help in improving the socio-economic condition of farmers through employment generation and added income.

Greater yield, more income

The average yield for Grand Naine and Malbhog banana were about 18 kg and 14 kg per plant. However, Bora obtained an average yield of 22 kg and 16 kg per plant, with a total yield of about 55 tonnes for Grand Naine and 40 tonnes for Malbhog cultivars. The secret to his success was the use of TC-propagated plantlets produced from quality suckers collected from elite mother plants and adoption of good management practices.

Bora said farmers know best about the planting and harvesting time, but they need help with obtaining quality planting material, manuring schedules, insect-pest, and technical knowledge in disease management.

With technical advice and timely supply of planting material coupled with good management practices, farmers of the region could increase their production and income for socio-economic upliftment.

Bora was able to earn Rs 115,000 from his 1800 banana plantation per season. He was the first person who could earn money from TC banana plantations in the area, inspiring other farmers to also join the practice after witnessing the demonstration plots. Farmers of Azara and nearby areas, too, opted for the technology. The project helped to promote scientific cultivation of TC bananas and gave confidence to the community through performance evaluation at fields.

TERI'S UNIQUE NANO-FERTILIZERS FOR CLIMATE-SMART AGRICULTURE

The use of chemical fertilizers and pesticides has given a tremendous boost to Indian agriculture production, making the country self-resilient in feeding its large population. However, the current agricultural practices are dependent on imbalanced use of fertilizers which are neither sustainable nor aligned to climate goals.

Chemical fertilizers have deteriorated soil to such an extent that for a similar yield, farmers are now required to apply more fertilizers than in the past. This phenomenon is known as 'reduced nutrient use efficiency (NUE)', which is affecting soil, groundwater, and costs more money to the farmers.

The alarming situation calls for an overhaul of agricultural practices, and a change in the focus of policymakers, farmers, and industries. Alternative to the subsidy on agri-inputs, investments should be made on public goods such as extension to help farmers in better utilization of fertilizer to improve the NUE.

TERI in forefront

The Indian Government through the PM-PRANAM scheme is promoting development of alternative fertilizers, particularly the nano-fertilizers, to support agricultural soil and farmer communities.

TERI is in the forefront in introducing these changes. Realizing the need of 'nano intervention in agriculture', TERI approached the Department of Biotechnology, Government of India, for funding Centre of Excellence for Advanced Research in Agri-nanotechnology in 2018.

A big budgeted CoE project, amounting to Rs 15 crore, was granted in 2019 for end-to-end development of nano-micronutrients. This enabled the capacity and infrastructure development for research and development in agri-nanotechnology.

The same year, TERI was made the nodal agency for drafting the 'Indian guidelines' for nano-agri inputs and nano-products. The guidelines were

published in 2021 and developed for the evaluation of safety and efficacy of nano-fertilizers and nano-pesticides, nano-carriers for targeted delivery and nano-food. The Ministry of Agriculture adopted them for the approval of nano-fertilizers.

Unique nano-fertilizers

TERI's Biogenic Nano-fertilizers are extremely efficient fertilizers that provide nutrients to crops through clusters of nano-particles encapsulated in biomolecules, that have very high-surface area to volume ratio. A substitute to conventional fertilizers, nano-fertilizers can reduce the requirement of conventional nitrogen and phosphorous fertilizers by 25-50% in agricultural fields.

Since they are required in a small amount, farmers can reduce the dose of conventional fertilizers and yet attain higher yield benefits along with improvement in soil structure and soil microflora that support plant growth promotion activities. They are beneficial to crops, rejuvenates soil, and reduce the impact of climate change.

These fertilizers are quickly absorbed by plant surfaces and therefore NUE is 90-100% against 20-40% of conventional nitrogen, phosphorus, and potassium fertilizers. With unique optical and electrical properties, nano-fertilizers can also enhance photosynthesis.

The nano-fertilizers produced by TERI are synthesized using a biological process—not chemical synthesis process—that makes them highly efficient and safe in comparison to the other nano-products. The biological process includes identification and adaptation of microbes under laboratory conditions to perform a particular kind of activity when cultured in fermenters. Here the activity is conversion of bulk material into nano-materials.

Till date, TERI has developed three nano-fertilizers—nano-Urea (from conventional urea), nano-DAP (from conventional DAP) and nano-Phosphorus (from low-grade rock phosphate).

Nutrient dense

A matrix of biological molecules released by microbes during the bio-fermentation process surrounds the nano-particles developed by TERI. The biological matrix acts as a carrier for the nano-particles of urea, DAP, and phosphorus, that provide them with slow-release properties and keep them stable under unfavourable environmental conditions.

Such protected nano-fertilizers show better availability of nutrients for a much longer duration in comparison to the burst release seen in case of bulk fertilizers. The biological matrix also makes the interaction of nano-particles with plant surfaces more friendly as compared to the chemically developed nano-particles, which leads to their quick absorption in various tissues and sub-cellular compartments of plant parts. As such the biological synthesis is a green, economic, and easily scalable process with minimum carbon footprint.

Owing to their innocuous nature, researchers largely agree with the use of these nano-fertilizers for organic farming. Application of TERI's nano-fertilizers have reduced demand of chemical nitrogen and phosphorus fertilizers by 25-50% in different cropping systems and agro-ecological zones, while not disturbing the ecosystem. It has enhanced the yield by 8-25% in various crops such as grains, vegetables, millets, pulses, and cotton.

Support from public and private sectors

TERI's claims for the three nano-fertilizers are supported by extensive field efficacy tests carried out by renowned ICAR institutes and state agriculture universities, including Punjab Agricultural University (PAU), Haryana Agriculture University (CCS HAU), University of Agricultural Science,-Bangalore (UAS Bangalore), UAS Dharwad, ICAR-Indian Institute of Rice Research Hyderabad (IIRR), Indian Institute of Pulse Research Kanpur (IIPR Kanpur), Indian Institute of Oil Research (IIOR Hyderabad), Indian Institute of Wheat and Barley Research Karnal (IIWBR Karnal), ICAR-Indian Institute of Seed Science Regional Station, GKVK Campus, Bengaluru, and trials at many Krishi Vigyan Kendras (KVKs) and farmers' fields across several states of India.

Both public and the private sectors have joined hands with TERI to take the initiative forward. Zuari FarmHub Ltd has collaborated with TERI for nano-Urea and nano-DAP nano-fertilizers' development and technology transfer in 2021-22. Chambal Fertilizers and Chemicals Ltd tied up with TERI for marketing nano-Phosphorus.

In 2023, DCM Shriram collaborated with TERI for technology transfer of nano NPK nano-fertilizers.

TERI's products are being launched by commercial partners, Zuari Farm-Hub Ltd and Chambal Fertilizers and Chemicals Ltd. These products are backed with the approval of the Department of Agriculture, Government of India and marketed as Nano Shakti: Nano Urea, Nano Shakti: Nano DAP, Uttam Pranam: Nano Phosphorus, and Nano Power: Nano Urea.

UTTAM SUPERRHIZA: TERI'S PERFORMANCE ENHANCING GREEN BIO-FERTILIZER

Increased agricultural activity and excessive use of pesticides and chemical fertilizers have severely impacted productivity and fertility of land. A food-stressed world is grappling with drastic changes in soil health, biodiversity losses, water retention, and disturbance in bio-geochemical cycles.

The agriculture sector continues to play a vital role in India's socio-economic development. It remains the principal source of employment, with 45% of the workforce engaged in agricultural and allied activities. However, growth of the agriculture sector has led to the unsustainable use of natural resources like land, water and biodiversity, spread of insects and pests, indiscriminate use of agro-chemicals and adverse impact on ecology and environment.

Biofertilizer, is an alternative to chemical fertilizers that contains living or dormant microorganisms and promotes the growth of plants by supplying nutrition by natural processes. It leads to improvement in plant yield, improves soil health, and reduces environmental pollution.

Launching Uttam Superrhiza

The Sustainable Agriculture Mycorrhizal Research team at TERI has been successful in harnessing the native, beneficial microbial interactions in soil and developing a superior, functionally advanced mycorrhiza biofertilizer product.

The biofertilizer 'Uttam Superrhiza' was launched in India in July 2022 by Chambal Fertilizers and Chemicals Ltd. It is a disruptive product in the biofertilizer category not only due to its pure and efficacious mycorrhizal bio-input but also because it carries its naturally associating soil-partner bacteria.

The unique granular product is powered by TERI's *in vitro* P.E.G. Technology of Performance Enhancing Green Biologicals. Superrhiza is an innovative growth promoter technology, providing native, synergistic microbiota to enhance mycorrhiza performance in field conditions.

TERI's mycorrhizal technology is an outcome of the Institute's long-standing research using diverse soil microbes and commitment to combat climate change and achieving sustainability in agriculture.

Mycorrhiza-based biofertilizers are a natural alternative to chemical fertilizers. It helps in promotion of plant growth in an environmentally friendly manner as well as providing several other benefits to cultivation of plants. TERI's In Vitro Mass Production Technology offers the commercial production of viable, healthy, genetically pure, and high-quality mycorrhiza without contamination in a sterile environment using little space.

Contributing to sustainable agriculture

Superrhiza was developed to enhance the quality of mycorrhiza products existing in the market.

Additionally, it uses the natural soil microbial biodiversity to improve the soil quality in the longer run. Use of this fertilizer allows efficient use of water and plant nutrients, positive impacts on soil microflora, improves soil health and structure and benefits an environmentally stressed land.

Superrhiza is also compatible with chemical fertilizers such as urea, DAP, potash, compost, and organic manure, with the formulation being stable at room temperature for at least two years. This product supplements the recommended doses of chemical fertilizers (RDF) to provide superior results on agriculturally relevant plants. However, the field trial results indicate that it can also substitute ~20-25% of RDF.

Produced in a contamination-free environment, Superrhiza is enriched with natural mycorrhizal partner bacteria that form a biological film around the mycorrhiza. This provides Superrhiza a unique edge over other mycorrhiza products in the market. It delivers soil nutrients more effectively to a wide variety of plants and across different types of soils, thereby contributing towards sustainability in agriculture and combating changing climate patterns.

One of its kind

It is one-of-a-kind advanced mycorrhizal biofertilizer bioformulation which contains its native microbiome bacteria in addition to mycorrhiza with a unique mix of microbial stimulants finely coated onto bentonite granules for easy handling. This gives superior performance and re-establishment of the natural plant-microbe interactions once applied in soil, thus creating multiple short-term and long-term positive soil impacts on plant health and nutrition.

The soil quality is improved through the solubilization and availability of otherwise chelated or complex macronutrients, thereby restoring and enlivening the soils. Additionally, the biological health of soils also shows significant improvement due to more recruitment of soil beneficial microbes and defence from pathogenic microbes.

Superrhiza provides benefits to a variety of crops such as wheat, rice, maize, pearl millet, sorghum, sugar cane, chickpea, potato, and cotton; vegetables such as okra, tomato, capsicum, eggplant, etc.) and plantation crops like chilly, spices, pulses, oilseeds. Horticulture and ornamental plants also benefit by Superrhiza through nutrient uptake (macro and micronutrients) leading to augmented nutrient levels, disease-resistance, improved abiotic stress response to ensure plant growth in drought, and increased product yield.

In the first season of its launch in July 2022, Superrhiza fertilized 450,000 acres of agricultural land from August 2022 to March 2023. The testimony of the acceptance of the product by the farmers and market can be gauged by the fact that in the period from April 2023 to March 2024 the fertilizer was used in ~1,000,000 acres of agricultural land across different states and multiple crops.

Farmers across India have found an overall increase of 10-15% in plant productivity across different crops such as wheat, rice, maize, onion, fenugreek, chickpea and cotton from. Individually, their observations have been "robust root system with more root hair, increased grain filling, better response in fluctuating environments (such as unexpected heavy rainfalls), increased plant height, and root biomass (10-22%), early harvesting from plants which allowed farmers to take their produce earlier than others to the market."

Superrhiza also helped the farmers reduce the chemical fertilizer input by up to 30% while providing the benefits in productivity, thereby saving money for the farmers.

The huge success of the product has brought awards and laurels for TERI's research team. Uttam Superrhiza was named winner of 'International Product of the Year 2023' by Applied Microbiology International, United Kingdom. This prestigious prize recognizes a commercial product derived from microbiology research, with special consideration given to those products that have addressed the United Nations Sustainable Development Goals.

Market Research Firm Spherical Insights & Consulting have mentioned Uttam Superrhiza as a one-of-a-kind granular product powered by TERI's *in vitro* P.E.G. Technology, in their *Report on Global Biofertilizers Market* (March 2023, Report Id SI1568). "This is a remarkable growth promoter technology that provides native biological inputs to supplement mycorrhiza performance for synergistic effects and superior field performance."

The product has attested TERI's path-breaking contribution in research and innovation.


Uninoculated control-grown without additional supplementation of microbes


Treated with Superrhiza

Climate Change

- CONCEPTUALIZING CLEAN DEVELOPMENT MECHANISM
- ENVISIONING INDIA'S NATIONAL ACTION PLAN ON CLIMATE CHANGE
- SUPPORTING INDIA'S CLIMATE CHANGE NEGOTIATIONS
- MODELLING MITIGATION PATHWAYS FOR INDIA

CONCEPTUALIZING CLEAN DEVELOPMENT MECHANISM

Climate change is a wicked problem. One of its most robust manifestations is the rift between developed and developing countries who differ in terms of their historical contributions to the cumulated greenhouse gases (GHGs) emissions, in their technological and financial capabilities in addressing the problem, and their vulnerabilities to climate change.

The terms of cooperation between developed and developing countries are fraught with questions of climate justice, equitable burden sharing, and economic competitiveness. Finding innovative mechanisms that address the concerns of both developed and developing countries remains extremely challenging.

In this context, the use of market-based flexibility mechanisms is presented as innovative and attractive solutions for developed countries in achieving their obligation for quantified emission reduction.

The Clean Development Mechanism (CDM) has become a central pillar of climate policy in facilitating exchange-based cooperation between developed and developing countries.

Delhi Workshop: brokering the deadlock

After the celebrated adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, the interim period till the first Conference of the Parties to the UNFCCC (COP-1) in 1995 was a period of apprehension as well as innovation in global climate policy.

The negotiations leading up to the adoption of the UNFCCC, where India took lead in developing first draft of the framework convention text, made it clear that early action and forward thinking was essential for safeguarding the interest of developing countries in the future global climate governance architecture.


O_2
CO_2
CARBON CREDIT

In early 1992, there felt a need for an 'operations manual' for joint implementation. The initial response came in the form of a policy note *The Climate Convention: criteria and guidelines for joint implementation* published by CICERO with lead contributions from TERI and scholars from Germany and the Netherlands for the benefit of delegated negotiating the architecture of the UNFCCC.

This was followed by the first technical workshop organized by TERI and CICERO from July 1–3 1991 on possible innovative instruments for implementing the provisions of the UNFCCC, particularly relating to the role of developing countries, keeping in mind the principle of equity in accordance with the common but differentiated responsibility.

The workshop produced a report *A Comprehensive Approach to Climate Change: additional elements from an interdisciplinary perspective* for the benefit of negotiators developing the architecture of the UNFCCC.

It was forward looking in its agenda and eventually built ideas that brokered the deadlock during the COP-3 negotiations, leading to the Kyoto Protocol in 1997.

Design of CDM foretold

The foundational ideas of CDM were explored during a workshop that TERI and CICERO had organized in New Delhi on January 21-23, 1994, titled 'Joint Implementation of Abatement Measures under the FCCC'.

It aimed at exploring operational aspects of the Joint Implementation mechanism. The workshop report *What Might be Minimum Requirements for Making the Joint Implementation Under the Climate Convention Credible and Operational* listed many key issues that provided foundation for the design of the CDM. Issues such as baseline definition, additionality of emission reductions, and reporting and verification, were elaborated upon.

This early work not only shaped the debates on design aspect of the CDM but continues till date to serve as a framework, a collective memory of climate policy making, guiding the implementation of Article 6 of the Paris Agreement.

ENVISIONING INDIA'S NATIONAL ACTION PLAN ON CLIMATE CHANGE

Since the beginning of global environmental debates, particularly during the climate change negotiations, India has strongly advocated for prioritizing social and economic development of developing countries. This is embedded in the Article 4.7 of the United Nations Framework Convention on Climate Change (UNFCCC).

The *Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC-AR4) had conclusively determined the empirical evidence of climate change and warned with confidence of its negative impacts.

In that context, adaptation to climate change while taking actions to avoid greenhouse gases (GHGs) emissions becomes inevitable for developing countries. Integrating such a climate strategy into the developmental aspirations and strategies at national level, therefore, became a central policy question in pursuit of sustainable development.

TERI's technical study informing the NAPCC

The central dilemma that all countries have faced ever since the recognition of climate change as an inevitable policy problem is the difficult navigation through the multi-layered trade-offs between developmental needs/aspiration and climate action.

It was only expected therefore that India was reluctant to take any absolute obligations under global climate regime.

Yet, it needed to find an innovative solution to the impending crisis, environmental as well as developmental, posed by climate change. The framework of such a development strategy is provided by the National Action Plan on Climate Change (NAPCC) for India.

The Prime Minister's Council on Climate Change, in its first meeting on 13 July 2007, had decided that "A National Document compiling action taken by India for addressing the challenge of climate change, and the action it proposes to take" be prepared.

Such a document was expected to provide the basis for preparing national action programmes to address effects of climate change as per the Article 4.1(b) of the UNFCCC.

Later, at the 13th Conference of the Parties to the UNFCCC (COP-13) in 2007 held in Bali, the Bali Action Plan was adopted which included a negotiating track on long-term cooperative approaches, including a shared vision, for a comprehensive legal instrument for effective implementation of the UNFCCC post-2012.

It is in this background, the Government of India tasked TERI to prepare a detailed technical note. This note provided the background to the drafting of the National Action Plan on Climate Change (NAPCC) and was submitted to the Prime Minister's Council on Climate Change along with the draft NAPCC for consideration at a meeting held on 2 June 2008.

In fact, the NAPCC, drew to a great extent from a technical study that TERI conducted for the Government of India.

Comprehensive overview on climate change impacts

The study conducted by TERI provided a comprehensive overview of the scientific findings on climate change with specific reference to possible impacts on India. It also documented examples of adaptation and mitigation interventions already in place then as part of India's development planning.

These examples provided a convincing illustration of how the 'co-benefits' approach may be adopted to address climate change while pursuing the overriding developmental priorities. Taking the assessment a step further, the study identified six national programmes on adaptation and mitigation each, in addition to emphasizing the need to strengthen climate science research in India.

The adaptation programmes covered interventions in agriculture, forestry, disaster management, water, coastal zones, and health sector. The mitigation programmes included interventions in residential and commercial buildings, agriculture and forestry, industry, transport, power generation, and solid waste management and recycling.

Mitigation interventions in the power generation were emphasized for the importance of alternative sources of power for India's energy security and industrialization. The expectations from the multilateral process on global climate governance were also articulated for meaningful implementation of these programmes.

Standing the test of time

Today, it is almost taken for granted that the co-benefits approach as articulated in the NAPCC and its 8 national missions are the foundational pillars of India's climate policy. These 8 missions focusing on solar power, industrial energy efficiency, sustainable habitat, water, Himalayan ecosystem, forestry, sustainable agriculture, and strategic knowledge for climate change, have their roots in the 13 programmes identified in the technical study conducted by TERI.

In fact, the Long-Term Low-Carbon Development Pathways that India submitted to the UNFCCC in 2022, 15 years after the NAPCC, do not deviate in any substantial manner from the recommendations of the technical study conducted by TERI then.

Furthermore, India's missions on solar power and industrial energy efficiency are among the most influential transition programmes for many countries in their pursuit of long-term transition to net-zero emission economy.

SUPPORTING INDIA'S CLIMATE CHANGE NEGOTIATIONS

India has played an influential role in the evolution of global climate regime since beginning. It was backed by a rigorous ideation, technical research, and scrutiny of positions taken by other Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

Keeping track of latest scientific developments as well as ideas emerging for the future governance of climate change required skilled human resources. The then Ministry of Environment and Forests (MoEF) had limited staff available compared to the quantum of work involved.

Through a decade-long proactive engagement on issues relevant to global climate governance, TERI had built a strong team of skilled, experienced researchers. It was an obvious choice for the MoEF to engage TERI for filling the human resource gap.

Providing technical support

With the Marrakech Accord in 2002, when the rulebook for the CDM was finalized, the designing of the implementation structure of the Kyoto Protocol was completed. The commitment period for the developed countries to reduce their emission reductions under the Kyoto Protocol was 2007-12.

However, the USA had withdrawn from the Kyoto Protocol. Given that the USA was the leading contributor to greenhouse gas (GHG) emissions, both in terms of stocks and flows, it was evident that the Kyoto Protocol was rendered an inadequate legal instrument for full and effective implementation of the UNFCCC.

The negotiations for an additional legal instrument were on horizon. Political and economic circumstances had also changed since the early negotiations on climate change, due to economic growth of major developing economies, including India. An increased direct targeting of China, India, Brazil, and South Africa was expected, pressurizing them to commit to mitigation commitments.

A number of technical proposals emerged from the developed countries, primarily by the research organizations based out of developed countries, suggesting mitigation targets for developing countries. Also, as per the Kyoto Protocol, negotiations on a global climate regime for the commitment period after 2012 were to commence from 2005 onwards.

It became critical that more rigorous assessment directly aligned with key issues in negotiations (KIN) was conducted keeping in mind the fundamental principles of India's negotiating positions: historical responsibility, equity in accordance with the common but differentiated responsibilities and respective capabilities (CBDR&RC), equal per capita emissions, overriding priority to social and economic development, and climate actions conditional upon technology, finance, and capacity-building support.

Recognizing the role TERI's technical research had played in informing negotiations leading to the framing of the UNFCCC and subsequently elaborating on the mechanisms of the Kyoto Protocol, particularly the Clean Development Mechanism (CDM), the MoEF engaged TERI for providing technical backstopping support in drafting position papers, responses to submissions by other Parties, and technical notes to support India's position on various agenda items.

During 2003-09, through this project TERI was integral to India's preparation for climate change negotiations.

Towards and beyond Bali Action Plan

The project titled Key Issues in Negotiation (KIN) commenced in 2003 and continued till 2009 till the Copenhagen Conference. This period saw many difficult negotiations on a number of issues from the scope of post-2012 global climate regime, mitigation action in developing countries, mechanisms for mobilizing finance and disbursement, technology transfer, equitable burden sharing and distribution of the available carbon budget among countries, sectoral approaches to global carbon trading, and so on.

In the hindsight the project contributed to the negotiations leading up to the adoption of the Bali Action Plan (BAP) in 2007 and issues emerging from it. The BAP outlined the scope of a legal instrument for long-term cooperation action for the full and effective implementation of the UNFCCC with five pillars: a shared vision, mitigation, adaptation, technology, and finance.

TERI reviewed numerous proposals submitted by different countries, scrutinized them for their differences or compatibility with India's negotiating position substantiated by technical assessments, and advised the government on probable course of action for consideration.

For example, developed countries insisted on including mitigation actions by developing countries. Scrutiny of these proposals led to an articulation which qualified the mitigation actions with a prefix 'nationally appropriate' following by conditionality of them being supported by developed countries with technology and finance.

Similarly, a comprehensive assessment of technological needs and barriers to accessing clean technologies formed India's submission of the technological mechanism which was eventually adopted as a formal submission from the G77+China.

Laying ground for new frameworks

The years of negotiations aligned with the KIN project turned out to be the most contested, yet formative years that eventually shaped the architecture of the Paris Agreement. Although, the Copenhagen COP in 2009 failed to meet the objective of delivering on the BAP agenda, positions taken by India with technical support from TERI were instrumental in providing an early characterization of the financial mechanism and technology mechanism that evolved in the form of the Green Climate Fund (GCF) and the Climate Technology Centre and Network (CTCN), respectively.

These mechanisms were agreed as part of the Copenhagen Accord and subsequently adopted by the COP held in Cancun in 2010.

The insights gained by the TERI team through this project, also led to a study developing a framework of determining national appropriateness of mitigation action, which was included as part of the capacity-building programme by the UNFCCC Secretariat for the developing countries in the Asia-Pacific region.

MODELLING MITIGATION PATHWAYS FOR INDIA

There is no escaping from taking greenhouse gases (GHGs) mitigation action to avoid disastrous impacts of climate change. The challenge, however, is in integrating GHGs emission reduction solutions into the development process, particularly the energy sectors.

Besides availability of mitigation technologies, it is the cost implications of adopting these technologies that pose a fundamental barrier to transitioning to a low-carbon development path. The choice of mitigation strategies is further made difficult by the multiplicity of technological options for mitigation in different sectors. Modelling tools in such context become extremely crucial for long-term decision making.

Carrying out robust modelling assessments

Even though India did not commit to taking mitigation targets for about two decades of climate negotiations, it was not merely based on political insistence on historical responsibility of the developed countries and the principle of equity, specifically the equal per-capita principle.

Regular robust energy-economy-emission modelling assessments conducted by TERI, as early as 1992, provided the empirical basis for requirements of large-scale transfers of finance and technology to India if its growth path were to be maintained, thereby justifying India's position.

These assessments also substantiated the in-principle global agreement that emissions from developing countries like India would need to grow in order to provide the environmental space for their development. Later, starting from the Cancun pledges, again, the modelling studies carried out by TERI provided the supporting empirical basis.

Cost of mitigation and transfers of technology are the defining barriers to emission reductions. Since burden sharing has been the sticky issue in climate negotiations, estimates of national and global costs of achieving mitigation targets are needed as a reference point for determining level of effort needed as well as its adequacy.


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In 1992, TERI led the first ever marginal abatement cost estimations of developed as well as developing countries as part of the United Nations Environment Programme's (UNEP) Greenhouse Gas Abatement Costing Studies. Findings of these studies substantiated the demand of developing countries that their climate actions were not possible without developed countries providing full, incremental, new and additional financial support and technology transfer. These studies also helped conceptualize the Clean Development Mechanism (CDM).

A more advanced modelling assessment followed during 1995-98 when TERI, in collaboration with the National Physical Laboratory, assessed India's GHG emissions projected till 2020, and identified abatement strategies in alignment with India's development priorities. This was part of the ADB, GEF, and UNDP supported Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS) assessments in 12 countries where the national counterpart agency for India was the Ministry of Environment and Forests.

Analysing emission reduction scenarios

In 2009, when the pressure on India was mounting from developed countries for taking mitigation targets, the Government of India tasked TERI to provide a comprehensive assessment of range of possibilities.

In response, TERI conducted a comparative analysis of emission reduction scenarios for India till 2030-31 from five latest modelling assessments based on a computational general equilibrium (CGM) model, MARKet ALlocation (MARKAL) model, an Activity Analysis model, and sectoral Marginal Abatement Cost Curves-based analysis.

The two major findings of this assessment: (a) a substantial and continuous decline in India's energy intensity of GDP and CO_2 intensity of GDP across studies, and (b) no need to define a single 'baseline' or 'business-as-usual' trajectory for a country's GHG emissions were foundational in determining India's choice of using a GHG emission intensity of GDP-based economy wide target as part of the Cancun Pledge in 2010.

This formulation of India's mitigation targets continues till the recently updated Nationally Determined Contributions.

Steering India's modelling approach

Subsequent modelling assessments conducted by TERI, many in collaboration with other organizations/consortia, examined questions pertaining to possibility of achieving 100% renewable energy-based power supply by 2050 (2014), the 20C consistent emission reduction scenarios (2015), net-zero emission by 2050 scenarios (2020), and so on.

A major insight emerging from these assessments was that no economically viable transition away from coal is possible before 2035 in India. This remains a central reference point in India's mitigation strategy discourse, not only among the national interest-oriented analysts but also developed country commentators arguing for steeper mitigation efforts by India.

TERI's pioneering work on modelling-based mitigation pathways for India has an undeniable policy and analytical imprint. Currently, TERI is leading Task Force 1 (Net Zero Pathways) of India Climate Energy Modelling Forum (ICEMF).

This initiative was established by NITI Aayog and it involves all major research and academic organizations from India with relevant expertise. In a way, TERI is again steering India's modelling approach to mitigation pathways to the next generation of modelling assessments.

Energy

- REVIVING SMEs WITH RECP
- DEVELOPMENT OF SOLAR-PASSIVE BUILDING FOR SILKWORM REARING AND SEED PRODUCTION
- ENERGY EFFICIENT CUPOLA AND POLLUTION CONTROL SYSTEM FOR FOUNDRY UNITS

REVIVING SMEs WITH RECP

The small and medium enterprises (SMEs) are the backbone of India's economy. With diverse businesses, they make significant contributions to income and job creation.

Data elucidates the monumental impact of SMEs. In 2021-22, 36.2% of output from manufacturing was from SMEs and in 2022-23 they contributed 43.6% of exported products. They also make for around 30% of GDP and are responsible for employing more than 100 million people.

The SMEs are equally important to other economies of South Asia. In fact, SMEs make up more than 96% of all Asian businesses, providing two out of three private sector jobs on the continent.

However, due to the lack of awareness and perceived cost implications, SMEs operations are often inefficient. This is particularly true in the case of operations which involve high resource consumption and high heat requirement, making such firms less competitive.

RECP comes to the rescue

To make industrial production more sustainable, the Resource Efficient and Cleaner Production (RECP) has proven, particularly, efficacious, and is central to many global initiatives today. The idea is simple. To reduce source pollution through efficient use of resources. The concept came into practice from the mid-1980s when industrialized countries, starting from North America and Western Europe, launched programmes to demonstrate this preventive approach in manufacturing and related sectors. Since then, the RECP has spread to many countries and business worldwide.

Over the last decade, through various projects, the RECP consulting and implementation support has been provided to various sectors in India and South Asia. The sectors include metal finishing, metal products engineering, dyes, and intermediates.

These sectors face issues of lack of modernization, sub-optimal operation, lack of technical and financial support for improving operations, limited skilled manpower and a traditional mind-set. They are also resource intensive with high chemical use (e.g. electroplating, dyeing), need high temperature operations (e.g. melting, metal rolling) and often generate waste that needs treatment (e.g. wastewater). The inefficiencies could range from housekeeping measures (drain board between tanks in electroplating) to leakages in compressor lines.

TERI takes the lead

In collaboration with European, Indian and South Asian organizations, TERI was involved in two projects under the European Union Switch Asia programme. The ACIDLOOP project from 2012 to 2016 covered metal finishing sectors in India. The METABUILD project was from 2016 to 2020 and covered metal sector in Bangladesh, Nepal, Sri Lanka. TERI was the lead partner for these projects. These projects involved the implementation of RECP in the participating SMEs with the aim of achieving energy, water, and materials savings along with minimized waste.

Mobilization workshops were conducted to introduce the project and for selecting the SMEs. The firms were shortlisted based on their interest, improvement potential and technical and financial resource availability. The assessments of selected SMEs were done through on-site visits, and data collection. Based on the assessments, customized recommendations were provided for improvements. The implementation of the recommendations was supported through training, by providing links to the technology providers, and access to finance.

To convince the SMEs to implement the recommendations, it was important to show the business case through calculations of resource savings, cost savings and examples in similar sectors and geography. It was also essential to start with low-or no-cost recommendations for the SMEs, so that they could start experiencing the benefits before moving on to high-cost implementations.

Success that inspires

The projects led to greater awareness, savings in resources, and cost savings for the SMEs. These include use of efficient LED lighting, optimizing compressor operations, improving combustion efficiency, insulation of hot and cold surfaces, minimizing water leakages, and reusing RO reject. The projects also achieved GHG emissions reduction and environment improvement. With some implementations such as good housekeeping and insulation, the working environment also improved.

Several clients acknowledged the benefits by following the prescribed RECP measures, be it having 'reduced electricity consumption and electric bill' or becoming 'aware of the necessity of maintaining cleanliness in workplaces' or having an 'increased production'.

Mr Surya Mani Dhital, Manager, Global Cable Industries Pvt. Ltd, Nepal is one among them. "Before the METABUILD project, we didn't know about resource efficient cleaner production, but now we are practising it in our company. After implementing RECP measures, there are monetary savings through reduced electricity consumption, and we feel safe and comfortable working on the company shop floor. We will continue implementing RECP measures. I would like to convince other companies with the success stories we have in our company," he said.

With TERI in lead, the projects helped the SMEs owners in India and the neighbouring countries carve out an effective blueprint for others to follow.

DEVELOPMENT OF SOLAR-PASSIVE BUILDING FOR SILKWORM REARING AND SEED PRODUCTION

Sericulture is an agro-based cottage industry which plays an important role in the rural economy of India. It involves a few processes including cultivation of plants, rearing of silkworms, reeling, spinning, dyeing, and weaving, printing, and finishing.

The industry provides employment to about 60 lakh people, most of whom belong to small and marginal farmers, minority, tribal and backward communities, and economically weaker sections.

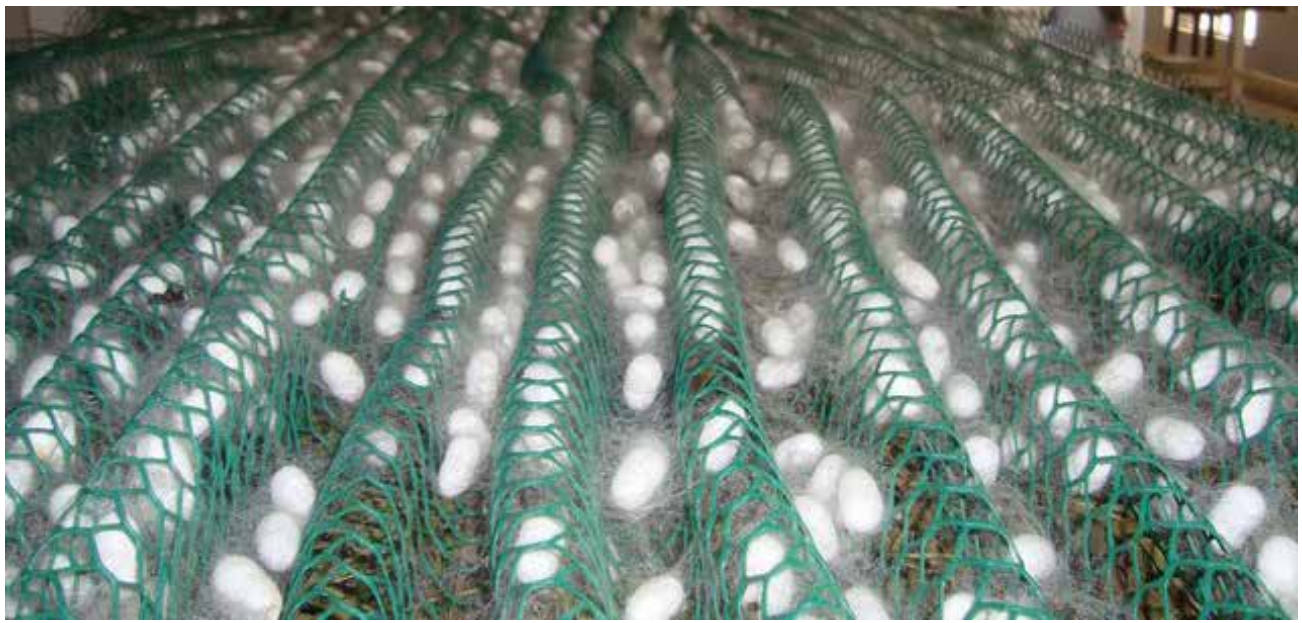
The sericulture sector has the distinction of cultivating all four commercially known varieties of silk. Mulberry silk contributes to almost 70% of the total silk production in India. The area under mulberry plantation in the country spreads to almost 239,967 hectares and annual cocoon production is recorded at 185,143 MT.

During 2020-21, about 35,820 MT of raw silk was produced, out of which 70.46% (i.e. about 25,239 MT) was mulberry and 29.53% (i.e. about 10,581 MT) was non-mulberry.

Solar-passive house

Silkworms by nature are delicate and sensitive to environmental conditions. Silkworm-rearing house, therefore, is an important component for producing qualitative and quantitative cocoons. That is why rearing house structures, and materials used for building these houses are crucial for maintaining the apt environmental conditions.

There are several reasons attributed to low yield such as quality of leaf, silkworm race, variation in temperature, humidity, etc. But it is the environmental conditions inside the rearing houses, mainly temperature and humidity, which play a decisive role in the growth of silkworms and productivity. The temperature for optimal growth of silkworm's ranges between 23°C and 28°C and the desired relative humidity should be in the range of 70% to 85%.



Some traditional methods are being adopted for maintaining the temperature and humidity, but these methods are far from satisfactory.

TERI has been working on natural air-conditioning systems based on concepts such as Trombe wall, solar chimney, and roof cooling (sack cloth cooling). A combination of these concepts along with reduction of heat gain/loss of the structure resulted in the development of a solar-passive house located at Gwal Pahari Campus of TERI in Gurugram.

TERI and Silkworm Seed Technology Laboratory (SSTL), Silkworm Seed Organization, Central Silk Board (CSB), Ministry of Textile, Government of India undertook a collaborative research project. TERI contributed to the designing and building of the solar-passive silkworm house, the first of its kind, at the SSTL Campus during 2011. The project was also supported by the Ministry of New and Renewable Energy (MNRE), Government of India.

All-season performance monitoring

The main aim of the project was to utilize solar-passive energy for maintaining

optimum condition for silkworm rearing throughout the year with improved quality and quantity of the cocoon.

It was decided to carry out a comprehensive survey of rearing houses in Karnataka and adjoining areas to understand the existing practices of rearing and formulate a rationale for introducing solar-passive concept for rearing house design.

Based on earlier experiences on natural air-conditioning systems based on concepts such as Trombe wall, solar chimney, and roof cooling, TERI developed the design and constructed a rearing house at SSTL Research Campus in Bengaluru.

The rearing house consisted of three rooms: a rearing room (11mx6m), chawki room (2.4mx1.8m) and ante room (2.4mx3.97m). The sample rearing house in this project was designed for 200 DFLs (diseases-free laying). The ante room was required for storing leaves.

The design strategies adopted include insulated building envelope (walls and roof), external east and west wall shaded, roof pond with insulation, solar chimney on roof with adjustable vents to improve ACH (air change per hour) in the rearing room, Trombe wall on south wall for winter, which could be shaded in summer season, Air Inlet from north wall covered with wet gunny bags for added humidity and evaporative cooling in dry summer months and natural ventilation through north ventilators and stack effect through solar chimneys.

Tests were conducted for performance verification of solar-passive building in all the seasons by carrying out silkworm seed crop rearing in solar-passive building. The environmental conditions such as temperature and humidity were also monitored through data loggers.

Rearing was conducted both in solar-passive building and SSTL rearing house to find out the suitability and performance of

solar-passive building. Performance monitoring and rearing was carried out for one complete year after the construction of the set-up.

For maintaining the temperature and humidity, the electrical heater was used in SSTL rearing house (control) in the winter seasons whereas in the solar-passive building, rearing was conducted in natural conditions with passive design strategies that operated both day and night.

Better rearing performance

The SSTL test verified the efficiency of this model rearing house in all the seasons along with TERI during 2011-13.

The required temperature and humidity for silkworm rearing was maintained in passive building without the use of any conventional energy. The temperature range between 23°C and 28°C was maintained in all the three seasons in the solar-passive building compared with control and ambient temperature ranged between 22°C and 32°C.

In the case of humidity, in a solar-passive house; it was maintained between 60% and 80% compared with that of control which ranged between 40% and 85%.

The overall rearing performance, especially the yield of cocoon, increased 4.065 kg per 100 DFLs in solar-passive building compared with control rearing house.

The technology was handed over to Central Silk Board (CSB), which has been promoting sericulture across India, including construction of rearing houses under Silk SAMAGRAH and Northeastern Region Textile Promotion Scheme (NERTPS) through the state government. It has the potential to make a lasting impact in the sericulture sector in India.

ENERGY EFFICIENT CUPOLA AND POLLUTION CONTROL SYSTEM FOR FOUNDRY UNITS

Dirty grey and smoky black—the sky in Howrah during the early 90s. Fumes of toxic gases billowing from the clusters of small-scale foundry units had made the place a living hell.

The 90s was also the decade that transformed India. Economic liberalization set the country firmly on track for high growth. These foundries, though, were untouched by economic benefits. They were struggling to stay afloat in the fast-changing industrial landscape. The small and medium enterprises (SMEs), thus far shielded from the competitive currents of both indigenous and global markets, were now open to market forces and competition. Not just from large enterprises in India, but also from competition abroad. An existential crisis was staring at them.

There was another front these foundries were pressed to tackle quickly—the environmental degradation they were causing. Concerns regarding the dangers of air pollution were growing. The Supreme Court of India was pushing for small-scale sector to meet emissions norms, or face closure.

A fight for survival

A foundry is a factory that produces metal castings and a major source of emissions. Most small-scale foundries in India use outmoded, low-efficiency cupolas (the predominant melting furnaces) that generate considerable quantities of greenhouse gases and particulate emissions.

The scenario required a sustainable and practical solution which would not risk the closure of about 3,500 foundry units across India that produced grey iron castings. Almost all units are in the small-scale sector. The Howrah cluster, for instance, has approximately 300 foundries. Most of the foundries there produce low value-added castings such as manhole covers and sanitary pipes.

In many foundries, the charge materials are lifted manually for loading into the cupola. This is not only a physically taxing task, but it also poses major hazards to workers, for they are exposed to heat and high levels of carbon monoxide (CO) at the cupola charging door.

Primarily family-owned and managed, these foundries directly employed half a million people and produced about 10 million tonnes of castings annually. Dwindling profit margins had anyway been threatening these traditional foundries for some time. Studies conducted by TERI revealed that the cupolas used in these foundries were substantially responsible for the dismal energy and environmental performance.

TERI steps in

TERI, with the support of the Swiss Agency for Development Cooperation (SDC), and in collaboration with ABB India, Sorane SA, Switzerland, and Castings Development Centre, UK, demonstrated an energy-efficient design of a cupola and a pollution control system for Indian foundries. It was the answer to the needs of foundry owners and environmentalists alike.

Conventional cupolas have several drawbacks like incorrect selection of the blower, improper distribution of air, lack of control on feed materials. Poor operating and maintenance practices further lowered their performance.

The suspended particulate matter (SPM) emissions from these cupolas were higher than the permissible environmental standards, because of the lack of effective gas-cleaning device.

The initiative undertaken by TERI aimed to turn around the conventional cupola furnaces of this industry and make them environment friendly, energy-efficient, and profit-making unit.

Breaking new ground at Howrah

TERI developed an improved cupola prototype that considered all the failings of the previous design of the cupola, the DBC or the divided blast cupola. It is different from its infamous predecessor in that it supplies air blast at two levels.

These, in tandem with other optimized design modifications in the DBC and a high efficiency venturi scrubber-based pollution control system, are responsible for its energy efficiency and minimal polluting nature.

Not only did the workers breathe a sigh of relief but the owners of the most efficient foundries also saved up to 25% in coke; the least energy-efficient plants saved coke up to an impressive 65%. Usually, the savings from coke pay for a new DBC within a year.

Additional benefits include lower oxidation losses of silicon and manganese and a reduction in rejection levels. The pollution-control system brings down the quantum of SPM released into air—from a range of 1,300–3,900 mg/Nm^3 (milligram per normal cubic metre) to about 50 mg/Nm^3. The SO_2 emissions are brought down from the prescribed 300 mg/Nm^3 to 40 mg/Nm^3.

A success story for ages

In 1998, the Indian Foundry Association nominated Bharat Engineering Works, Howrah, for setting up a demonstration plant. It was a win-win situation for all involved—foundry owners, workers, and their families. The coke saving in this foundry unit that manufactures ingot moulds was 35%. There was an increase in metal tapping temperature and reduction in silicon and manganese losses.

Encouraged by the success of the demonstration plant, a foundry unit located in Nagpur set up a DBC in 2000 with technical assistance of TERI. TERI-designed DBCs have been proceeding at a brisk pace since 2003.

To date, TERI has provided technical assistance to more than 100 small-scale foundry units for replicating the DBC. Some of these units are in major foundry clusters in Ahmedabad, Coimbatore, Howrah, Rajkot, and Bhavnagar. TERI has also helped a foundry unit located in West Bengal successfully avert closure by providing the design for a pollution-control system. Subsequently, TERI started a social action initiative to improve the socio-economic conditions of foundry workers in Howrah.

The project bears testimony to TERI's legacy of participatory approach. The programmes were undertaken with complete involvement of local communities, tapping into their local skills and traditional wisdom to ensure their adoption, making for a success story that is inspiring and enduring.

Environment

Forest and Biodiversity

- REHABILITATING RED MUD DUMP
- ENHANCING INCOME OF FOREST-DEPENDENT COMMUNITIES
- TRANSFORMING TOPOGRAPHIC SHADOW CORRECTION WITH OPTICAL REMOTE SENSING
- TRANSFORMING PUNJAB'S AGROECOSYSTEM
- EVOLUTION OF COMMUNITY-BASED FOREST GOVERNANCE IN INDIA

REHABILITATING RED MUD DUMP

Mining is one of the most important activities in India influencing infrastructure development, national gross domestic product (GDP), and land degradation. However, mine overburden and waste are erosion prone, choking drainage and producing acid drainage water. This can lead to forest degradation, loss of biodiversity and ecosystem services, depletion in the quality of water resources, impact livestock and human health besides causing air, water, and soil pollution.

It, thus, makes mine reclamation extremely important. The process of reclamation converts a site, as far as possible, to pre-mining conditions and ensures its sustainability. It has significant ecological, social, and economic benefits, too. Adequate and effective mine reclamation and land rehabilitation is critical to the sustainability of industry, in ensuring productivity of land, and minimizing impact on human health and environment.

TERI takes over red mud site in Ranchi

Located 65 kilometres from Ranchi, Jharkhand, and close to Chota Muri, along the banks of the Swarnarekha River is the plant of Hindustan Aluminium Corporation Ltd (HINDALCO). This red mud dump site has been given to TERI by HINDALCO for restoration efforts.

The site is surrounded by residential areas, agricultural fields, and the Swarnarekha River. Red mud waste is produced in large quantities. The alkaline nature of the waste has the potential to contaminate both groundwater and river water.

The project primarily focused on creating a green cover at the disposal site and transforming the alkaline-inhospitable red mud deposits into a substrate for plant development. It is done by enhancing their physico-chemical properties and removing the inhibiting substances. The project includes providing technical assistance, creating appropriate plantation protocols, selecting suitable soil amendments, planting specific tree species to make the area green, and conserving soil and water to restore the red mud area.

Creating a green cover

Red sludge is produced during the production of aluminium. Red mud is a poor substrate for plant growth because of very high pH, salinity, and sodicity; it renders the land unproductive. During the dry season, particles of red mud become airborne and during the wet season the soda leaches from the mud and contaminates the groundwater. At present, most of the red mud is dumped directly in the disposal field by dried treatment; it leads to farmland occupation, environmental pollution, and contamination of river water.

To address the problems of red mud area, TERI undertook the project activity aimed at remediation of red mud pond at Chotamuri from 2021 onwards. The project envisaged for providing technical support and developing the suitable plantation protocols for reclaiming the red mud area, through identification of suitable soil amendments, plantation of tree species for initiating the process of ecological succession, and soil & water-conservation measures.

TERI has been actively involved in mining rehabilitation activities with a strong focus on research and technology development for rehabilitation/ remediation of mined-out areas. Additionally, it undertook dissemination of rehabilitation technology through the implementation of the pilot projects and training and capacity building of the stakeholders associated with the mining activities.

Currently, TERI is implementing a 100-acre red mud area into green cover considering the objectives: (i) to develop green cover to reduce mud erosion and wind-blown dust during the summer season; (ii) to ensure the green belt restoration to help in filtering out the rainwater, thereby improving the water quality (pH neutral). This filtered water will be contamination free and can be drained out in the downstream of Swarnarekha River and can be further used for irrigation, afforestation, and agricultural activities in nearby forest area or for other household activities.

Breathing life into soil

Various significant interventions have been undertaken at the red mud pond site to enhance its environmental sustainability and productivity. These efforts include the establishment of a nursery for propagating and nurturing plant species, as well as the pilot-scale implementation of a vermicomposting unit to recycle organic matter effectively.

The site has undergone extensive transformation with levelling and bench slope construction, coupled with soil and water management initiatives. Advanced soil improvement techniques, such as the incorporation of various soil amenders like gypsum, farmyard manure, fly ash, and mycorrhiza, have been employed to enhance soil quality and fertility. Furthermore, extensive plantation activities and seed sowing have been conducted to restore vegetation and biodiversity, complemented by the essential measure of fencing the plantation area to protect it from browsing animals and ensure successful reforestation efforts.

Owing to the rehabilitative intervention, changes were noted in the soil characteristics wherein the electrical conductivity and pH of the soil showed a decreasing trend across all levels of the soil depth. Besides, organic carbon, phosphorous, potassium, and nitrogen values in the soil showed an increasing trend. Thus, the remedial measures undertaken at the red mud pond area helped in changing the physio-chemical properties of soil and making it viable for the plantation to survive and grow.

The project is in its third phase and changes in soil properties are already being observed because of the rehabilitation intervention. In fact, all levels of soil depth indicated a decreasing trend in both electrical conductivity and pH.

Today nearly 48 species of plants are grown in Muri which include bougainvillea, bamboo, rose, wood apple, curry tree, neem, seasonal flowers, among others. The improved soil health also promises long-term health and economic benefits.

The approach in this initiative has emerged as a blueprint, with added iterations like green manuring, and is critical in ensuring that the mined lands are returned to its beneficial use.

ENHANCING INCOME OF FOREST-DEPENDENT COMMUNITIES

India is home to over 300 million forest dwellers, who rely heavily on forests for their subsistence and livelihoods. These forest dwellers are primarily dependent on selling minor forest produce (MFP) for their subsistence.

During the slack season, MFP becomes the chief source of income for several tribal communities who practise agriculture. They provide nutrition to people living in these areas and include all non-timber forest produce of plant origin including bamboo, brush wood, stumps, cane, tussar, cocoons, honey, wax, lac, tendu or kendu leaves, medicinal plants and herbs, roots, tubers (Under Forest Rights Act, 2006).

However, the limited skill sets of these forest dwellers pose a challenge when it comes to adding value to the MFP before selling them. To cover this disparity, the concept of minimum selling price (MSP) was first implemented in 1965.

MSPs for sustainable harvest

A significant disparity was observed between the prices of raw MFP sold by the forest dwellers and the value-added products derived from them. This deficit presents a significant hurdle for the forest dwellers who, despite risking their lives during the collection of MFP, receive inadequate compensation.

The urgency of the situation compelled reflection on the need to determine appropriate) for MFP. The initiative was designed to address the economic disparities and improve the livelihoods of the forest dwellers by ensuring fair compensation for their efforts put in the collection of MFP.

The MSP thus, performs an important function in realizing the various objectives related to agricultural price policy. The Cabinet Committee on Economic Affairs (CCEA) determines the MSP at the beginning of the sowing season of various agricultural commodities based on the recommendations of the Commission for Agricultural Cost and Prices.

However, the conventional approach of MSP for agricultural sector cannot be applied for MFP. The absence of stock assessments and cultivation cost data for MFP makes the conventional approach impractical. Promoting sustainable harvesting requires a different strategy, where pricing should incentivize responsible collection. Furthermore, efforts and traditional knowledge of harvesting need to be compensated through market mechanism. Consequently, establishing an effective MSP for MFP proves to be a distinct challenge compared to the conventional MSP framework designed for agriculture.

TERI joins hands with the Ministry of Tribal Affairs

The Ministry of Tribal Affairs (MoTA) through Tribal Co-operative Marketing Development Federation of India (TRIFED) assigned TERI the responsibility for providing methodology for fixation of MSP for the selected MFP. The MFP included species with wide range of applications such as gum and resin (gum kraya), spices and condiments (kala jeera, chironjee, tamarind), medicines (wild honey, arjun bark, giloy), fruits (jamun, amla), oil seeds (karanj, sal seed) and other products that include lac, bamboo, tendu leaves, etc.

TERI conducted detailed studies in the year 2017-18 that focused on estimating MSP for a total of 76 selected MFP. The studies were carried out in nine Schedule V states, namely Chhattisgarh, Uttar Pradesh, Andhra Pradesh, Odisha, Meghalaya, Jharkhand, Himachal Pradesh, Karnataka, and Madhya Pradesh.

A total of 12,000 households were interviewed and 1,200 work studies were done to make a one-time assessment of the cost of collection, cleaning and primary processing, packaging and carriage to the first point of sale for each selected MFP.

The individual MFP collectors across the nine states were tracked for activities of harvesting to selling. The documentation on sustainable yield has been done using literature. MFP-wise techniques of sustainable harvesting have been also discussed during the Focused Group Discussions and mentioned in the description of each MFP.

Opening doors of opportunities for forest dwellers

TERI accomplished the submission of comprehensive reports encompassing abundance, stock availability, and sustainability of MFP, including proposed rates, to TRIFED. This initiative resulted in the revision of MSP rates for MFP by TRIFED and MoTA.

The revised rates, implemented in 2020, reflected a substantial increase, with approximately 45 MFPs witnessing a 15% surge in MSP, and the remaining MFP experiencing a noteworthy elevation of up to 50%, surpassing the prevailing market prices at the local level.

As a consequence, TERI's efforts directly translated into significant benefits for around 300 million forest dwellers nationwide. This positive outcome ensured that these individuals received a fair price for their labour during the challenging process of collecting MFPs.

TRANSFORMING TOPOGRAPHIC SHADOW CORRECTION WITH OPTICAL REMOTE SENSING

In the field of remote sensing, accurate topographic shadow correction is crucial for various applications, ranging from terrain analysis to forest cover mapping and land-use land-cover classification.

The Indian Himalayan Region (IHR) boasts a tapestry of diverse ecosystems, including high-altitude terrain and dense forests. However, the rugged landscape poses challenges for remote-sensing applications, particularly in accurately correcting topographic shadows. Traditionally, Synthetic Aperture Radar (SAR) and Light Detection and Ranging (LiDAR) data have been relied upon for shadow correction due to their ability to penetrate cloud cover and capture terrain information.

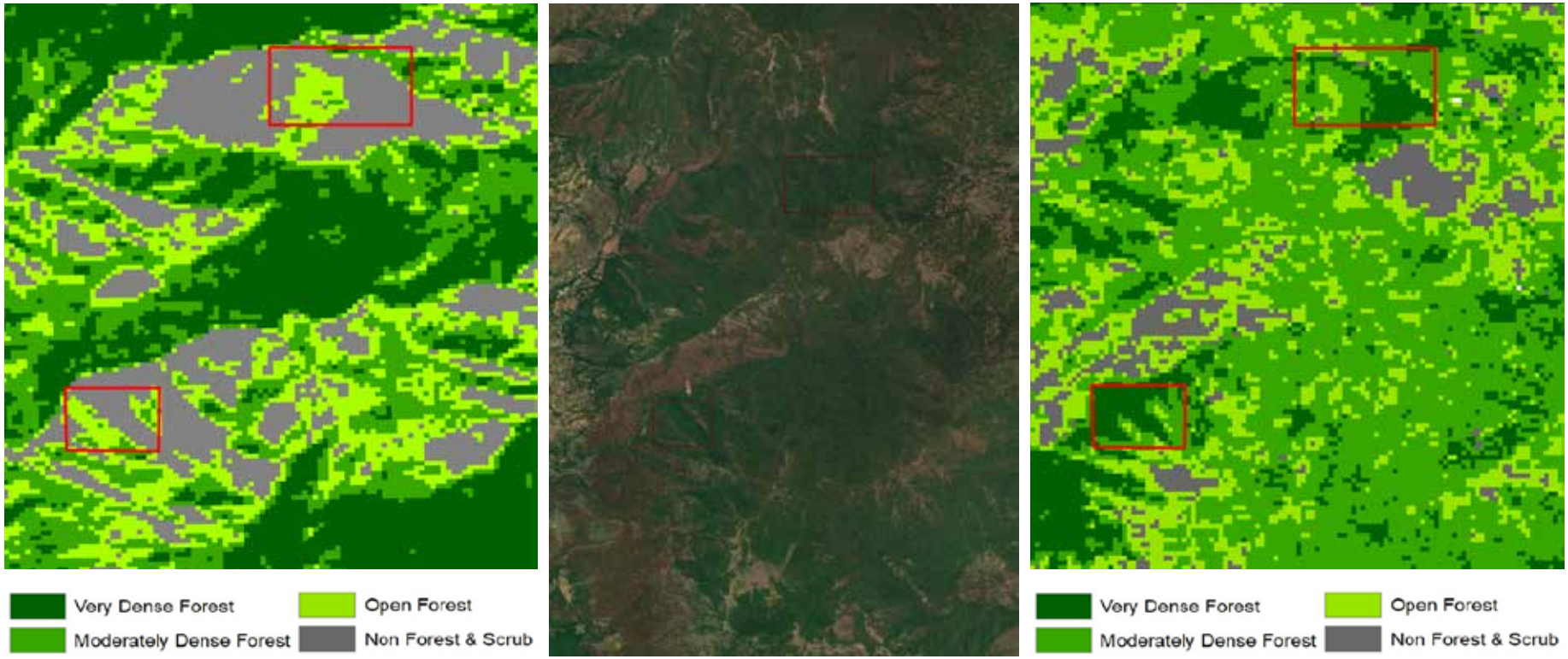
However, the cost associated with acquiring and processing SAR or LiDAR data can be prohibitive, especially for large-scale projects or in resource-constrained environments. Recognizing the need to look for alternative ways, the TERI team embarked on a mission to develop a cost-effective solution using Short Wave Infrared (SWIR) and Near Infrared (NIR) bands of optical remote-sensing data for topographic shadow correction.

Developing cost-effective alternative

Topographic shadows impede optical remote-sensing imagery, leading to inaccuracies in various applications such as land cover mapping, change detection, vegetation monitoring and carbon stock assessment in these areas.

Traditional methods rely on SAR or LiDAR data for shadow correction, which can be costly and resource-intensive, particularly in remote and climate-fragile regions. There is a pressing need for a cost-effective alternative that leverages existing optical remote-sensing data.

TERI researchers developed an innovative approach to topographic shadow correction using optical remote-sensing data, specifically SWIR band-based vegetation moisture indices. Building upon existing algorithms and techniques, a sophisticated methodology was developed that combines advanced image processing techniques with spectral analysis to accurately identify and correct topographic shadows.



By integrating terrain information with spectral signatures of surface features, the method effectively distinguishes shadows from true land cover elements, resulting in precise and reliable shadow correction. Employing the SWIR-based algorithm, the researchers mapped the fractional vegetation cover, forest degradation/deforestation and the associated carbon stock assessment for different forest strata in high-altitude area of IHR, particularly selected Van Panchayats of Uttarakhand & Community Conserved Areas (CCAs) of Nagaland state.

High accuracy and reliability

TERI's approach eliminates the need for expensive SAR or LiDAR data, thus substantially reducing the financial burden associated with topographic shadow correction in rugged terrain and high-altitude areas of Uttarakhand and Nagaland.

The methodology can be applied to large-scale projects and across diverse geographical regions without incurring significant additional costs.

Extensive validation against Forest Survey of India's forest cover maps, ground truth data and comparative analysis with SAR and LiDAR-based methods demonstrate the high accuracy and reliability of TERI's approach in correcting topographic shadows.

The developed algorithm can be integrated into existing remote-sensing software platforms, enabling automated processing of optical imagery for shadow correction, thereby saving time and resources. The methodology is applicable across various optical remote-sensing platforms, including satellite, aerial, and unmanned aerial vehicle (UAV) imagery, enhancing its versatility and utility in different scenarios.

Demonstrating efficiency through case studies

To illustrate the effectiveness of our approach, TERI conducted two case studies in selected Van Panchayats of Gairsain, Gagas and Mukteshwar ranges of Uttarakhand as well as CCAs of Nagaland.

The effect of topographical shadow can be minimized by the SWIR-based moisture index for vegetation assessment. This index assists in evaluating the vegetation water content and mesophyll structural information.

As per the formula, the moisture index integrates the information from both near-infrared and short-wave infrared, providing precise information regarding vegetation assessment in rugged terrain. A higher value of the index indicates the presence of dense canopy cover and vice versa.

Here, forest density assessment for selected Van Panchayats of Uttarakhand and CCAs of Nagaland state have been carried out using spectral un-mixing algorithm-based Fractional Vegetation Cover (FVC) maps.

The necessity for including this index arises due to the limitation of Normalized Difference Vegetation Index (NDVI) to minimize the effect of topographical shadow.

While evaluating LULC (land use land cover) and FVC (fractional vegetation cover), NDVI falls short in analysis of canopy density and landscape properties of mountainous regions. To precisely map the forest and land cover by minimizing the effects of topographical shadow, Normalized Difference Moisture Index (NDMI) has been used to develop the machine-learning-based (Linear Spectral Unmixing) fractional vegetation cover maps.

NDMI is valuable for evaluating vegetation water content and mesophyll structure. The synergy of NIR and SWIR bands improves satellite data quality by mitigating atmospheric errors and topographic shadow effects. Additionally, NIR identifies reflectance from both leaf internal structure and dry matter content, and when combined with the SWIR band, it serves as a robust indicator for monitoring vegetation health and moisture content.

Here, in this attempt, researchers mapped forest density and land cover by assessing the moisture content as well as vegetation water content using SWIR-based moisture index. Outputs were further validated against ground truth data, high-resolution satellite imageries (< 30 cm), ISFR reports and demonstrated a significant improvement in classification accuracy.

This novel approach to topographic shadow correction using optical remote-sensing data is a breakthrough for forest cover change analysis and forest biomass mapping in high-altitude terrain of Uttarakhand and Nagaland.

By offering a cost-effective, precise, and scalable solution, TERI researchers have transformed the way remote sensing is conducted in this challenging terrain, enabling informed decision-making and sustainable management of natural resources.

TRANSFORMING PUNJAB'S AGROECOSYSTEM

India significantly depends on Punjab for its agricultural produce. The agrarian state is also known as the 'Food Basket of India.' It meets 12% of the country's food grain requirements.

A paradigm shift is, however, needed in its agricultural practices. A large part of its economy primarily depends on intensive agriculture, which causes loss of soil fertility and land degradation.

It also adds to the cost of cultivation as higher quantities of agricultural inputs are required to maintain productivity. In the longer run, this is affecting the socio-economic and ecological conditions in the state. Climate change, causing extreme weather events like flash floods, droughts, untimely rain, hailstorms, and heat waves, tends to lower agriculture's overall productivity.

Sustainable land-use practices

Practising agroforestry can mitigate adverse impacts of climate change, enhance carbon sequestration, contain land degradation, and create additional source of income opportunities for the farmers.

Agroforestry systems include both traditional and modern land-use systems where trees are managed together with crops and/or animal production systems in agricultural settings. They are dynamic, ecologically-based, natural resource management systems that diversify and sustain production in order to increase social, economic and environmental benefits for land users at all scales.

According to the Food and Agriculture Organization of the United Nations, the global population is expected to increase by 2 billion people, from 7.7 billion currently to 9.7 billion in 2050. To meet the demand for food by 2050, production will have to increase by over 60%.

Changing the way we manage lands and our production of agricultural and tree goods is a way to deal with the issue. Because of its multifunctional properties, agroforestry can provide solutions to environmental, economic and social concerns.

Unique solution to encourage agroforestry

However, there are several barriers faced by the farmers to adopt agroforestry practices on their farmlands. Generally, farmers face the problem of availability of superior quality planting material of woody perennials. Another reason that inhibits farmers from practising large-scale agroforestry is the unavailability of local markets for their timber harvest and fluctuations in the prices. To overcome these barriers, TERI pitched the idea of developing a carbon finance project with the Punjab Forest Department.

The project was developed to mitigate climate change and enhance farmers' income by providing them with an additional source of revenue from the sale of carbon credits. These credits would generate from the agroforestry practices and thereby aid in eliminating risk caused due to price fluctuation in the timber market.

TERI professionals prepared a detailed Standard Operating Procedure for the implementation of the project activities and guided the Punjab Forest Department in implementation of the project. Punjab Forest Department distributed quality seedlings of Clonal Eucalyptus (*Eucalyptus* sp.), Shisham *(Dalbergia sissoo)*, Clonal Poplar (*Populus* sp.), Drek *(Melia azedarach)*, Teak *(Tectona grandis),* and Chandan *(Santalum album)*. These tree species were planted on farmlands along with field crops in agroforestry models such as HDBP high-density block plantation, LDBP low-density block plantation and PBP periphery boundary plantation.

The seedlings were planted by farmers from 2017-18 till 2019-20. The project was implemented in the Malwa region of Punjab comprising six forest divisions: SAS Nagar, Rupnagar, Nawanshahr, Hoshiarpur, Dasuya, and Pathankot.

Carbon Finance Project

TERI developed an ARR Carbon Finance Project for the voluntary market for the project activities along with an investor. TERI has extensive experience in providing consultation for developing carbon finance projects.

A Tripartite MoU was signed between Punjab Forest Department, TERI and VNV Advisory (serving as investor) in 2020 to develop two carbon finance projects in the voluntary carbon market. The MoU outlined a detailed set of roles and responsibilities of the entities involved in the implementation of the project. The TERI professionals organized capacity-building and training workshops for the frontline forest staff on assessment of eligible pools of carbon and development of a carbon finance project. Stakeholder consultations were organized to inform them on the progress of the carbon finance project and the benefits of the project.

TERI, as a project developer, helped the Punjab Forest Department by acting as a Project Proponent on the behalf of the registered farmers in data collection and preparation of relevant documents including Project Description (PD) and Monitoring Report (MR).

The monitoring activities were conducted in December 2021. This was followed by a rigorous process of validation and verification by third-party independent assessors accredited under VERRA platform. The projects got approved and registered on VERRA Platform in April 2024.

Reaping rewards

The carbon finance projects are now yielding significant environmental, economical, and social benefits.

Environmental benefits: These projects help remove CO_2 from the atmosphere and conserve natural ecosystems, mitigating the adverse effects of climate change. During the first monitoring cycle (2017-21), agroforestry initiatives sequestered a total of 684,620 tCO_2e or verified carbon units (VCUs) over an area of 8,327.4 hectares.

Economic benefits: The revenue generated from the sale of these carbon credits provides an economic incentive and supplements the income of 3,686 farmers. The carbon credits issued by VERRA are expected to generate approximately INR 35 crore, which will be distributed among the registered farmers by the Punjab Forest Department.

Social benefits: These projects support the achievement of various Sustainable Development Goals (SDGs), including SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land).

By integrating environmental conservation with economic incentives and social development, these carbon finance projects create a holistic approach to sustainability.

EVOLUTION OF COMMUNITY-BASED FOREST GOVERNANCE IN INDIA

The pre-colonial India had a rich history of community-based forest protection, management and institutions. The establishment of British rule in the 19th century led to the onset of centralized forest governance and commercial timber-oriented forestry. This transformed the collectively managed natural resources into state property. This period witnessed significant degradation of forest resources, state control, and a lack of access to forest-dependent communities.

The post-independent India continued the colonial era legacy of commercial use of forests, while also committing to increasing the national forest cover to one-third of the country's geographical area. While the needs of the forest-dependent communities were recognized, under the National Forest Policy of 1952, it also placed national interests and development needs of a growing economy over the needs of the communities.

The 'fortress of model of biodiversity conservation' in the 1970s and early 1980s, through the enactment of some stringent forest and wildlife laws, further curtailed the rights and needs of the forest dwellers. But the National Forest Policy, 1988 changed the perspective of forest management by treating forests as an ecological resource than the source of revenue unlike the previous forest policy of 1952.

The National Forest Policy, 1988 also recognized that the rights and concessions from forests should primarily be for the bonafide use of the communities living within and around forest areas, especially the tribals and other forest-dependent communities. It envisaged a people's movement for participatory conservation and management of forests across the country. This paved the way for the National Forest Policy, 1988 and Joint Forest Management Programme in the 1990s and an onset of community forestry in India.

Pioneering joint forest management in Haryana

TERI has played a pioneering role in developing and facilitating community-based forest governance institutions in the country. This initiative began with the successful scaling up of the landmark Sukhomajri project by the Government of Haryana and the formalization of participatory forest management in the state during the late 1980s.

The collaborative efforts of the Haryana Forest Department and TERI were instrumental in establishing community forest institutions in 60 villages across the Morni-Pinjore and Yamunanagar forest divisions, organized in 55 village institutions known as hill resource management societies (HRMSs).

These institutions were found on the principle of involving local communities in the regeneration, protection, and sustainable harvest of forest resources in partnership with forest departments. The success of such experiences contributed to the formal adoption of joint forest management in the National Forest Policy of 1988 and led to the Government of India's circular to the states in June 1990

The Joint Forest Management programme in Haryana gained international acclaim and became one of the three projects, worldwide, to be conferred the prestigious 'Saving the Drylands' award for the year 1997–98 by the United Nations Environment Programme. This global recognition was a testament to the dedicated efforts of the state forest department, TERI and the local communities in conserving and protecting their forests.

Research and policy support for community forest resource management in India

The 1990s and the subsequent decades ushered the era of recognition of community forestry through the enactment of the Provisions of the Panchayats (Extension to Scheduled Areas) Act, 1996, The Biological Diversity Act, 2002, Forest Rights Act, 2006 (FRA 2006). These legislations mainstreamed community-based sustainable forest management in the country.

TERI has consistently worked with the policymakers for developing community forest management models through empirical research initiatives. In one notable project for the Ministry of Tribal Affairs (MoTA) during 2018–19, TERI developed Governance Models for Community Forest Resource (CFR) Areas in tribal regions of India.

In another study for the Indian Council of Forestry Research and Education (ICFRE), TERI reviewed existing community forestry institutions and formulated Natural Resource, Forest, and Biodiversity Governance Models for Schedule V, Schedule VI, and Non-schedule Areas.

This study analyzed the diverse community-based institutions involved in natural resource management, such as BMCs, JFMCs, EDCs, CFRMC, Van Panchayats, and others. To address overlapping mandates among these institutions, the study proposed three distinct governance models for Schedule V, Schedule VI, and Non-schedule areas.

Each model suggested establishing a common committee at the Gram Sabha level in Schedule V areas, at the village council or equivalent institution in Schedule VI areas, and at the Gram Panchayat level in Non-schedule areas. These committees, formed with the consent and authority of the Gram Sabha, would streamline natural resource governance. The study also delineated the roles and responsibilities of the Gram Sabha, state forest departments, access and benefit-sharing mechanisms, and financing strategies among various stakeholders.

At the time of these studies, over 1 million hectares of land, across Schedule V area, had been recognized as CFR areas. However, no guidance was provided regarding the governance of these CFR areas, prompting local communities to seek clarity from state governments.

As part of the aforementioned studies, TERI conducted nationwide consultations with state forest departments, tribal departments, Gram Sabha members, NGOs, and other stakeholders. The findings were presented at a National Workshop, and a report with customized governance guidelines for each state was submitted to the Ministry of Tribal Affairs (MoTA).

Meanwhile, formal discussions were taking place between the Ministry of Environment, Forest and Climate Change (MoEFCC) and the MoTA to resolve CFR governance issues. In response, MoTA took cognizance of TERI's report and issued the Guidelines for Conservation, Management, and Sustainable Use of Community Forest Resources in September 2023 (CFRR Guidelines, 2023). This is a remarkable step and guidance to states where CFRs are recognized.

Resource sustainability and community empowerment

From the evolution of JFM to the strengthening of CFR governance in the country, TERI has been a frontrunner in offering technical, research, and policy support to various stakeholders, contributing significantly to these initiatives. These initiatives have led to policy-level implementation for SFM in letter and spirit of the NFP 1988 and FRA 2006.

Since the issuance of the JFM Guidelines in 1990, over 1,00,000 JFM committees have been established in India, encompassing approximately 23 million hectares of land.

The CFRR guidelines, 2023 will benefit over 5 million hectares of forest land, declared as CFR area governed by Gram Sabhas in tribal regions in Schedule V areas. The guidelines issued by MoTA to manage these resources is an important milestone for the sustainable management of forests and livelihood of the forest dwellers dependent on the traditional forest areas.

Air

- DECODING THE EFFICACY OF ODD-EVEN SCHEME
- CHASING A PAN-INDIA DREAM OF CLEAN AIR

DECODING THE EFFICACY OF ODD-EVEN SCHEME

Delhi is among the world's most polluted cities today. In the Indian national capital, more than 16 million people are exposed to severely high pollutant concentrations on an annual average.

To improve ambient air quality, the Delhi Government introduced its flagship Odd-Even Scheme, a temporary traffic rationing system, to curtail the air pollutant levels. The scheme involved privately owned cars being restricted on alternate days based on the last digit (odd/even) of the registration number.

The first phase of the scheme was launched in January 2016, and thereafter, it was re-introduced from 15–30 April 2016, prompting TERI to analyze the effectiveness of the scheme in reducing air pollution and congestion in Delhi.

Understanding odd-even

Delhi air quality often dips to alarming levels due to various sources such as vehicular emissions, industrial activities, construction dust, and agricultural residue burning. The Odd-Even Scheme specifically targeted vehicular emissions, which contribute significantly to the city's air quality deterioration.

The rapidly increasing number of vehicles on Delhi's roads led to chronic traffic congestion, resulting in longer commute times, fuel wastage, and increased stress for commuters. The Scheme looked to reduce the overall number of vehicles on the road, thus providing a targeted solution during the critical period. The Scheme hoped to bring about tangible improvements in air quality and reduce the health risks associated with prolonged exposure to pollution. The first phase of the Odd-Even Scheme received mixed reactions, but it was generally considered a bold and innovative step to address air pollution. Some studies even suggested a temporary improvement in air quality during the implementation period. The second phase incorporated lessons learned from the first, with a few modifications to improve effectiveness and address challenges encountered earlier.

TERI conducted an analysis to assess the impact of the Odd-Even Scheme on air pollution and traffic congestion in Delhi. Such evaluations are crucial for refining policies and understanding their effectiveness.

Study findings

TERI provided a set of policy recommendations to the state government based on its study findings. During Odd-Even phase II, TERI carried out traffic counts at six locations—Ghazipur border, DND Noida, Gurgaon border, Shankar Road, Ring Road (Hyatt Hotel), and BSZ Marg. The counts were carried out between 7 am and 11 pm on Mondays and Thursdays, during, and after the Odd-Even Scheme period. Average speeds of cars were monitored using a GPS device on a selected route, traversing through a total distance of about 90 km. The route was planned to cover different parts of the city in north, west, south, and east directions.

TERI carried out an analysis of air quality in Delhi and nearby towns. The 24-hour data was collected and analyzed for the period between 4 April, 2016, and 6 May, 2016, accounting for both odd-even and non-odd-even days in between.

Based on the findings, TERI proposed strategies to manage traffic congestion and the associated pollution while also recommending various measures to enhance air quality in Delhi and its surrounding areas. It found the major challenge was the lack of evidence-based research on the impact of the government initiated Sdd-Even Scheme on the ambient air quality and traffic congestion in Delhi.

Unravelling the Odd-Even Scheme

The study by TERI found a positive impact on the number of cars on the road and the speed of travel. However, a decline in impact in both parameters has been observed in the second phase in comparison to the first phase. This could be due to people opting for second cars with alternative number plates or enhanced use of taxis.

On the air quality front, the Odd-Even Scheme has provided limited benefits. This is the share of private cars is small in the $PM_{2.5}$ levels in Delhi and consequently, only marginal reductions could be achieved through the Odd-Even Scheme.

The absolute reduction in $PM_{2.5}$ concentration due to Odd-Even Scheme summer season is less compared to winter season, because, in summers, when the pollution levels are relatively lower and the share of vehicular sources is lower too, the impact of the scheme is further reduced. The analysis of the two phases of the scheme suggests that regularizing this scheme can reduce its impact.

As in the case of other cities in the world that have tried out the Odd-Even Scheme in the past, people could look for alternatives by purchasing new/old cars or motorbikes, which would, over a period, neutralize or negate the positive impacts.

TERI issued its recommendations that the Odd-Even Scheme should be used only as an emergency measure when the pollution levels are expected to be very high, such as in winters. Regularizing it or its frequent use may only reduce its impacts, unless public transportation is improved, and sales of alternative vehicles are checked.

Further, TERI recommended that alternative solutions such as 'congestion pricing' must be introduced to increase effectiveness and sustain the gains accrued from the odd-even. The detailed breakdown of TERI's research team provided a much-needed evaluation of a measure that was pitched to fight the menace of air pollution. In fact, the Graded Response Action Plan (GRAP) for Delhi & NCR finds the mention of Odd-Even Scheme, which is based on TERI report.

CHASING A PAN-INDIA DREAM OF CLEAN AIR

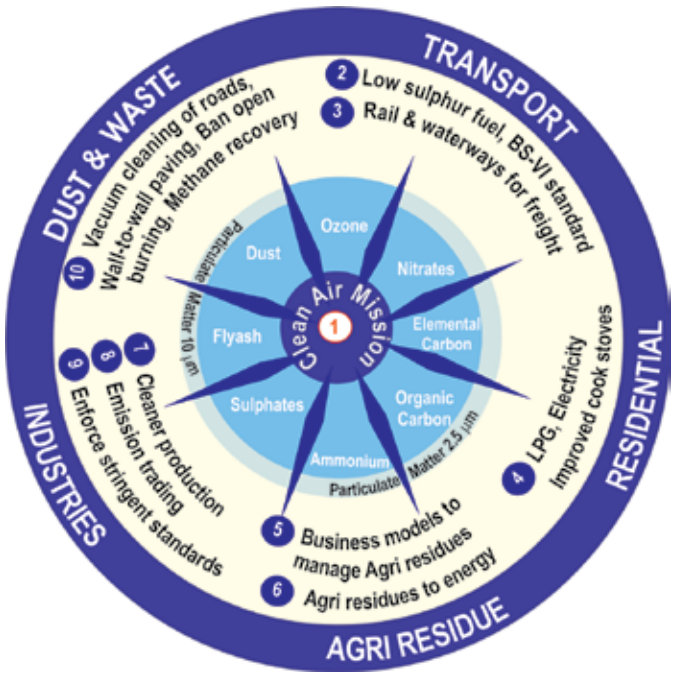
Come winters, and Delhi is engulfed in a thick cloud of toxic air. Hazy sky and low visibility pervade. In the last few years, the polluted air has become the grim reality of the national capital. Back in 2017, several Sri Lankan cricketers fell sick during a test match in Delhi when pollution hit severe levels. Today, respiratory problems are escalating. Schools are forced shut.

The scenario has now spread to the other parts of the country too. In this backdrop, India's initiatives in promoting cleanliness and addressing various environmental challenges through initiatives like Swachch Bharat (Clean India) is a step in right direction and should be leveraged upon.

However, an index to measure air pollution is needed to initiate action, which is nationwide and multi-sectoral.

Ten Scalable Solutions for Indian Cities

To address the worsening air quality, TERI in 2016 came out with a report listing the solutions to the prevailing crisis. Titled *Ten Scalable Solutions for Indian Cities*, the report was a collaborative effort of TERI, United Nations Environment Programme (UNEP) and University of California, San Diego.



The ten solutions were developed for six key sectors—Transport, Residential, Industries, Agriculture-Residue Burning, Dust, and Waste.

Considering the enormity of the challenge, and the trans-boundary nature of air pollution the report, among other things, strongly recommended the setting up of nationwide clean air mission (CAM-India). The targets for the CAM-INDIA were particles referred to as PM_{10} to $PM_{2.5}$ and ozone.

The self-organized task force synthesized available data on sources of air pollution, its transport over long distances, the impact on public health, food production, regional climate, to arrive at these solutions that have the potential to significantly reduce air pollution in Indian cities and states.

In the interim report, the team focused on the winter season in Delhi and Uttar Pradesh since it was during this period the worst pollution episodes were experienced. Additionally, these areas suffered acutely from air pollution.

The report advocated that by prioritizing improved governance and multisectoral coordination, the Indian Government can create a comprehensive and sustainable framework to combat air pollution. This approach aligns with the interconnected nature of environmental issues and underscores the need for collective action at various levels of governance.

The team's strategic thinking is on the line that if we can drastically reduce winter pollution, we can effectively solve the problem for the entire year.

Tracing the pollutions woes of California

It was in the summer of 1943 when 'The Golden State' of California in the United States of America (USA) first experienced 'smog'. Visibility in the city of Los Angeles reduced to three blocks, people suffered from burning eyes and lungs, and nausea. The phenomenon was termed a 'gas attack' and blamed on a nearby butadiene plant.

However, the smog didn't ease even when the plant shut down. It forced the city to take rapid measures, be it establishing the Los Angeles County Air Pollution Control District or regulating smoke-belching power plants and oil refineries. It was only in the early 1950s could the real reason behind the persisting smog be identified—the automobiles. It prompted the officials to launch a series of statewide measures, which included establishing the first tailpipe emissions standards in the USA in 1967. By the 1980s and 90s California's cars became the cleanest in the world, and so was its fuel.

The vision of TERI team is on the lines of one which transformed California. With a concerted effort by a team of scientists, technologists, policymakers, and a committed citizenry, California managed to drastically cut its pollution. There are opportunities for India to collaborate with California as it worked to tackle similar pollution concerns.

TERI's key emphasis, too, is on improved governance and government initiatives since air pollution emissions arise from many sectors.

Government recognition

The efforts gone into the *Ten Scalable Solutions for Indian Cities* got its recognition when it was taken up by Government of India as the first report which recommended a national-level intervention in the form of programmes, such as National Clean Air Programme (NCAP).

The five-year NCAP was launched by the Indian Government to reduce PM_{10} by 20-30% by 2024 in non-attainment cities in India. Later, the Centre revised the target of reducing air pollution to 40% by 2026

The implementation of the several TERI's solutions such as wall-to-wall paving of roads, vacuum cleaning of roads, low-sulphur fuel, BS 6 standard, LPG penetration and improved cook stoves, electricity supply to residential sector along with commercial sector, emission trading and enforcement of stringent standards can be seen in various sectors such as road dust re-suspension, transport, residential, DG sets and industrial.

Waste

- DID YOU SAY GAS FROM WASTE?

DID YOU SAY GAS FROM WASTE?

In the backdrop of ever-growing population and urbanization, Indian cities face a daunting challenge of waste management. The past years have witnessed a sharp increase in waste generation, a trend which is only going to see a spike in the near future.

As per government estimates, about 65 million tonnes of waste is generated annually in India, and over 62 million tonnes of it is municipal solid waste or MSW (organic waste, recyclables like paper, plastic, wood, glass, etc.). Only about 75–80% of the MSW gets collected; out of this only 22–28% is processed and treated. The remaining MSW is deposited in the dump yards. By 2031, MSW generation is projected to increase to 165 million tonnes, and further up to 436 million tonnes by 2050.

The waste collection efficiency needs to urgently measure up to the waste generated in India. Currently, it ranges in 70–90% in major metro cities and is below 50% in many smaller cities.

Exploring the scope of urban waste management

In a pioneering initiative, TERI's Bio-waste Technologies team of Circular Economy and Waste Management division (CEWM) contracted a project by EverEnviro Resource Management Pvt. Ltd to tackle the pressing challenges of MSW management. It was an acknowledgement of TERI's strong knowledge in dealing with bio-waste and biomass resource mapping effectively.

Owing to the lack of standardized data, the project focused on understanding the dynamics of municipal solid waste in urban areas. The goal was to plan and establish effective waste management plants by analyzing waste segregation patterns, best management practices, and conducting biomethanation potential tests as it yields biogas that can replace conventional fuels and provides digested sludge that can be used as organic manure.

This comprehensive study also emphasized a holistic understanding of overall waste dynamics. This data-driven initiative highlighted the significance of grasping the potential of waste management in urban areas and emphasized the need for informed decision-making throughout the process.

The project started in 2022–23 when TERI and EverEnviro Resource Management Pvt. Ltd began a significant effort to improve waste management. TERI's profound knowledge in bio-waste and biogas technology research was instrumental in kickstarting this journey towards more sustainable waste practices.

The project encountered several challenges—difficulties in obtaining permissions from municipal corporations for waste access, absence of standardized market data, especially in urban and rural areas. Furthermore, there was insufficient knowledge about waste dynamics and uncertainties regarding waste segregation patterns. However, these challenges served as catalysts for innovative problem-solving strategies and active community involvement.

Employing innovative strategies

Despite facing challenges, TERI's innovative approach involved a comprehensive proximate analysis and biomethanation potential (BMP) tests on samples sourced from seven cities including Prayagraj, Meerut, Lucknow, Chandigarh, Bengaluru, Ghaziabad, and Noida for evaluating the biogas and methane production from the waste generated from urban landscapes.

The experiment assessed biogas yield from segregated organic fractions of municipal solid waste (OFMSW). Over 50 days, the innovative approach demonstrated a consistent trend where the 10% total solid (TS) samples outperformed the 8% TS counterparts in biogas production. Highlights include Bengaluru's impressive 100 L/kg biogas yield from 10% TS OFMSW, Chandigarh's commendable yields of 98 L/kg from 8% TS OFMSW and Lucknow's significant 109 L/kg biogas yield from 10% TS OFMSW.

Prayagraj achieved noteworthy results with 102 L/kg from 10% TS OFMSW. This conclusive correlation between higher TS percentages and increased biogas production underscores the success of innovative waste management strategies, paving the way for sustainable energy solutions and environmental benefits across diverse urban landscapes.

The pandemic-related disruptions notwithstanding, the team successfully engaged local communities in the waste collection process. In a noteworthy strategy dry ice preservation was implemented, demonstrating resilience and adaptability. This approach not only preserved the integrity of the collected waste samples for a critical 50-day analysis but also provided valuable insights for EverEnviro Resource Management Pvt. Ltd.

Establishing resilient waste management practices

TERI's dedicated efforts in sampling and testing MSW have been instrumental in overcoming waste management challenges and guiding strategic decisions for plant establishment. After conducting an in-depth study, developers are now prepared to design and set up plants in seven cities. Assuming that each plant is projected to have a capacity of 10 tonnes per day (TPD) of compressed biogas (CBG) production, cumulatively resulting in 70 TPD of CBG production across all plants. Additionally, each plant will have the capacity to treat around 300 TPD of organic waste, leading to significant emission reductions of 38,181 tonnes of CO_2 equivalent per annum per plant. Collectively, the seven plants will treat 2,100 TPD of organic waste and achieve an estimated annual emission reduction of 267,267 tonnes of CO_2 equivalent.

This initiative not only contributes significantly to the country's economic growth but also aligns seamlessly with the national waste to energy plan.

TERI's success in this project highlights its pivotal role in guiding stakeholders towards resilient and sustainable waste management practices. By addressing several Sustainable Development Goals (SDGs)—including SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 15 (Life on Land), and SDG 17 (Partnerships for the Goals) this initiative is making a tangible difference both in the waste management sector and at the national level.

Water Resources

- RIVERBANK FILTRATION TECHNOLOGY: AN EFFICIENT AND SUSTAINABLE WATER-TREATMENT SOLUTION
- WASTEWATER TREATMENT AND REUSE FOR INDUSTRIAL AND MUNICIPAL SECTOR
- TERI'S INNOVATIONS FOR AGRI-IRRIGATION WATER EFFICIENCY
- UNLOCKING WATER EFFICIENCY IN INDIA'S INDUSTRIAL LANDSCAPE
- REJUVENATING PONDS TO ENHANCE WATER SECURITY

RIVERBANK FILTRATION TECHNOLOGY: AN EFFICIENT AND SUSTAINABLE WATER-TREATMENT SOLUTION

India's water availability per capita has been declining due to rapid increase in population. Scanty and irregular rain patterns directly affect water availability, causing stress on groundwater availability for meeting water demand. Additionally, in India, surface water resources are getting polluted by agricultural runoff, domestic untreated effluents, and industrial effluents.

Together with the unsustainable use of groundwater, particularly in the agro sector, overuse and quality concerns have resulted in widespread depletion of available water resources.

Non-point sources, such as stormwater runoff containing high loads of silt and associated nutrients, pesticides from urban lawns and gardens, or heavy metals and petroleum hydrocarbons associated with runoff from paved surfaces are also impacting freshwater ecosystems. Despite improvements in water sources and better access to sanitation facilities, several hundred million people in rural areas still cannot access adequate water supplies.

To address these issues and meet the needs of rural areas, cost efficient, and simple implementation systems are needed. TERI has implemented Bank Filtration Systems either by upscaling them or combining them with other water treatment technologies to provide sustainable systems for dependent communities in India.

Introducing riverbank filtration to southern Indian states

When it comes to drinking water supply, rural Indian villages usually receive a mixture of public and/or private water supplies. This water is mainly from groundwater wells, piped water supplies from river or lake water. Many poor rural areas have no public supply. Private supplies are generally unaffordable, and groundwater supplies are often only intermittently available because of irregular rainfall patterns and high demand.

Communities with proximity to rivers therefore rely on untreated river water for a significant proportion of their water needs. Whereas groundwater supplies are most vulnerable to chemical contamination due to geological formations and leaching, river water supplies are contaminated with industrial wastewater and human-derived effluent, resulting in both chemical and microbiological contamination. Poor quality water is a major contributor to diarrhoea and other waterborne diseases.

The story is similar in rural farming communities. Most farmers who have small land holdings are dependent on irrigation water from either rainfall or polluted stretches of nearby rivers or lakes during dry periods.

One way to overcome these challenges is to use a natural water-treatment system that permits the cost-effective treatment and re-use of polluted surface water resources to meet the water demand for drinking, domestic and irrigation needs.

Bank filtration (BF) and or riverbank filtration (RBF) are solutions for overcoming these issues. The RBF is an alternative sustainable pre-treatment technique proven to be cost-efficient for providing safe drinking water.

TERI together with the University of Rhode Island applied for the World Bank Development Marketplace award, where the organization was selected as a finalist in Development Marketplace 2007 Global Competition in Washington, DC.

Since then, TERI has been working with the University of Rhode Island illustrating the potentials of RBF projects across southern India.

Providing safe water

In an RBF system, water is withdrawn from one or more wells near a river or lake. Wells may either be vertical or horizontal and typically are installed more than 50 m away from the river. By pumping an RBF well, the groundwater potential is lowered, and river water (together with groundwater) is induced to flow through porous riverbed sediments.

As the raw surface water travels towards the RBF well, dissolved, and suspended contaminants, as well as pathogens, are potentially removed or significantly reduced in numbers due to a combination of physical, chemical, and biological processes. The projects that were implemented using RBF technology addressed issues pertaining to clean and sustainable water supply. So far, TERI has undertaken eight projects making notable contributions.

For instance, a project funded by Ramboll Environ Foundation, USA and implemented along Sal River of Goa was to demonstrate the potential of RBF for providing clean and sustainable water supply source to the marginal farming communities with small land holdings. The project aimed at providing clean irrigation water, powered by solar energy (solar water pump) for which RBF has a great potential to deliver improved irrigation water to off-the-grid farming communities in remote areas. This conversion to green energy lowered and, in some cases, even eliminated petrol-based, carbon dioxide-emitting power sources.

Another project that involved joint efforts by TERI and BITS Pilani KK Birla Goa was awarded by Department of Biotechnology, Government of India for "Demonstration of River Sal Cleaning by Vertical Wetlands and Riverbank filtration". This project worked at cleaning wastewater from nallah reaching River Sal by combining vertical constructed wetlands (VCWs) with RBF. TERI's team treated 40 m^3 per day, through a demonstration plant which required a low energy input, being one of the most cost-effective wastewater technologies, and easy to operate.

While collaborating with NIT, Goa and Ennovation Stack, TERI team worked to provide clean water to farmers using bank filtration technology along with renewable electric power to off-the-grid farmers for irrigation purposes thereby reducing stress on current electricity infrastructure. It was also designed to provide an effective solution for water use by farmers using Internet of Things (IoT)-based systems. The lake bank filtration was successfully demonstrated and implemented to meet the demand of the marginal farmers who were dependent on polluted lakes in Goa. TERI also joined the Indo-German Competence Centre for Riverbank Filtration, which is funded by the Federal Ministry of Education and Research (BMBF) of Germany, to exchange knowledge and strengthen its expertise.

TERI has made a commendable impact on society through its projects and will continue to contribute to provide sustainable water supply solutions.

WASTEWATER TREATMENT AND REUSE FOR INDUSTRIAL AND MUNICIPAL SECTOR

India, the world's most populous country, is also among the most hit by water scarcity. Once the summer hits this sub-continent, the situation turns dire. Despite having 18% of the world's population, India has only 4% of its water resources, making it among the most water-stressed countries in the world.

The industrial sector is the second-highest user of water after agriculture, consuming 8% of the total freshwater withdrawal. Today most industries for manufacturing processes rely on fresh sources of water such as rivers and groundwater, prompting an unfettered draining of groundwater sources. With the escalating scarcity and cost of freshwater, required to have a more reliable source of water with reuse of 'treated wastewater' from effluent and sewage treatment plants (ETPs and STPs).

An alternative source of treated water is available from STPs. However, conventional STPs rely on biological treatment systems, necessitating large land footprints and long treatment times on an average between 24 and 48 hours. This results in substantial resource and energy consumption.

Hence, there is an urgent requirement to integrate innovative approaches and advanced technologies into existing systems to address these shortcomings.

TADOX for Swachh Bharat Mission

Driven by the ambition to craft tailor-made solutions for various industries for wastewater treatment, TERI researchers have done rigorous assessment and analysis to not only reduce wastewater issues but also help industries comply with government's discharge regulations and norms. The hard work resulted in TERI's patented technology, TADOX® (TERI's Advanced Oxidation Technology) that treats municipal and polluted industrial wastewater having

issues of high colour, COD (chemical oxygen demand), BOD (biological oxygen demand) and dissolved organics which cause environmental and health hazards. The treated water quality is also cost effective, reducing 30-40% capital expenditure (CAPEX) and operational expenditure (OPEX), fostering a win-win situation for both businesses and the environment.

TADOX's® efficacy was first proven at a 10-kLD TADOX®-based wastewater treatment plant commissioned in August 2020, treating mixed sewage at TERI Campus in Gwal Pahari. It is directly collected from the underground sump and no stream segregation is required. Direct TADOX treatment is given which takes only a few hours without any biological treatment before or after this. The treated effluent from this plant has been tested from NABL-accredited laboratory which is fit for high end re-use application. The compliance certificates have been obtained for reuse of this treated water for meeting norms for Land Irrigation as per GSR 422 (E) and Green Building Wastewater Management.

In fact no stream segregation, reduced treatment time, smaller footprint are some of the key features which make this technology a path-breaking initiative for installations in commercial and housing complexes for treatment and high-end reuse applications.

TADOX's contribution in National Mission for Ganga: NMCG-TERI CoE on Water Reuse

Looking at TERI's pioneering work in water reuse with its advanced wastewater treatment technology TADOX® that makes ZLD more affordable and sustainable while boosting treated wastewater reuse.

The NMCG established a dedicated Centre of Excellence (CoE) with an aim to drive research and innovation by identifying knowledge gaps and fostering new ideas. The goal is to support targeted research and nurture innovation for developing cost-effective wastewater treatment technologies, promoting the reuse of treated water.

First pilot demonstration for textile sector

At the heart of TADOX's success is TERI researcher, Dr Nupur Bahadur who headed the research project under the Water Mission, Water Technology Initiative (WTI) Programme of Department of Science and Technology (DST), Government of India during July 2017-July 2020.

The core emphasis of the research was to devise clean and sustainable technology for treatment of industrial effluents, sewage and municipal wastewater, open drains, and landfill leachate.

TERI commissioned a 20-kLD TADOX Plant to treat textile industry wastewater that was polluting the river, Ganga. The innovative technology was set up at a Common Effluent Treatment Plant (CETP) in Rooma Kanpur—a textile hub—under the Namami Gange Programme by National Mission for Clean Ganga (NMCG). This textile cluster is a significant contributor to the local economy, housing 11 large cotton and hosiery dyeing and finishing units. It generates around 1.55 MLD of wastewater.

Additionally, the threat of wastewater generated from the textile and dyeing industry is huge. The textile wastewater effluent contains odour, colour and high amounts of chemical reagents, suspended and dissolved solids, high BOD and COD, causing damage to the environment and human health.

Rooma plant's wastewater treatment process did not meet the CPCB discharge norms. To optimize their wastewater treatment efficiency, to improve the quality of treated water, and increase water reuse efficiency, phase I of the project was sanctioned by NMCG to demonstrate TADOX® at an on-site pilot of 20 kLD capacity in a textile CETP Cluster in Kanpur.

During TERI's engagement with the Kanpur textile project, there was a significant lack of awareness among workers and their families regarding the environmental and health risks associated with the inadequate treatment of wastewater using conventional methods.

After six months of operation, the TADOX® plant in Rooma showcased remarkable efficacy in removing colour and various pollutants, ensuring compliance with stringent regulations. This success prompted the release of a policy brief advocating for the integration of TADOX® for achieving net-zero wastewater treatment. Drawing on life cycle assessment (LCA) findings and the benefits of TADOX® integration, the brief underscores its cost-effectiveness, with operational expenses reduced by 30% and greenhouse gas emissions by 32%.

Enhancing wastewater treatment efficiency

By leveraging Advanced Oxidation Photocatalysis treatment, the TADOX® significantly enhances wastewater treatment efficiency, addressing complex pollutants inherent in textile industry effluents. Through innovative approaches that minimize chemical usage, TADOX® promotes resource conservation and mitigates the generation of sludge, thereby preventing potential secondary pollution. The treated water from the plant also holds potential for enhanced water reuse within the textile industry, fostering sustainable water management practices.

TADOX® stands as one of TERI's pivotal sustainable solutions for the market, showcasing a proactive approach towards sustainable development.

TERI'S INNOVATIONS FOR AGRI-IRRIGATION WATER EFFICIENCY

India's agriculture sector, which accounts for nearly 85% of the total water withdrawals, grapples with challenges like water scarcity, environmental degradation, and low productivity. Inefficient irrigation practices exacerbate these issues, especially in states like Punjab and Maharashtra, where water-intensive crops strain already dwindling water resources.

TERI has created innovative solutions to enhance water-use efficiency in irrigation and promote sustainable practices.

Interventions in Punjab and Maharashtra

Recognizing the urgent need for action, TERI has collaborated with policymakers, farmers, and technology partners to promote water-saving and climate-resilient technologies.

In Punjab, TERI has partnered with Punjab Agricultural University and ITPI on a World Bank-funded project to introduce water and energy-saving practices in selected areas.

Another project in Maharashtra was undertaken in collaboration with Cenergist Ltd and Jain Irrigation Systems, funded by GITA, Department of Science and Technology, to develop a device which can further enhance the water and energy savings in a micro-irrigation system.

Demonstrating effective water management practices in Punjab

In 2018, the Punjab Government initiated a scheme to tackle the interconnected challenges of declining groundwater levels, escalating electricity consumption, and the growing fiscal strain of power subsidies in agriculture.

To address these issues, a pilot of the Direct Benefit Transfer for Electricity (DBTE) scheme or Paani Bachao Paise Kamao (PBPK) scheme was launched in three selected feeders in Punjab. TERI's purpose was to assist the Government of Punjab and the Punjab State Power Corporation Ltd (PSPCL) in refining the scheme based on insights gained from the pilot, thus facilitating its broader implementation across the state. The scheme's objective was to incentivize farmers to improve their agricultural groundwater usage efficiency by offering financial rewards.

In collaboration with its partners and the government, TERI devised a comprehensive package of interventions to reduce water withdrawals through on-farm practices. To showcase their effectiveness, demonstration farms were established across different villages, engaging farmers directly in the process.

Through the adoption of practices such as alternate wetting and drying (AWD), plotting, laser levelling, and the installation of underground pipeline systems, significant water and energy savings were achieved, in the cultivation of water-intensive crops like paddy and wheat. Farmers received on-field

training and regular guidance from experts, empowering them to implement these water-efficient practices on their own farms.

Additionally, TERI conducted research on further improving the water-use efficiency in micro-irrigation In Maharashtra. A pressure-independent flow controller, designed to optimize water distribution, was tested rigorously in both laboratory and field settings, with a focus on suitability for Indian irrigation conditions.

Through multiple rounds of testing and refinements, the device demonstrated remarkable potential in enhancing water efficiency. Its application promises to revolutionize micro-irrigation systems, ensuring precise water delivery while minimizing waste.

Impressive results in Punjab

The results in Punjab were impressive, demonstrating significant water and energy savings in both the Kharif (2018) and Rabi (2018-19) seasons in the selected areas in the districts of Jalandhar and Hoshiarpur.

Adoption of water-efficient practices on 17 demonstration farms led to savings, ranging from 6% to 30% in Kharif and 5% to 21% in Rabi, compared to controlled farms. These findings showed that water conservation could get a huge boost if the measures were implemented statewide.

Scaling up to feeder level from demo farms

The demonstration indicated that there were electricity and water savings, which when upscaled to the feeder level can have a huge impact on water usage. The percentage savings range is given below:

Intervention-wise potential water savings range from demo farm experience:

Intervention	Potential saving (kL)
Short/medium-duration paddy varieties	10-15%
Alternate wetting and drying	10%
Happy seeder	5-21%

The feeder water usage in 2019-20 was also considered to further estimate the potential of water that can be saved due to the above interventions.

Water withdrawal for irrigation was reduced in the range of 26% to 47% which will indirectly help in improving the water situation in the region.

Water withdrawal can be further reduced if farmers aptly follow the suggested interventions. In Bambiwal-1, the savings range from 17,72,776 kL to 30,42,945 kL if farmers switch to short/medium-duration paddy varieties from long-duration varieties, undertake alternate wetting and drying in Kharif season, and sow wheat by Happy seeder in Rabi season. Similarly, the savings could range from 19,64,746 kL to 33,72,459 kL in Dhanoya and 21,17,363 kL to 36,34,423 kL in Nawajipur.

Financial gains

Furthermore, farmers participating in the PBPK scheme realized financial gains by embracing these practices, highlighting the dual benefits of environmental and economic sustainability.

In different feeders, the incentives given under the PBPK scheme per brake horsepower (BHP) increased from the year 2018 to 2019.

In Bambiwal-1, the average per BHP incentive increased from INR 384 in 2018 to INR 980 in 2019 during paddy season and from INR 129 in 2018 to INR 318 in 2019 during the non-paddy season.

In Dhanoya, the average per BHP incentive increased from INR 379 in 2018 to INR 465 in 2019 for the paddy season and in the non-paddy season, it increased from INR 113 in 2018 to INR 125 in 2019.

In Nawajipur, the average per BHP incentive increased from INR 238 in 2018 to INR 332 in 2019 during paddy season and from INR 130 in 2018 to INR 137 in 2019 in non-paddy season.

Promising results in Maharashtra

In Maharashtra, TERI's project focused on developing a water flow controller designed for micro-irrigation systems. The results were remarkable. The flow controller maintained a constant flow with a variation of less than 2%, outperforming traditional spring-based controllers that exhibit variations ranging from 8% to 15%.

Additionally, the innovative controller achieved water savings of up to 12% compared to systems equipped with spring-based controllers. Not only did it conserve water, but also contributed to a reduction of approximately 4% in overall power consumption, showcasing its potential for enhancing both water conservation and energy efficiency.

Promoting sustainable agriculture

TERI's initiatives demonstrate the feasibility and benefits of enhancing water-use efficiency in agriculture. Beyond water conservation, these efforts contribute to increased productivity, cost savings, environmental protection, and climate resilience.

By aligning with Sustainable Development Goals and promoting resilient communities, TERI has shown the way for a more sustainable future in agriculture.

UNLOCKING WATER EFFICIENCY IN INDIA'S INDUSTRIAL LANDSCAPE

India's burgeoning population and rapid industrial expansion has made water conservation a necessity. Water-intensive industries stand out as significant players with both economic clout and environmental impact.

Under the National Water Mission (NWM), the Government of India aims to develop a framework for optimizing water-use efficiency by 20%.

In the absence of an established national guideline or sector specific benchmarks on industrial water use, the implementation of water-conservation and efficiency measures remains a pipedream.

Landmark effort

To address the escalating water usage within India's water-intensive industries, TERI, supported by the NWM, has undertaken a pioneering initiative which started in 2016.

Through a comprehensive evaluation of key sectors, including thermal power plants, textile industries, pulp and paper industries, and iron & steel industries, TERI aims to set benchmarks and pave the way for enhanced water-use efficiency across the industrial landscape.

TERI's approach encompassed technical assessments, 24 field (industrial) water audits, stakeholder consultations, and policy analysis to unearth opportunities for water savings and efficiency enhancements.

Through rigorous evaluation, the project identified a range of interventions, from technological upgrades to policy recommendations, tailored to the specific needs of each industry.

Substantial opportunities

The assessments revealed substantial opportunities for water savings, with potential interventions ranging from 10% to 40% in water consumption.

Specifically, in each of the selected sector, the following interventions were recommended:

Thermal power plants

Short-term interventions: Recirculation (~70%) of water in ash-handling system; increasing the cycles of concentration (CoC), up to 6 in cooling system, and reuse/recycle of wastewater (zero discharge)

Long-term interventions: Switching from wet ash-handling to dry ash-handling system and shifting from conventional wet cooling to dry cooling system.

Pulp and paper industries

Short-term interventions: Reduction of nozzle size in paper machine and reusing at least 50% of the wastewater being discharged from the mill.

(While most of the integrated mills were already reusing about 50% of their wastewater, refractory ceramic fibre (RCF) mills were yet to adopt this intervention in a significant manner).

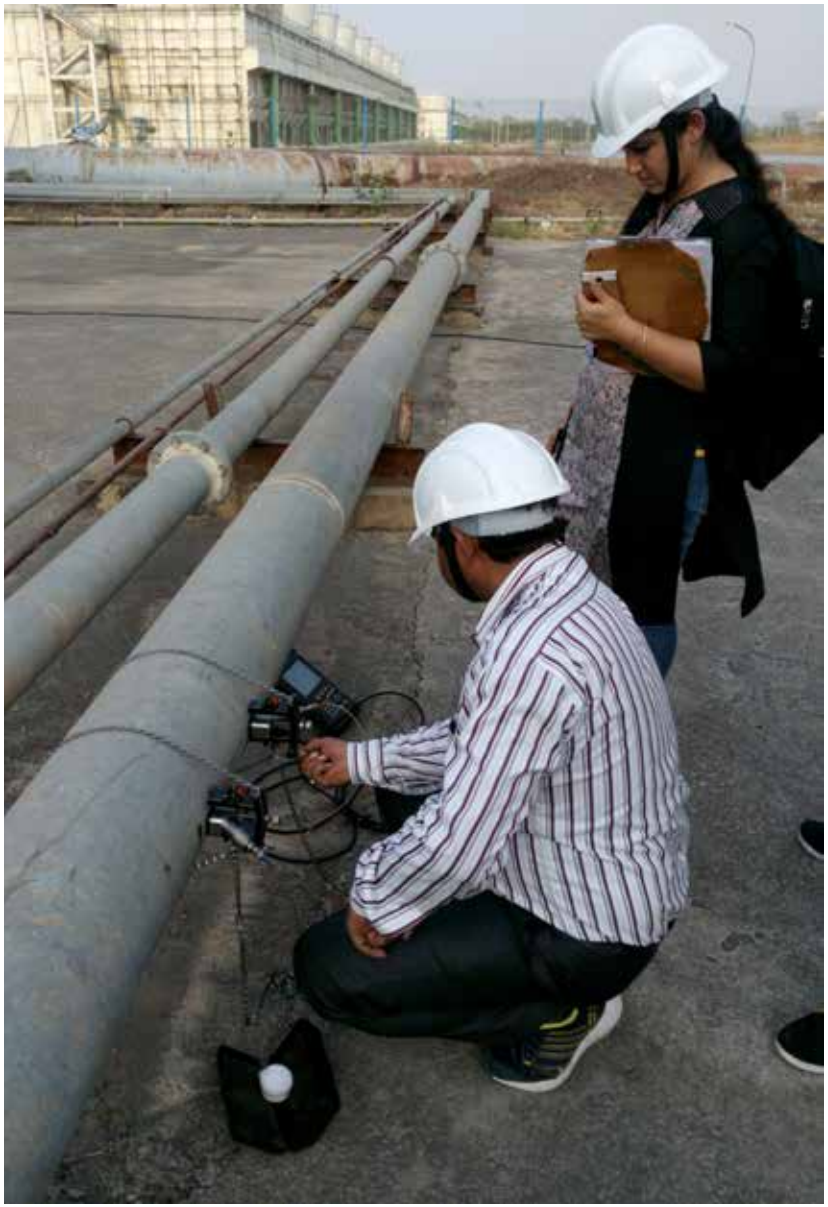
Long-term interventions: Reclamation of processed water save all clarification system and poly-disc filtration system along with approaching ZLD.

These measures promised substantial water savings in both the categories of the mills.

Textiles industries

Significant water savings can be achieved through

- Recycle and reuse of wastewater
- Replacing the existing washing machines with highly efficient computer-integrated machines (CIM)



However, a few opportunities exist within the processes, such as reusing water from pre-treatment processes, reusing final rinse water from dyeing for dye bath makeup, etc., which could as well be adopted to achieve immediate water savings.

Iron and steel industries

Water-saving interventions that hold significant potential include

- Switching to coke dry quenching (CDQ)
- Reusing/recycling wastewater

Although cost-intensive, they can be effective in improving the water-use efficiency in the iron and steel plants.

Existing specific water consumption and potential benchmarks for different industrial sectors:

Industry	**Sub-industry type**	**Existing specific water consumption (SWC)**	**Achievable benchmark SWC**	
			Short-term interventions	Long-term interventions
Thermal power plants (m^3/MW)	Small (up to 1000 MW)	2.3–3.9	1.5–3.4	0.5–2.7
	Medium (between 1000 and 2500 MW)	1.9–6.5	1.3–3.0	0.3–1.6
	Large (2500 MW and more)	3.0–3.2	1.5–2.0	0.6–1.7
Pulp and paper (m^3/MT)	Integrated mills	30.5–33.0	29.2–32.2	13.0–14.5
	RCF-based mills	9.9–13.0	7.1–9.9	4.0–7.8
Textiles (m^3/MT)	Integrated industry (cotton)	104.1–343.5	104.1–182.5	
	Fabric-processing industry (cotton)	51.1–97.5	51.1–74.0	
	Integrated industry (woollen)	237.1	185.6	
Iron and steel (m^3/MT)	Iron and steel	5.3–7.7	3.9–6.1	

Significant financial benefits

The project further assessed cost-effectiveness, indicating significant financial benefits for industries adopting water-saving measures.

For example, in thermal power plants—ash water recirculation enhancing the CoC and implementing wastewater recycling/reuse can lead to substantial cost savings, offering attractive financial advantages and favourable payback periods.

A rough estimate indicates that adopting these short-term interventions can yield a collective average monetary benefit of about INR 30 crore/year with an accompanying water savings of nearly 10 million m^3/year.

Similarly, in pulp and paper industries, adopting practices such as nozzle size reduction in jet showers and process water reclamation through poly-disc filtration systems reflects considerable water savings in a very short period. The technology of poly-disc filtration has a payback period of less than 2 years in integrated mills and about 8 years in RCF-based mills.

In the textiles industries, counter current in wet processing, adoption of CIMs, and reuse/recycle of wastewater can bring down the specific water consumption significantly while also having some financial benefits.

Similarly, for the iron and steel industries, use of CDQ can be costly but can lead to huge financial savings with attractive payback periods. The major source of savings comes from electricity generation and reduction in coke consumption in blast furnace.

Beyond monetary gains, the initiatives promise multifaceted benefits, including water conservation, energy efficiency, environmental protection, and enhanced social responsibility.

The project also looked into the best international practices which can be adopted in India to further improve the water use efficiency in the industrial sector.

Interventions for improving water-use efficiency in water-intensive sectors:

Thermal power plants

» **Ash-handling process**
- Increasing recirculation rate of water from the ash dykes
- Switching to high concentration slurry disposal system (HCSD)
- Shifting from wet ash-handling to dry ash-handling

» **Cooling system**
- Increasing the CoC (up to 6) in cooling system
- Wet cooling to dry cooling systems where it is feasible
- Shifting to closed-cycle cooling system from once-through cooling system

» **Wastewater reuse/recycling (zero discharge)**

Pulp and paper industries

» **Pulp mill**
- Dry debarking
- Improving pulp washing technology such as using twin-wire roll press washer, belt washing, etc.
- Utilizing membrane filtration in de-inking plant and improving technology of de-inking plant
- New technologies like flash condensing steam and dry pulp

» **Paper machine**
- Reduction of nozzle size in paper machine
- Recirculation of sealing water
- Turbo air blowers
- Process water recirculation
- Save all clarification system
- Disc filtration system

» **Wastewater reuse/recycling (zero discharge)**

Textiles industries

» **Washing machine replaced with highly efficient CIM machine**
» **Use of counter current washing in continuous wet process**
» **Opportunities in pre-treatment and dyeing process**
- Reuse and recycle of pre-treatment process water
- Adoption of cold pad batch technology for dyeing, and others like winch dyeing, beam dyeing, jig dyeing, cheese dyeing, etc.

» **Wastewater reuse/recycling** (zero discharge)

Iron and steel industries

» **Coke dry quenching**
» **Dry gas cleaning system for submerged arc furnace (SAF)**
» **Considering emerging technologies**
- The latest emerging technologies like water spray dry cooling (WSDC)
- Optimizing nozzle design and placement
- Using nano-fluid mix for casting

» **Wastewater reuse/recycling** (zero discharge)

TERI's endeavours in benchmarking industrial water-use efficiency not only contribute to the goals of the National Water Mission and Sustainable Development Goal 6 but also pave the way for sustainable industrial development.

REJUVENATING PONDS TO ENHANCE WATER SECURITY

Ponds are valuable water-storage reservoirs, especially in regions with erratic rainfall patterns or water scarcity. Rejuvenating ponds help in conserving water for various purposes like irrigation, livestock watering, and household use, especially during the dry spells. Well-maintained ponds can facilitate groundwater recharge by allowing surface water to percolate into aquifers.

Pond rejuvenation in India is crucial for ensuring water security, biodiversity conservation, climate resilience, cultural preservation, livelihood support, and water quality improvement.

Recognizing critical role of ponds

In a concerted effort to address the pressing issue of declining groundwater levels and water scarcity in selected villages, a transformative initiative to restore and rejuvenate ponds was undertaken by TERI. It was supported by UBL in the year 2018.

Recognizing the critical role of ponds in conserving rainwater and replenishing groundwater, the project aimed to not only safeguard water resources but also enhance the aesthetic appeal of village surroundings by 2020.

Eight ponds were identified and rejuvenated in the districts of Ludhiana and Patiala (Punjab) and Shahjahanpur (Rajasthan). The process involved a multi-pronged approach, encompassing community engagement, ecological restoration, and sustainable management practices.

The budget for implementation varies depending on the size, volume, and scope of work, depending on its the size and volume. It takes about eight months to rejuvenate one pond.

Local communities were actively involved from planning and implementation to maintenance and monitoring. The Village Development Committee (VDC) was formed to engage the villagers and sensitize them on the importance of pond rejuvenation and water conservation.

State of a pond: Before (L) and after (R) restoration and rejuvenation

Ecologically sensitive techniques, such as desilting, revegetation, and the introduction of filtration systems, were employed to enhance the ecological integrity of the ponds while ensuring long-term sustainability.

Steps undertaken to rejuvenate the ecological health, functionality, and visual appeal of ponds:

Dewatering and desilting: Lowering water levels in ponds facilitated ecological health and water quality improvement by removing accumulated sediments, organic matter, and debris, thus restoring depth and storage capacity of the pond.

Bank stabilization: Preventing accelerated bank erosion through measures like vegetative buffering, rock lining, or gabion walls, maintained bank integrity and prevented sedimentation.

Vegetation management: Vegetation was managed within and around the pond as it is crucial for ecological balance.

Hydraulic structures: Spillways, weirs, and outlet pipes were installed to ensure proper water flow and flood prevention, maintaining consistent water levels, and controlled excess water release.

Community engagement: Collaboration with grassroots and local communities fostered project success. This was done by creating a sense of ownership and involvement in the planning and implementation phase of the project.

Creating a water secure future

The project's estimated water-recharge potential is substantial, with approximately 1,951,475 kilolitres (kL) per year across the rejuvenated ponds. This comes to 587,439 kL/year in Ludhiana, 896,772 kL/year in Patiala, and 467,264 kL/year in Shahjahanpur.

Moreover, the initiative has led to increased awareness and engagement within the community, fostering a sense of responsibility towards water conservation and ecosystem preservation.

The rejuvenation of ponds represents a crucial step towards sustainable water management and ecosystem conservation in rural areas.

By conserving rainwater, replenishing groundwater, and enhancing the aesthetic value of village landscapes, this initiative not only addresses pressing water challenges but also fosters community resilience and well-being.

Biotechnology

- BIOREMEDIATION OF OIL SPILLS AND OIL-CONTAMINATED SOIL BY OILZAPPER
- PREVENTION OF PARAFFIN DEPOSITION IN OIL WELL TUBING
- MEOR: RECOVERING THE OIL FROM THE STRIPPER WELLS
- DEVELOPING CLEAN ENERGY THROUGH COAL BED METHANE
- INTEGRATED PRODUCTION OF ALGAL BIOFUELS AND BIOCOMMODITIES

BIOREMEDIATION OF OIL SPILLS AND OIL-CONTAMINATED SOIL BY OILZAPPER

Oil spills are a worldwide phenomenon that poses a major threat to the ecosystems. Despite the efforts of the petroleum industry and consumers,oil spills throughout the country are increasing.

Aside from oil spills, oil refineries produce a significant amount of toxic hydrocarbon waste that must be managed in an environmentally responsible manner. Physical (storing oil sludge and drill cutting in secured pits) and chemical techniques of removing these hydrocarbons are costly and harmful to the environment.

Oilzapper: TERI's patented technology for cleaning oil spill

In 1992, just after the first Gulf War, the Department of Biotechnology, Government of India, initiated a programme on Petroleum Biotechnology. TERI, with the support of the Department of Biotechnology, came out with its invention called, 'Oilzapper'. The technology was developed after six years of extensive research by a team of scientists led by Dr Banwari Lal, Senior Diirector at TERI.

Oilzapper was developed by the assembly of five natural occurring bacterial species which could biodegrade different fractions of crude oil and oily sludge (hazardous

hydrocarbon waste generated by oil refinery). In this cost-effective technology, Oilzapper is immobilized onto a carrier material which is powdered corn cob for its application in an oil-contaminated environment. The products of biodegradation of oily sludge are carbon dioxide and water.

Oilzapper is used for clean-up of oil spill sites, treatment of oily sludge (hazardous hydrocarbon waste generated by oil refineries) and oil-based drill cuttings.

Reviving the ecology and livelihoods

TERI has developed a fermentation facility of different capacities fermenters ranging from 150,00 litres, 1,500 litres, 300 litres, 100 litres to 30 litres, 10 litres, and 3 litres at TERI Gram, Gurugram, for large-scale production of Oilzapper to cater to ONGC TERI Biotech Ltd.

Because most oilfields are in the farmers' fields, there are regular episodes of oil spills as a result of day-to-day activities. Farmers were previously losing a source of income during numerous crop seasons. However, following the usage of Oilzapper via Bioremediation, the oil spilt land is treated, recovered, and returned by ONGC TERI Biotech Ltd to the farmers for their livelihood.

Those who depend on fisheries for livelihood also lose their jobs because of oil slicks in rivers and lakes. Oilzapper was used to cleanse water in numerous lakes around India. As a result, Oilzapper has played an important role in recovering the ecology and livelihoods of many fishermen and farmers, whose land was damaged by an oil spill. It is an outstanding example of science being used for the benefit of humankind.

Enduring legacy

Oilzapper has been successfully used by various oil companies across India as well as abroad. The users of Oilzapper are all major oil companies in India and abroad, such as ONGC, IOCL, BPCL, HPCL, OIL India Ltd, Numligarh Refinery, Bharat Petroleum Corporation Ltd, Tata Power, Reliance Industries, BG Exploration and Production India Ltd, Mangalore Refinery & Petrochemicals Ltd (MRPL), Canadian Nexen Petroleum Yemen, Kuwait Oil Company (KOC), Kuwait, Abu Dhabi National Oil Company (ADNOC).

The technology has also been used in Yemen, Petromashila and for a mega project in the oilfield of Kuwait Oil Company (KOC) to treat a large oil-contaminated area of 4 km^2 in Kuwait where TERI had treated 2,17,000 m^3 soil through application of Oilzapper.

Considering the wide-scale implication of Oilzapper, TERI and ONGC developed a joint venture named ONGC TERI Biotech Ltd (OTBL) on 26 March, 2007. More than one million tonnes of oil-contaminated soil has been treated by Oilzapper till date.

It is a remarkable achievement of TERI in its fight for a sustainable future for all.

PREVENTION OF PARAFFIN DEPOSITION IN OIL WELL TUBING

Paraffins are naturally occurring organic compounds found in crude oil. Various kinds of asphaltenes and aliphatic hydrocarbons combine to form complex paraffins with extremely high melting and cloud points. Although paraffinic crude oil flows freely at high temperatures, at below 30°C temperature it begins to precipitate out and deposit on the inner wall of the oil well tubing.

These deposits keep getting thicker and complex due to deposition of asphaltenes, paraffins, clay and corrosion products being added onto them. Eventually there is a complete blockage of oil well tubing and crude oil stops flowing.

These paraffin depositions are responsible for the loss of billions of dollars per year world over due to enormous cost of prevention and remediation, reduced or deferred production, well shut-in, pipeline replacements and/or abandonment, equipment failures, extra power requirement, and increased manpower needs.

Conventional techniques for control of paraffin deposition in the oil tubing flow are extremely expensive and plagued with other associated problems. Steam, chemicals, and solvents used to dissolve paraffin deposition are also expensive, environmentally hazardous and can even be a fire hazard. In fact, pipelines at times burst due to pressure build up during the above process.

Periodic mechanical scrapping and pigging of the pipeline is currently being employed but that also requires a frequent shut down of the well, leading to production losses.

TERI's sustainable solution

Prevention of paraffin deposition in oil well tubing and flow pipelines by using microbes offers a cost-effective approach. To solve this problem, a mesophilic paraffin degrading strain(s) was developed by TERI and IRS ONGC for degradation of paraffin deposition inside the surface oil pipeline.


NATIONAL CRANE
VISUAL ENTERPRISE

After five years of research, paraffin degrading bacterial strain was developed jointly by TERI, and Institute of Reservoir Studies (IRS), ONGC, Ahmedabad. The paraffin-degrading bacterial strain, designated as PDS-10, was tested under laboratory conditions at TERI, New Delhi and IRS, ONGC, Ahmedabad. It got a joint patent for ONGC and TERI.

A memorandum of understanding signed with ONGC in 2008 permits the oil company to use prevention of paraffin deposition technologies in its various installations, assets, basins and plants, and other such technologies to be developed by OTBL in future.

A success story to cherish

The technology has been implemented in 341 paraffin mitigation jobs. It was monitored to have a success ratio of 84% with an average scrapping free period being 5-6 months against daily/alternate day/weekly scrapping of ONGC at Western Oilfield of India. The paraffin deposition was eliminated in these oil wells for more than two-and-a half years.

Subsequently OTBL did a PDB job in flowlines of ONGC, Ahmedabad Asset, Mehsana Asset. After treating a 20-km crude oil transport flow line by paraffin degrading microbes to prevent paraffin deposition at ONGC, Ahmedabad Asset, the line pressure has reduced to more than 50%.

Utilization of microbes is an economically viable and sustainable approach to prevent paraffin deposition, and a success story spearheaded by TERI.

MEOR: RECOVERING THE OIL FROM THE STRIPPER WELLS

The ageing of oil wells is a significant issue for the global oil industry. Thousands of oil wells are left dry because either they are unproductive or have scarce oil production capacity. About 30% of the oil in place must be collected for an oil well to be classified as a stripper well.

In simple language, a stripper well is an oil or gas well that is nearing the end of its economically useful life. The reason is that deep extraction reduces the amount and pressure of natural gas in the reservoir, which drives oil up to the well's mouth. Consequently, the flow of oil diminishes and ultimately ceases.

However, there is still a sizeable amount of oil in these so-called dead or stripper wells. The cost of using conventional recovery techniques might range from $140,000 to $200,000 per well. However, when the world's oil supplies run out, wells get deeper, and the temperature inside the reservoirs rises (to 120°C), these strategies lose their efficacy, and the work gets harder.

Solving the age-old problem

The Industrial Biotechnology Programme at TERI and the Institute of Reservoir Studies (IRS) teamed up to address the issue of stripper oil wells. On April 23 April 1999, they signed a memorandum of understanding (MoU) to collaborate on microbial techniques for enhanced oil recovery over a ten-year term. The same year TERI and IRS began conducting research and development to create a facultative, anaerobic, thermophilic bacterial system for microbial enhanced oil recovery. IRS and TERI provided funding for the study.

TERI and IRS, along with ONGC jointly cultured a set of microbes that could survive temperatures as high as 90°C, air pressure up to 140 kilograms per square centimetre, and strong salinity with concentration levels ranging from 4% to 8%. Techniques used earlier for oil recovery employed microbes that could bear temperatures only up to 65°C.


TERI BIOTECH LTD.
STOP
HORN

After five years of extensive joint research work between IRS and TERI, a technology known as Microbial Enhanced Oil Recovery (MEOR) was developed. This technology was then tested in laboratories of both IRS and TERI. The technology is effective in enhanced oil recovery from stripper oil wells and is used to mobilize crude oil trapped in pores in oil reservoirs.

The MEOR mechanism of extracting oil from less productive wells has solved an age-old problem that perplexed the oil industry the world over. Also called the huff-puff method of oil recovery (it involves injecting microbes and then sucking up oil), it extracts over three times the oil than any other conventional process.

To understand it better, detailed studies were conducted for secondary metabolite productions including carbon dioxide and methane that enter the pores and squeeze out every ounce of oil. Microbes also produce bio-surfactants (detergent-preparing nutrients for injection into the oil well regent-like compounds) that reduce the tension between oil and the rock surface and help release the oil. The reaction of these microbes in oil also releases alcohol and volatile fatty acids. The alcohol reduces the viscosity of oil, making it light enough to flow out. The fatty acids solubilize the rock surface and thus push oil off them. The MEOR process of oil recovery offers more advantages than the conventional methods, in addition to the added strengths of the microbes.

Microbial consortia metabolite in the oil wells thus increase the sweep efficiency of crude oil from reservoirs leading to enhanced oil production. Further investigation showed that microbes can reduce the viscosity of heavy oil. A pilot field trial for viscosity reduction of heavy oil using microbe B-90 was carried out in five wells of Becheraji and Lanwa fields of Mehsana Asset in Gujarat. Reduction in viscosity was observed in the range of 17-25% and 11-18% for Becheraji wells and Lanwa wells, respectively. Additionally, efforts are being made to organically enhance oil recovery from thermophillic oil reservoirs.

Scent of success

Microbial enhanced oil recovery technology was jointly developed and applied by IRS, ONGC, Ahmedabad and TERI in 50 oil wells of ONGC, Ahmedabad and Oil India Ltd which proved to be highly successful. More than 43,590 MT of additional oil recovery was done from 50 oil wells in six months which is equivalent to US$ 15.6 million. The researchers also succeeded in getting a joint patent for this technology.

After successful implementation of MEOR technology in 50 oil wells, a joint venture company between ONGC and TERI was created for commercial-scale application of this technology. The joint venture company today is known as ONGC TERI Biotech Ltd (OTBL).

The OTBL has applied this technology in 60 oil wells of ONGC, Ahmedabad Asset, Assam Asset, and Jindal Petroleum at Georgia. So far, the technology is being applied in 107 oil wells, and is a success story that underlines the rich legacy of TERI.

DEVELOPING CLEAN ENERGY THROUGH COAL BED METHANE

Climate change is compelling the world to radicalize the processes of energy production and consumption. Coal bed methane (CBM) has become a major energy source both in India and abroad. It is anticipated to have a big impact on the energy portfolio in the future.

Microbiological enhancement of CBM is a two-fold benefit to the environment by producing cleaner energy sources and efficient utilization of resources.

The microbial diversity of CBM wells carries the extreme potential to enhance methane production when provided with specific conditions. The process of biological enhancement of CBM can be implemented in two ways—biostimulation and bioaugmentation.

The process of biostimulation involves the amendment of nutrients for the stimulation of indigenous microbes in their natural environment. The bioaugmentation process comprises growing microbial consortia in laboratory conditions and then introducing the consortia in the well for the enhancement of biogenic methane.

Producing clean energy

The successful implementation of field jobs requires an extensive understanding of various parameters and factors that modulate CBM production.

Today, TERI, with its industrial partner, is working to decipher the microbial processes and their application in the enhancement of CBM in the CBM wells.

The journey of TERI in the field of enhanced CBM started back in 2007. TERI in collaboration with Oil and Natural Gas Corporation (ONGC) worked on a project in April 2007 to develop nutrient formulation for the enhancement of CBM using indigenous microbial diversity by conversion of coal to methane.

Similar work was initiated in collaboration with Indian Reservoir Studies in 2007 where successful development of anaerobic consortia for biological methane generation/production under subsurface conditions was performed.

Both these collaborations resulted in 2-3 folds of biomethane enhancement, resulting in efficient and clean production of energy.

Successful demonstration

TERI in collaboration with ONGC has successfully demonstrated the technology at Jharia coal mines where the reservoir temperature is greater than 50°C.

TERI delivered the technology for the development and growth of thermogenic methanogens and demonstrated successful implementation of technology at high temperatures. The projects optimized nutrient recipes for long-term enhanced CBM production.

TERI has also demonstrated the bioaugmentation process and developed two consortia, CBM50-03 and CBM50-08 at 50°C and 65°C, respectively. A successful demonstration of the developed consortia for their biomethanantion ability was done on 13 February, 2015, in collaboration with the ONGC Energy Centre (OEC-ONGC).

Lately, TERI has also worked on developing technologies to demonstrate enhanced methanation in poor, marginal, and non-producing wells.

The developed technology has been tested in the field and resulted in the enhancement of biomethane in the low-producing wells of Bokaro assets. The technology significantly helps in the efficient utilization of resources by generating cleaner fuel.

Recognition from scientific and industrial groups

To date, the developed technology has been tested in Jharia, Bokaro, and Raniganj CBM fields with ONGC and ESSAR Oil and Gas Exploration and Production Ltd.

The patent application on 'methane production from underground coal bed methane wells' was filed in India in 2016. It was granted on 26 December 2023. These developed processes have great potential and could provide a gaseous fuel that is clean and almost renewable, as large amounts of methane can be generated from small quantities of coal.

In these years TERI has received significant recognition from its industrial partners which has led to transforming the way CBM potential is viewed. Successful implementation of CBM enhancement technologies has led to efficient production of clean energy from underutilized resources.

TERI has come a long way in contributing towards catering to sustainable solutions for the development of clean energy sources and continuous efforts are being made for further enhancement in its efficiency.

INTEGRATED PRODUCTION OF ALGAL BIOFUELS AND BIOCOMMODITIES

The climate change threat from carbon emissions has made the pursuit of renewable energy paramount. Microalgae are seen to be a promising feedstock for the development of biofuels. In fact, they are tipped as a renewable alternative for transport fuels which account for 25-30% of the total global primary energy production.

Microalgae are microscopic unicellular suspensions in water. They are among the fastest growing organisms in the world. They produce oil similar to vegetable oil. Their oil yield is 10-50 times that of conventional oil crops. They can be grown in non-arable land using seawater or wastewater as water source.

Along with the lipids that would find application as biofuels, there are a number of components that make up the full composition of algae from which a variety of products could be developed. These include food supplements, animal feed, aquafeed, industrial platform chemicals, biodegradable plastics, nutraceuticals, and other novel materials. So, an integrated production of biofuels and co-product biocommodities for value addition needs to be pursued for overall economic viability.

Collaborating for renewable transport fuel

During the mid-2000s, there was a push around the world and in India to develop renewable transport fuels such as lignocellulosic biofuels and algal fuels. TERI initiated algal biofuel research through such public research grants.

Since 'climate change and sustainable development' was at the core of TERI's vision and activities, R&D on renewable transport fuels was a natural thing for TERI to get involved in and build upon. TERI collaborated with organizations such as Indian Agricultural Research Institute (IARI), Indian Institute of Technology Guwahati and Transtech Green Power Ltd, in this initiative.

The project started in 2018 and marine (isolated and domesticated) production started in 2019 onwards in the 100,000-litre scale specially designed sunlight distributed algal photobioreactor, commissioned at TERI Mumbai, Airoli.

Production and processing of marine algae

Demonstration of outdoor algal production, downstream processing technologies and development of value addition co-products as an integrated process is a key challenge facing the algal biofuel field.

TERI has set up a marine algal production and processing project site in Navi Mumbai, as part of the DBT-TERI Centre of Excellence on Integrated Production of Advanced Biofuels and Biocommodities, to address this challenge. This includes a 100,000-L (220 sq. m) algal growth system, algal harvest mechanism, industrial centrifuge that processes harvested algal slurry to wet algal paste, lipid extraction unit, lipid-solvent separation distillation system, algal inoculum development systems and a laboratory with relevant equipment.

The algal growth system is indigenously developed, based on systematic distribution of outdoor sunlight to improve outdoor productivity. Translating the high laboratory yield to outdoor productivity has been a major challenge. Outdoor sunlight is 4-5 times in excess of saturation light intensities of algae. The system has been seen to yield 1.5 times the productivity of raceway pond standard. Harvesting of algae has been a decisive barrier in the field of algal biofuels.

A viable harvest methodology has been developed based on self-aggregating features of select marine microalgae. Here harvesting is carried out in the growth system itself by a simple sweeping-collection mechanism of settled algae. A method to recover lipids without the need for drying algae has been developed. Drying requires large tracts of land or energy intensive equipment. A 100-L extraction unit has been set up based on this method that has been found to yield complete lipid recovery at lab-scale.

The extracted lipids are converted to biodiesel and are being tested for aviation fuel. De-oiled algal biomass (DAB) comprising carbohydrate fractions is processed to use as feed for biohydrogen production at pilot scale (100 L biorecator). Under other verticles, the DAB is processed by other groups and partners of TERI for development of value-addition commodities such as aquafeed, animal feed, platform chemicals, and biodegradable plastics.

Illustrating integrated production of biofuels and biocommodities

Techno-economic analysis is carried out for the various integrated production streams of biofuels and the value-addition co-products. Standard aquafeed substituted with 40% de-oiled algae has shown 80-180% more growth in tested fishes (TERI, Goa). Standard cattle feed substituted with 50% de-oiled algae has shown performance as good as that of the standard (Partner: Transtech). Food packaging bioplastics developed from de-oiled algae has shown better biodegradability and other comparable properties with other feedstock (Partner: IIT Guwahati). Cellulose nanocrystal platform chemical that offers potential for development of a number of products has been developed from de-oiled algae (Partner: IIT Guwahati).

Biofuel co-production with aquafeed shows the most viable commercial production scenario in the near/medium term at Rs 80-100/L. Challenges, however, remain in terms of sustained long-term annual yields, harvesting other types of algae and more/advanced value-addition streams.

Beta-carotene, an antioxidant, and Vitamin A precursor nutraceutical, is being developed for commercial application. Outdoor production of beta-carotene alga, Dunaliella salina has been demonstrated in 350-1000 L systems. The alga has been harvested and beta-carotene has been extracted. Distributors for commercial sales have been identified with a potential investment partner lined up for commercial production.

The project helped illustrate integrated production of biofuels and co-product biocommodities from algae at scale. It helped evaluate the potential and development status of various value-addition co-products and the overall economic viability. This integrated collaborative project showed the key areas that need development and the kind of targets to strive to achieve overall economic viability. The project showed that there is potential to realize viable algal biofuel production in the foreseeable future.

A project of this this kind, in terms of integrated production and evaluation of a variety of value-addition co-products and at scale, has not been taken up at the national level so far. In fact, there have been very few like this even at the international level, thus adding to the rich legacy of TERI.

Resources and Sustainable Dvelopment

- POLICY INNOVATION OF GREEN BUDGETING

POLICY INNOVATION OF GREEN BUDGETING

Climate change, environmental degradation, and biodiversity loss are deeply impacting our society and global economy. This has brought an increased focus on the budgets in furthering the environmental and climate objectives.

In the use of budgetary policy-making tools to achieve environmental and climate goals, and formulation of sustainable fiscal policies, 'Green Budgeting' has emerged as a transformative approach.

This innovative policy framework involves the comprehensive evaluation, identification, and integration of existing fiscal and economic policies into budgeting procedures, aligning them with environmental objectives and contributing to Nationally Determined Contributions (NDCs), climate action plans, and Sustainable Development Goals (SDGs).

Drawing an action plan

TERI colleagues initiated the journey towards green budgeting in 2012, when it entered an MoU with the state of Punjab and held discussions on the subject. With the support of the Punjab State Council for Science and Technology, an 'Action Plan on Green Budgeting for Punjab, India' was formulated.

Building on the framework developed for Punjab, TERI with local partners, played a pivotal role in assisting Bihar and Puducherry in embracing green budgeting through capacity building, stakeholder consultations, and a participatory approach to budget analysis.

TERI worked with stakeholders to design a multidimensional model of green budgeting to contribute to environmental and climate-sensitive planning, resource allocation, and implementation.

While environmental regulation is the principal responsibility of environmental ministries, their locus standi in terms of implementation is limited. This is because much of the implementation lies with other line ministries or departments and public agencies. Hence, it is essential that 'environment' is mainstreamed across ministries, departments, and sectors.


PCCC
Department of Puducherry
Department of Science, Technology & Environment
THE ENERGY AND RESOURCES INSTITUTE
2nd WORKSHOP ON
GREEN BUDGETING FOR THE U.T. OF PUDUCHERRY
10th January 2024, Puducherry

Public spending and the instruments for revenue raising can greatly impact the environment and can be both beneficial and detrimental. Addressing the anthropogenic climate change, biodiversity loss, and environmental degradation requires coordinated efforts in terms of planning, coherent policy design, and system-wide approaches.

Considering the urgency due to climate change risks, planning, and self-assessment need to be done more frequently. Budget processes offer a high level of periodicity since planning is not only done annually but also throughout the year.

Simplifying green budgeting

TERI's involvement in the project was to simplify the green budgeting concept and assist the states and the union territories in its adoption. It, though, turned out to be an arduous task.

The team faced challenges in simplifying the concept due to western jargon. Capacity-building sessions became essential to overcome these hurdles. Also, such innovations require financial support to execute workshops, field work, and other processes involved. Regular sources of funding remained a persistent challenge. Undaunted, the TERI team worked with single-minded dedication to ensure the seamless integration of green budgeting into the existing processes.

For Bihar, TERI worked with the Asian Development Research Institute (ADRI) and in Puducherry with the Puducherry Climate Change Cell (PCCC). In both these units, TERI designed a multidimensional approach wherein mapping was undertaken for themes, activities, and SDGs.

Portal with toolkit on green budgeting

The TERI-led initiative involved the creation of a knowledge resource portal, further amplifying the process of green budgeting by providing a one-stop resource-based on green budgeting. The dedicated portal also contains a toolkit on green budgeting. It is the first ever toolkit on web portal on green budgeting in the world.

Bihar achieved the distinction of being the first state to embrace green budgeting and table the same in its legislative assembly, while Puducherry became the first federal unit to announce its green budget in the budget session in its legislative assembly.

The impact of green budgeting policy innovation has also been encouraging. Bihar witnessed a substantial increase in the budget from INR 5,694 crore in FY 2020/21 to INR 7,710.25 crore in FY 2023/24. The number of schemes increased from 103 to 319, and participating departments increased from 17 to 19.

Puducherry's green budget increased by 153%, from INR 191 crore in FY 2022/23 to INR 483 crore in FY 2023/24. The baseline schemes increased from 120 to 134, and participating departments grew from 9 to 15. The knowledge resource portal established by TERI further enhanced awareness and understanding of green budgeting practices; it can be accessed from <https://greenbudgeting.teriin.org/>.

The initiative's success in Bihar and Puducherry underscores the potential for systemic change, with the knowledge resource portal serving as a valuable tool for wider adoption and understanding.

Habitat

- MAHINDRA-TERI CENTRE OF EXCELLENCE: BUILDING THE GREEN WAY
- TRANSFORMING PANAJI THROUGH PULL
- GRIHA: SHAPING A GREENER INDIA

MAHINDRA-TERI CENTRE OF EXCELLENCE: BUILDING THE GREEN WAY

In India, building a house is a deep emotional investment. With people spending more than 80% of their time indoors, the building characteristics and prevailing indoor environment significantly impact them. However, we seldom think of a sustainable habitat that offers energy-efficient, resilient buildings.

In line with India's aim to reduce the emissions intensity of its gross domestic product (GDP) to less than 45% by 2030 from 2005 level, India needs Green Buildings. These Buildings use less energy, water, and natural resources, create less waste and are healthier for residents compared to a standard building.

Potential for energy savings

The building material industry is witnessing several new and innovative technologies. For example, monolithic concrete construction, which consists of creating buildings by casting all the concrete components at once, is an innovative technology for good-quality housing projects in a faster and cost-effective way.

At the same time, the houses constructed using MIVAN technology (Aluminium Formwork System that involves the use of aluminium alloy formworks for casting concrete) are warmer due to high rate of heat transfer through the structure with less wall thickness leading to higher cooling demand.

There is a massive potential for energy savings in the new construction of residential buildings. The Bureau of Energy Efficiency (BEE) even launched the Residential Energy Conservation Building Code in 2018, Eco Niwas Samhita (ENS), to enhance thermal performance and reduce energy consumption.

However, there is little support available for developing the dedicated infrastructure required for testing and validation of thermo-physical properties of materials.

Likewise, the unavailability of measured luminance data (the intensity of light emitted from a surface per unit area in a given direction) restricts the use of the CIE (Commission internationale de l'éclairage - International Commission of Illumination – technical non-profit organization) standard sky model for window design in many countries. The CIE Standard Sky type for any Indian location is unidentified.

On top of it, Indian cities are facing one of the worst water crises in history. Water-use efficiency, water harvesting and storage, and recycling and reuse of wastewater after treatment are some of the low-hanging solutions to deal with urban water challenges in Indian cities.

Aligning with SDGs

The real estate sector in India is expected to reach US$ 1 trillion by 2030. At the same time, the building sector accounts for over 30% of the total electricity consumed in the country annually. With rapid urbanization, the importance of understanding relationships between the changing urban landscape and human health and wellbeing is being increasingly recognized.

On these lines, Mahindra-TERI Centre of Excellence (MTCoE) for Sustainable Habitats, a collaborative research initiative between Mahindra Lifespaces and TERI, was established. Operational since June 2018, the MTCoE is located at TERI's Gwal Pahari Campus in Gurugram.

The primary focus of the Centre is to develop real-time solutions to foster sustainability in India's future-built environment. Additionally, it aims to curtail the energy footprint of the real estate industry.

Equipped with state-of-the-art research techniques, tools, and performance measurement solutions, the Centre is playing a pivotal role in generating performance data and metrics. The valuable insights generated are instrumental in facilitating the expansion of energy-efficient building practices across India. Furthermore, the Centre offers numerical toolkits and material databases derived from its research outcomes, serving as open-source materials accessible for public use.

Research at the MTCoE is directly aligned to the SDGs of climate action, reduction in energy demand through development of guidelines for thermal and visual comfort, and sustainable water use.

The MTCoE has achieved success in providing a diverse range of solutions, encompassing energy-efficient materials and technologies that are not only market-ready but also scalable.

Pathbreaking study

The Centre has facilitated built environment professionals to evaluate the realistic performance of homogenous materials as well as the entire walling and roofing assemblies. This enables end users to check and meet building code compliance as well as green building rating envelope requirements.

The CoE has assessed the linkage of climate change to sky condition parameters to determine how it may affect our daylight use and energy patterns inside the buildings. This is the first of its kind study in India at such a large scale, which intends to monitor the sky data of a location for at least three years and create a rich database. This study therefore lays the foundation for accurate estimation of useful daylight illumination which guides the lighting design to use maximum natural light.

The work on thermal comfort and integrated daylighting is envisaged to support ongoing government initiatives through developing prescriptive guidelines and design support toolkits. This forms the basis of climate-responsive design that can help the development of low-carbon homes for upcoming Indian buildings. Given that 70% of buildings required by 2030 are yet to be built, there is a tremendous opportunity to design better buildings using these guidebooks.

The rapid water audit of selected residential townships across the country (Pune, Nagpur, Chennai) has been conducted in order to examine their water-use pattern and management and eventually lay down generic recommendations for the townships in India to enhance their water efficiencies.

Global interest

The CoE has generated interest amongst government institutions, academia, and industry, globally. The University of New-South Wales (UNSW), Sydney, has signed an agreement with TERI to share materials across continents developed in its SM@RT center, utilizing waste, for testing thermal properties.

The collaborative research and laboratory expansion have gained support from industry partners, including Saint-Gobain Research India (SGRI) and the Glazing Society of India (GSI). This collective effort transforms the initiative into a multilateral collaboration, evolving from its initial bilateral focus.

The MTCoE has been able to establish itself as a frontrunner in the testing, analysis, and validation of building materials and envelope design. The credible outcomes have fostered confidence among the research community, students, and the green building fraternity.

TRANSFORMING PANAJI THROUGH PULL

The urban landscape in India is rapidly changing. They have become symbols of people's ambition and aspirations. In the pursuit of jobs and growth opportunities, people are overcrowding the cities and pushing their infrastructure to limits. This has raised the need to plan the infrastructure that can mitigate environmental concerns of our cities.

Most cities face the challenge of effectively planning and developing infrastructure. Finding sustainable means to do it, while dealing with the impacts of the triple planetary crisis of climate change, biodiversity loss, and pollution is a challenge.

Integrated planning is a powerful tool to ensure environmentally sensitive and just urban development. Sustainable and integrated urban design is a holistic approach that creates synergies by combining various aspects of city design and management, such as place-making, transportation, housing, health, and biodiversity.

The Project Urban Living Lab (PULL), Panaji, stands as India's premier urban living laboratory, focused on fostering sustainable and livable cities through collaborative efforts involving residents, policymakers, public bodies, businesses, and academia. Initiated under the Green Strategic Partnership between India and Denmark, PULL is a joint effort by the Royal Danish Embassy in India (RDE), Imagine Panaji Smart City Development Ltd (IPSCDL), and TERI, along with other partners.

Addressing the urban challenges

Panaji has been facing various challenges such as mobility issues, water body management concerns, and data governance gaps. For instance, the growth in vehicular numbers was causing congestion and safety hazards, while the management of water bodies was becoming increasingly unsustainable. These challenges not only impacted daily life but also hindered the overall development of the city.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As a knowledge partner, TERI played a crucial role in addressing Panaji's urban challenges through PULL. The project adopted a comprehensive approach to tackle these issues, involving stakeholders at various levels.

TERI decided to incorporate global best practices and collaborative partnerships. Reputed organizations like Ramboll and Safetipin were roped in to develop sustainable solutions. For water resilience, PULL rejuvenated the St. Inez creek using Nature-based Solutions (NbS) and conducted flood mitigation planning. In mobility, it focused on cycling infrastructure and pedestrian safety. PULL also conducted data pilots to drive evidence-based governance and planning.

Sandbox approach

TERI adopted the sandbox approach as a strategic platform to address the challenges effectively. This approach served as a valuable mechanism for diverse organizations to trial and showcase established urban solutions under realistic city-like conditions.

Through this initiative, TERI aimed to introduce innovative solutions and methodologies, enabling the city to identify and communicate its problems to relevant stakeholders equipped with proven approaches.

The sandbox provided crucial institutional, regulatory, and technical support for pilot programmes, enhancing the feasibility and scalability of implemented solutions. It brought a more sustainable and impactful transformation within Panaji's urban landscape. A participatory and inclusive approach was undertaken by working closely with the government and citizens to evaluate and determine the outcomes of these testing initiatives.

The implementation of PULL led to significant improvement in Panaji's urban landscape. The impact was felt across different sectors and at the national level too as it showcased the potential of sustainable urban development initiatives such as:

Pedestrianization of 18th June Road: Through detailed surveys, on-site documentation, and stakeholder consultations, eight key pedestrianization strategies were formulated in Panaji under PULL. These strategies aimed at creating a safe, interactive, and people-centric street environment. The plans included a pedestrianization plan, a vehicular movement plan, and an alternate parking plan.

Cycling Report for Panaji (Cycles 4 Change): Groundwork was laid for promoting non-motorized transport in Panaji under 'Cycles 4 Change' initiative. A cycling policy report based on experimentation and best practices, provided design recommendations for a cycling connector lane. This initiative aimed to nudge residents towards adopting walking and cycling as viable modes of transportation, contributing to a more sustainable urban mobility landscape.

Flood Mitigation Plan for Panaji: To address stormwater runoff and enhance climate resilience in Panaji, PULL's urban flooding plan utilized sustainable nature-based solutions (NbS). Through data-driven analyses and partnerships with experts, the plan offered short-term relief interventions and a long-term road map for integrating NbS into urban projects. This approach aimed to reduce infrastructure reliance and manage urban stormwater effectively, contributing to a more resilient and sustainable city.

St. Inez Rejuvenation Plan: The St. Inez creek rejuvenation plan focused on aligning visions and goals among stakeholders to preserve Panaji's ecology and cultural heritage. Site-specific solutions were proposed for the creek's management, integrating ecological considerations with urban development needs.

Inclusive Streets Report: PULL also addressed gender-specific mobility challenges faced by women in Panaji. Through a comprehensive framework and location-specific actions, the reports aimed to improve women's access to the city by promoting non-motorized transportation and enhancing public space safety.

Toolkit for Panaji's Nature-based Solutions: The toolkit provided a quick guide for stakeholders to leverage NbS for urban challenges such as flooding and food/water security. Highlighting the role of ecosystems like mangroves and khazan agricultural systems, the toolkit offered restoration steps and strategies to bolster the city's resilience.

Whitepaper on Developing a Data-driven Approach: PULL's whitepaper highlighted the challenges and opportunities for adopting a data-driven approach in Panaji's governance and planning. The whitepaper presented propositions to enhance technical capacities, institutional efforts, and regulations for urban data innovation.

Global Urban Solutions Knowledge Product: By aligning with SDG targets and highlighting funding sources, the document facilitated the identification and implementation of sustainable practices in smart cities.

PULL significantly contributed to Panaji's transformation towards a more sustainable, resilient, and inclusive urban environment, setting a benchmark for smart city development and fostering collaboration among diverse stakeholders.

With the strong interest demonstrated by the Danish Prime Minister on jointly working on issues of water resilience and sustainable and smart cities through the Green Strategic Partnership, PULL formally launched its website <https://urbanlivinglabindia.org/>, to disseminate knowledge on the 'urban living lab' showcasing the work in Panaji under multiple focus areas.

PULL goes to other Indian cities

PULL has played a pivotal role in advancing the concept of Urban Living Labs, setting a strong foundation for sustainable urban development. Building on this success, TERI is now working on replicating this model in three different cities: Visakhapatnam, Coimbatore, and Shimla.

By extending the Urban Living Lab model to these cities, TERI aims to harness local expertise, engage stakeholders, and tailor solutions to specific urban contexts. This expansion is a significant step towards fostering sustainable and livable cities across diverse regions, leveraging the insights and experiences gained from PULL's pioneering efforts.

GRIHA: SHAPING A GREENER INDIA

In the realm of sustainable development, green buildings and sustainable construction practices have gained significant momentum, playing a pivotal role in combating climate change. In this journey, GRIHA (Green Rating for Integrated Habitat Assessment) has been steadfastly contributing to the nation's green development. But what led to the creation of GRIHA and what motivates its efforts towards transforming the building and construction landscape in India and beyond?

Conceptualizing GRIHA

The seeds of GRIHA were sown back in the early 2000s when environmental concerns and climate change were gaining widespread recognition. The rapidly rising population and growing urbanization raise an enormous demand for buildings with subsequent pressure on the availability of resources such as water and energy.

In 2003, TERI acted as a green building consultant to CII-Godrej headquarters in Hyderabad which became India's first platinum-rated green building under the LEED (Leadership in Energy and Environmental Design) certification (a green building rating system devised by the U.S. Green Building Council). Building upon the success and learnings from the CII-Godrej project, TERI conceptualized TERI-GRIHA in 2005.

In 2007, the Ministry of New and Renewable Energy (MNRE), Government of India adopted GRIHA as the national green building rating system for the country.

Establishing credibility and transparency

GRIHA was incubated as an indigenous green building evaluation system exclusively tailored to the Indian climatic and geographical contexts. It quantifies environmental aspects such as energy and water consumption, waste generation, renewable energy adoption, social aspects, occupant comfort, etc.

to manage, control and reduce the same to the best possible extent. Based on the underlying principle of 'what gets measured, gets managed' GRIHA intends to minimize the carbon and ecological footprint of the built environment.

To implement GRIHA in India, an autonomous society known as ADaRSH (Association for Development and Research on Sustainable Habitats) was created (registered under the Societies Registration Act, 1860) in 2009 by the MNRE and TERI. It was formed to facilitate interaction on scientific and administrative issues related to sustainable habitats in the Indian subcontinent. Further, in 2015, ADaRSH was officially renamed as GRIHA Council under the Societies Registration Act, 1860.

On receiving autonomy, GRIHA Council was empowered to chart its course and pursue its mission of developing sustainable habitats with greater agility. GRIHA Council expanded its influence nationally and internationally, solidified its position, and emerged as a brand that advocates for sustainability and excellence in the built environment.

Being a credible, transparent, and reliable rating system, today, GRIHA-certified buildings serve as exemplars of environmental stewardship and architectural excellence, setting new benchmarks for sustainability and resilience. Some of the iconic projects associated with GRIHA in India and abroad include the Central Vista project, the Supreme Court of India, Bharat Mandapam, IIMs, IITs, AIIMS, ITC hotels, transit terminal, and many more.

Fostering sustainable architecture

GRIHA has maintained the relevance of its rating standards by regularly updating them and following the latest industry developments and market trends, whilst aligning itself to the vision and policies of the Government of India.

The national policies, building codes and standards such as the National Building Code, Bureau of Indian Standard Codes, and Energy Conservation Building Codes have been embedded in the GRIHA rating assessments and verification processes.

Recognizing the opportunities and constraints of varied building typologies, GRIHA Council formulated diverse rating tools (GRIHA for Existing Buildings, GRIHA for Large Developments, GRIHA for Existing Schools, GRIHA for Affordable Housing, GRIHA for CITIES, GRIHA, Simple Versatile Affordable GRIHA), which encompasses environmental and sustainability aspects such as energy and water efficiency, waste management, building materials usage, indoor environmental quality, social aspects, carbon emissions, etc.

By integrating traditional wisdom with modern technologies and innovations, GRIHA fostered a holistic approach to sustainable architecture that resonates with India's rich cultural and natural heritage.

A slew of initiatives

Aligning with India's Panchamrit climate action plan towards 2070 and Mission LiFE, GRIHA Council stepped up its scope of work by launching the Decarbonizing Habitat Programme, JAN (Jan Awas Nirman) GRIHA Certification along with Net Zero Energy, Water Positive and Net Zero Waste Certifications, an addition to the already existing strong foothold that GRIHA has in the field of green building ratings. These initiatives are envisioned to accelerate sustainable actions at the grassroots level, thereby contributing to climate mitigation and adaptation.

To provide a one-stop shop for sustainable and green building products and facilitate their adoption, GRIHA Council developed the GRIHA Product Catalogue. It is an online platform that provides all the necessary information on enlisted green building products to architects, engineers, builders, developers, other building professionals and end users.

Furthermore, through trainings, workshops, and outreach programmes, GRIHA Council has empowered professionals and communities across India and abroad to embrace sustainable building practices and contribute to the transition towards a greener and more resilient built environment.

Demystifying the idea that green buildings are cost-intensive, GRIHA Council's efforts have resulted in tax rebates for green constructions across various states in India, making sustainability more accessible to the public. The state government and urban local bodies (ULBs) offer financial incentives such as additional floor area ratio (FAR) benefits to the developers, faster approvals, tax benefits, and financial incentives to users and developers for adopting green building practices and obtaining GRIHA certification, that has further enhanced the adoption of green building practices in the country.

Widespread recognition

Over the years, GRIHA Council has steadfastly established its green footprint in the country with more than 4100 projects registered across India exceeding the 930 million square feet of built-up area.

For its efforts and contributions, GRIHA Council has received accolades and recognition at national and international platforms in spheres such as energy efficiency and efficient utilization of resources.

Extending its impact both nationally and internationally, GRIHA Council has evolved as a catalyst for the paradigm shift towards sustainable infrastructure development. Based on shared beliefs, values, vision, and goals it is committed to being at the forefront of building sustainable cities and communities.

Social Transformation

- BOATS RIDE INTO THE LITHIUM BATTERY AGE AT CHITRAKOOT
- CONTRIBUTING WITH GREEN SKILL DEVELOPMENT PROGRAMME
- EMPOWERING WOMEN THROUGH WEPS
- PRESERVATION AND PROTECTION OF TRADITIONAL KNOWLEDGE
- LIGHTING A BILLION LIVES

BOATS RIDE INTO THE LITHIUM BATTERY AGE AT CHITRAKOOT

It is hard not to fall for the beauty and charm of a boat ride; the soft parting of water, the brush of fresh wind and the time-arresting nostalgia. The romance of boat rides finds a distinct mention in the world of art and literature. The technology, however, sullied the imagery.

The advent of diesel-powered boats saved time, human energy and increased the income of boatmen. However, it took away much of the pleasure of a quiet, idyllic trip along lakes, rivers, and streams.

The diesel boats not only create stink, smoke, and oil spillage, they also generate considerable sound to make the ride uncomfortable for both human and aquatic organisms. This has become a regular feature if you visit any of the historical ghats in Varanasi, or Chitrakoot.

Identifying the problem

To address this crisis, in 2016, an e-boat project was launched at Varanasi by a local NGO, in association with boatmen. These boats were to run on lead-acid batteries, charged by the grid electricity at a centralized charging point. The advantages over diesel-powered boats were apparent: it did not emit heat, noise, fuel, and lubricant residue. And yet, it remained unpopular among the boatmen.

The cost of obtaining and the task of transporting four lead-acid batteries weighing more than 200 kg to the nearby grid electricity charging station became too much of a task for the boatmen. It did not help that these batteries needed longer charging hours, lesser energy density, and large space.

In consultation with boatmen and other stakeholders, TERI identified the problem. What was needed was a lasting, reliable supply to the trolling motor via a lightweight fast-charging battery to operate such a traditional wooden boat. Additionally, an economically sustainable business model was needed to keep boatmen's interest alive in this intervention.


Indus
TOWERS

Devising a hybrid solar-charging unit model

It was important that the solution was technologically effective while being economically sustainable. Accordingly, TERI devised a hybrid solar-charging unit model, which involves the use of just one lithium-ion battery weighing not more than 30 kg for each boat.

These storages have much higher capacity, longer cycle life, lesser weight, fast-charging rate and high energy density in comparison to lead-acid batteries. These batteries are charged at a centralized hybrid solar-charging station, located on the bank of the river. Boatmen can rent batteries and recharge these at hybrid solar-charging stations operated and managed by the boatmen association.

The expenditure of retrofitting and those associated with the charging centre are financed by the corporate social responsibility (CSR) fund mobilized by TERI. A local energy entrepreneur, selected by TERI, oversees installation of trolling motors and lithium batteries in the boat along with the required after-sales services. The battery, which takes about 2–3 hours to charge, is attached to a trolling motor connected to a propeller, which pushes the boat backwards or forward. A single charge lasts two and a half hours, enough for a boat to complete two trips on a 10–12 km stretch.

In comparison to the traditional hand-oared boat, the initial investment for a battery-powered boat is certainly higher. But compared to boats run by diesel engines there is not much difference in capital investment. And once the initial hurdle is crossed, it is possible to earn much more in a cost-effective, drudgery-free, and environment-friendly manner.

Opening the possibilities

During this three-year project (2019-22), TERI implemented this model with the fund mobilized from Indus Towers, under their CSR initiative. So far 10 hybrid solar-charging stations, capable of recharging batteries for 50 boats have been possible at Chitrakoot and other sites. Already 10% boats in the region are functioning under this model.

Mahabir Nishad, a boat rower in Chitrakoot, tells how his life became easier using TERI-devised solar boats. "We would come in the morning and row the boat, often the sun was very harsh, and we had to toil a lot as we operated the boat with our hands. We sweated a lot. When there were floods in the Mandakini and the river flow was very fast, it was difficult for us to row the boat. Sometimes we would even fall sick," Nishad says.

"Today in the same Mandakini, dozens of solar boats are running. The efforts by TERI and Indus Towers have brought this change. Our life became easy after TERI and Indus gave us solar batteries and other facilities. Now we tell the tourists that we have this motorboat. We tell them that it will take less time and they can see more places and feel good. We had never thought that we would see this change in our life, and be able to support our family so easily," added Nishad.

In the world governed by the din and pace of technology, this TERI initiative promises the return of those pleasant boat rides where time would just stand still.

CONTRIBUTING WITH GREEN SKILL DEVELOPMENT PROGRAMME

World economies today stand at a critical juncture. The future of our work is directly linked to the future of our planet. While several countries have committed to sustainable development, it is important they redefine their economies on the lines of energy transition.

The future workforce needs to be environmentally aware, thus demanding a spurt of new jobs with green skills. It has become critical that governments focus on skill development of their young population and impart technical knowledge to effectively use green technologies.

According to the International Labour Organisation (ILO), 100 million jobs can be created by 2030 through the transition to sustainable energy sources and a circular economy.

As per United Nations Framework Convention on Climate Change (UNFCCC), some existing jobs are expected to become obsolete, and the benefits of the transition are unlikely to be distributed geographically or demographically unless young people are provided with the necessary training and support system. The transition to these jobs, however, will not happen by default. People will need new skills to tap into these new job opportunities.

Focusing on skill development

India has set an ambitious renewable energy target of 500 GW by 2030 which is expected to create a surge of investments and job opportunities. The ILO forecasts that India's shift to a green economy could add 3 million jobs in the renewables sector alone by 2030. The government, therefore, must develop training, skills, and educational programmes for green jobs.

In line with this growing need for capacity building, Skill India Mission of the Ministry of Environment, Forest and Climate Change (MoEFCC), utilizing the vast network of Environmental Information, Awareness, Capacity Building and Livelihood Programme (EIACP), and National Mission on Himalayan Studies, has taken up the initiative for skill development.


Would you like to
Environment
GREEN SKILL DEVELOPME

Drawing from its experiences at the grassroots, TERI recognized the need to train and develop the skills of technicians and rural entrepreneurs. Despite being an integral part of the value chain, there is no upscaling of this workforce. The severity of the problem can be gauged, considering that India currently faces a severe shortage of well-trained, skilled workers. It is estimated that only 2.3% of the workforce in India has undergone formal skill training as compared to 68% in the UK, 75% in Germany, 52% in USA, 80% in Japan, and 96% in South Korea (Ministry of Skill Development and Entrepreneurship). TERI, therefore, focuses on scaling up skill development efforts to drive livelihood generation and economic growth.

As part of the EIACP funded by the MoEFCC, TERI was assigned responsibility to impart training through Green Skills Development Programme (GSDP). The course curriculum was approved by the National Skill Development Agency. In all such initiatives, gender balance remained a critical consideration.

Multi-pronged benefits

TERI has already successfully conducted 25 residential GSDP—each spanning 240 hours to 300 hours for over 750 students on solar energy systems and waste management in Bihar, Uttarakhand, Uttar Pradesh, West Bengal, Tamil Nadu, Maharashtra, Meghalaya, and Jharkhand.

Unemployed youths, including standard 10th and 12th dropouts, ITI, and graduate students, learnt about solar energy and waste management technologies. The course involved training by subject experts and hands-on exposure to technologies and applications. Trainees learnt through practical sessions on installation, maintenance, and repair of solar technology appliances like solar lanterns, charge controller, solar home lighting systems, biogasifier, LED bulbs, improved cook stoves, solar pumps, and solar water heaters.

TERI also became an interface linking students to industries looking to hire such a trained workforce. Industry meets were organized for the participants under which placement brochures were distributed to the waste and solar industries with trained candidates' profiles.

The result was overwhelming. Nearly 45% of the participants who enrolled in such courses got jobs or started their own businesses. Some of these participants were also engaged as 'Master Trainers' in more such awareness programmes and in other TERI trainings in future. Through these trainings participants were fully trained through hands-on training, practical exposure, and field visits.

The GSDP initiative brought along multi-pronged benefits for society. It generated livelihood, gave unemployed participants the opportunity to learn new skills and thereby lead a meaningful life. It helped the local economy to grow. It created awareness among communities about environment and sustainability and engaged them towards the larger goal of reducing carbon footprints.

EMPOWERING WOMEN THROUGH WEPs

Women play a vital role in contributing to the economy. However, their quest to become business owners often runs into systemic barriers. Recognizing the immense potential and the need to address these limitations, numerous organizations and governments have established women entrepreneurship programmes (WEPs).

Such programmes are the need of the hour and essential in dealing with the prevalent unemployment arising in India, especially after COVID-19. During the pandemic more (72%) women-led enterprises reported cash shortages than male-led (53%) enterprises. Even as the economy recovers and enterprises get back on track, women entrepreneurs are facing several challenges.

Catalyzing women's entrepreneurship programme

The WEPs contribute to fostering a more inclusive and equitable business environment, benefiting not only women but also the overall economy and society. However, foraying into entrepreneurship is not easy for women in India. Besides various social hurdles, women entrepreneurs face challenges such as access to finance, mentorship, and training in vital business areas.

TERI launched a month-long online Women Entrepreneurship Development Programme (WEDP) in 2021 to support women facing job losses and start their own enterprise. These free programmes empower and equip women with the necessary skills, resources, and networks to thrive in the entrepreneurial landscape.

With support from the National Science and Technology Entrepreneurship Development Board (NSTEDB) under the aegis of the Department of Science and Technology (DST), Government of India, TERI organized five successful online programmes from 2021 to 2023.

The initiative was aimed to empower women in the age group of 19-45 years with science, engineering, and technology backgrounds with essential skills to conceive, plan, launch, and manage successful enterprises. The initiative featured guidance from industry experts and successful entrepreneurs, helping aspiring women entrepreneurs establish their dream ventures.

The participants were provided training on marketing essentials, digital marketing, waste management, solar energy, sustainable livelihood, and product prototype. Additionally, virtual industry visits offered participants insights into real-world operations and the use of various instruments and machines.

Creating women entrepreneurs

The programme helped women participants understand the thought processes that come with field experiences and are necessary to make a rational choice of business product line, market mix, and related aspects of the projects.

Many participants were able to start their own enterprises after attending these programmes and are contributing to the overall development of the Indian entrepreneurship ecosystem.

According to a survey, at least 30% of participants could return to the workforce post this programme. Some are promoting grassroots sustainability by developing products to minimize water pollution, or selling eco-friendly products, others are working on water management and water saving, especially groundwater crisis for agriculture and leveraging digital media platforms to help entrepreneurs to make a social impact.

This small TERI initiative has boosted economic participation of women through entrepreneurship and is an inspiring success story.

PRESERVATION AND PROTECTION OF TRADITIONAL KNOWLEDGE

Indigenous and local communities possess a treasure trove of traditional knowledge. From unique agricultural practices beneficial to the region to treatment of various ailments through use of locally found plants and herbs of medicinal value, such traditional knowledge (TK) is passed on from generation to generation.

Even though a part of this knowledge is recorded in local languages, a major portion is still not recorded and remains confined to local communities. It is, therefore, extremely crucial to preserve it in a standardized contemporary format that would be familiar and relevant to the future generations. Preservation also empowers the community to protect its knowledge from misuse and utilize it for better development.

Leveraging traditional knowledge

TERI has been involved in a project to preserve and protect the rich and diverse traditional knowledge of the North-East Region. Titled 'Preservation and Protection of Traditional Knowledge—Documentation Initiative in the North-East Region, India' is a collaborative project of Bio-Resources Development Centre, (BRDC) and TERI, funded by the North-Eastern Council, NEC, Meghalaya.

The project aims to identify, document, and preserve various traditional knowledge that existed, and the one that is still being practised at the community level. Possibilities have been explored to integrate such indigenous knowledge in school curriculum through sensitization amongst teachers and students.

Awareness campaigns were initiated for promotion of such knowledge among youth through short-term workshops at district level, publications, etc. Additionally, stakeholder and sensitization programmes were undertaken.

A core working group and project advisory committee were constituted to carry out project activities strategically and smoothly.


INAUGURATION OF THE
"HOLISTIC WELLNESS CENTRE
&

Launch of Meghalaya Traditional Knowledge Portal

To this effect, Meghalaya Traditional Knowledge Portal (MTKP) was launched in February 2024. The portal is a repository of the knowledge resources obtained and captured after field research, assessment, and surveys carried out in Meghalaya. It is being developed to provide evidence-based efficacy of the traditional healing system, traditional knowledge on sustainable agriculture, fishery, handicraft, handloom and veterinary in North-East Region and Meghalaya state in particular.

The primary data and information were obtained through field visit surveys carried out in four districts of Meghalaya—East Khasi Hills, West Garo Hills, West Jaintia Hills, and Ri Bhoi district. The Portal also provides published knowledge resources on traditional knowledge from authentic and authoritative national and international sources.

Documenting initiatives

Indigenous practices in these places were documented through videography and audiography of around 15 traditional knowledge holders. Financial support was provided to traditional healers associations for furthering their practices. Medicinal treatment, formulation and targeted line of treatment and healer's profile was documented. A concise directory of traditional healers of Meghalaya was listed.

From jaundice, kidney stones, burns, high-blood pressure, diabetes, gastritis, tonsillitis, malaria, dog and cat bites, these healers treat a variety of ailments. The 'Healers Corner' in the MTKP has profiles of these healers and their specialities.

Such data in traditional healing practices and techniques can be helpful in creating a market for herbal products of medicinal value regionally, nationally, and internationally, as with time there is an increase in the usage of these herbal products due to their efficacy.

Sukindro A Sangma, an 87-year-old from Indrapara village, was suffering from jaundice when he approached a traditional healer in his neighbourhood.

"The treatment was herbal medicine. The medicine was a dry powder. I was prescribed to take—1 spoon of the medicine mixed with 1/2 cup of water. Within 10 days I completely recovered," says Sangma in his testimonial on the website.

Similarly, traditional agricultural methods unique to the region were studied, documented, and encouraged to be practised among farmers. The traditional agriculture calendar is a traditional agricultural practice still adopted by the indigenous people of Khasi, Ri Bhoi, and Jaintia tribes in the state of Meghalaya. This

knowledge has an old history, believed by the indigenous farmers for cultivation practices and management with reference to lunar planting.

It is observed that several farmers from Khasi region adopted the method of lunar planting for banana plantation and showed significant results in respect to growth of new leaves during the ascending period. Most of the farmers from rural areas adopted this method to obtain optimum yield, production and less infestation from pests and diseases.

Bamboo drip irrigation practised in the region, where hillslopes are quite steep with low soil depth and having boulder soil, is an excellent example of sustainable agricultural practices. The system prevents leakage and loss of water on the way.

The indigenous farmers of the Jaintia Hills have the skill and ingenuity to lay out the bamboo networks with proficiency so that the sites remain intact and productive.

The preservation and promotion of the traditional knowledge, innovations and practices of local and indigenous communities, especially in the developing countries can play a critical role in their health care, food security, culture, trade, and sustainable development as shown by this TERI initiative.

LIGHTING A BILLION LIVES

Technology has seeped into our lives, adding ease and comfort. Still, a big chunk of the world's population spends its life in darkness or cooking on earthen stoves that emit harmful gases. Electricity has not reached them, depriving them of development and equitable growth in society.

TERI, with over four decades of experience in the energy access sector, has undertaken a variety of projects and carried out intensive studies on the subject. The Institute has developed affordable and clean energy technologies supplemented by sustainable business models that align with commercial and social objectives. It has even promoted policy frameworks that can enable the clean energy sector to develop as a commercial, profitable, and viable market.

Using this vast expertise, TERI in 2007, put together a global initiative —Lighting a Billion Lives (LaBL)—and brought about a transformative change in the lives of people in remote areas of India and the world by providing access to clean energy. In the next decade, LaBL emerged as a key driver in addressing the basic energy needs of people, touching more than 9.10 million lives.


MAGIC
LAND

Beaming light and development world over

In 2007, at the Clinton Global Initiative annual meeting, TERI committed to bring light and socio-economic development to one million rural people in India.

The objectives of LaBL were to replace inefficient and harmful lighting and cooking methods with affordable and reliable clean energy alternatives and to boost education, health care, and livelihood opportunities. It also fostered capacity building and enterprise development.

Around one billion rural people living in poorly electrified villages and dependent on kerosene and paraffin lanterns benefited from solar lamps. A clean, reliable, and more efficient source of energy, solar-lighting devices illuminated their houses and provided a smoke-free environment for children to study and women to do household chores. It increased productivity hours and brought financial and health benefits to rural households. Women were trained to manage solar-charging stations and rent out lanterns which helped them to supplement the family's income.

The technology was customized according to the needs of households, shops, and business establishments. To address the concern of indoor air pollution in rural households, a clean cooking solution that reduces emissions by 30% was developed. At a macro level, local business models were put in place that can foster entrepreneurs and create sustainable market-driven value chains.

LaBL employed an entrepreneurial model of last-mile energy delivery to establish micro solar-enterprises in deprived villages. Under the model, a local entrepreneur, trained by TERI and its partner organizations, provides clean energy access to the community at an affordable rate. The initiative has now reached to around half-a-million people in 1860 villages across 24 states in India. It has also been expanded to 12 countries across Asia and Africa. It includes Afghanistan, Sierra Leone, Kenya, Uganda, Ethiopia, Mozambique, Myanmar, etc.

Contributing to global sustainable development

With its vision to work for global sustainable development and its commitment towards creating innovative solutions, TERI team evolved a model for clean lighting through a centralized solar-charging model. Since 2008, the programme has been innovated, evolved, and applied field experiences and feedback to improve, modify, and advance its energy solutions to suit end users. Some of the initiatives under LaBL include:

Solar-charging Station (SCS): Developed primarily to address basic lighting requirements for people who are not able to afford even kerosene lamps or candles, a solar-charging station consists of 5 solar panels with capacities of 50 to 80 peak watts (Wp), and 50 LED solar lanterns which are simultaneously charged to provide lighting for 5-6 hours daily. The lanterns are rented out to households or small shops on a daily or monthly basis. The SCS generates a livelihood opportunity for village-level entrepreneurs.

Solar Microgrid (SMG): Fixed, centralized installation of photovoltaic power panels that serve connections of two light points and a mobile-charging facility across 50-80 households in a village, SMGs are well suited for households or shops situated close to each other or in a cluster. The solution is modular and flexible and can be expanded in scale as necessary. The connection to an SMG provides the end user with 4-5 hours of clean and bright lighting.

Solar Home Lighting System (SHLS): These are independent system installations that can be customized and configured to serve specific requirements

and consumption needs of households and small shops. The system runs on its own solar panel and supports two to three light points and a mobile-charging facility. End users may incorporate a small solar fan or television into the system by modifying the panel size and battery backup. The system is also well suited for isolated homes in rural belts that are too far away to receive a solar microgrid connection.

Integrated Domestic Energy Systems (IDES): A hybrid version of the SHLS, the IDES is an integrated system that provides a clean cooking solution in addition to a solar panel, two light points, and a mobile-charging facility. The forced draft improved cook stove is improvised based on locally available materials and adapted to suit the region and usage behaviour. It is designed to provide 4 hours of cooking time in a day.

Additionally, TERI has installed 150+ solar power plants in schools for quality education in Jharkhand , Assam, and UP.

Also, 60+ solar power plants were installed in primary health centre for improving operational reliability and service quality of primary health centres through provision of clean and reliable power under PFC Sustainable Development at Jammu & Kashmir, Assam, and UP.

For weaving community, TERI installed 500+ lithium-based solar power plant for Energy Access for Livelihood Promotion Hybrid Solar Charging Units at UP and MP.

Changing lives

The impact of LaBL project has been multifold. The Integrated Tribal Development Agency (ITDA) partnered with Lighting a Billion Lives to equip the village and school with solar lanterns. As a result, children at Sorispadar village in Koraput district of Odisha, had to no longer study in poorly lit classrooms filled with smoke from the kerosene lamps.

Benudhar Sahoo, a teacher at the Sorispadar Primary School, shared how installation of the SCS gave students a good and clean atmosphere to study which reflected in their performance. All 40 children in the school showed marked progress in their results as they could now put in an extra 2.5 hours in the evening at home in comparison to the one hour of studying under kerosene lamps. By using solar lanterns, the school was also able to save nearly 350 rupees a month that were otherwise spent on kerosene.

Mahmuda, a small village located in the Islampur Block of Nalanda District in Bihar, is home to nearly 8300 people. Their primary sources of income are cultivating small plots of land and allied activities like poultry farming. Despite the village being covered under a Central Government electrification scheme, the village was not connected to the grid.

In 2012, an SCS was installed in the Mahmuda village under the LaBL project, and it changed their lives forever. Baby Devi, an enterprising woman, was selected to operate and manage this facility. The advent of solar lanterns opened new avenues of livelihood and income generation for many women in the village.

Similarly, Hemanti Sardar of Chakri village in Jharkhand's Saraikela district, was chosen to be an entrepreneur by the villagers. Hemanti now manages an SCS and the money she earns from renting out solar lanterns has also given her access to credit services from the self-help group in her village.

Countless such stories have emerged from the LaBl project, which, living true to its name, pulled out myriad lives sunk in darkness to the brilliance of hope and possibilities.

Outreach

- ENRICHING YOUNG MINDS TOWARDS SUSTAINABLE DEVELOPMENT
- GREEN SCHOOL: PROMOTING ENVIRONMENTAL STEWARDSHIP
- WORLD SUSTAINABLE DEVELOPMENT SUMMIT: DECADES OF SHAPING GLOBAL DISCOURSE
- KUMAON VANI: SPREADING GREEN WAVES THROUGH 90.4 MHZ

ENRICHING YOUNG MINDS TOWARDS SUSTAINABLE DEVELOPMENT

India is one of the fastest growing economies. The projected pace of India's economic development is going to put pressure on our already stressed natural resources and may lead to serious environmental degradation. This can affect the quality of our life unless we learn to manage our resources efficiently.

There is now an increasing focus on the judicious use of resources through conservation and efficiency measures and in advocating transition towards circular economy. Against this background, it is critical to understand the role of education and teaching the younger generation the importance of resource efficiency and leading a sustainable lifestyle.

In fact, children are already facing the brunt of climate change, which is only going to exacerbate in the years to come. According to a United Nations Special Rapporteur 2018 report on the rights of children and the environment, "Air pollution, water pollution and exposure to toxic substances, together with other types of environmental harm, cause 1.5 million deaths of children under the age of 5 every year, and contribute to disease, disability, and early mortality throughout their life. In addition, climate change and the loss of biodiversity threaten to cause long-term effects that will disrupt children's lives for years to come." It is, therefore, imperative that we empower the future generation in climate action so that they grow up to become environmentally aware and responsible citizens.

GREEN Olympiad: blazing a trail for 25 years

GREEN Olympiad, a project of TERI started 25 years ago, has done a pioneering work in raising awareness about environment and sustainability among schoolchildren. Schools across the country and abroad are encouraged to incorporate various aspects of 'environment and sustainable development studies' in their curriculum.


Date-18th Sept, 2019
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The programme covers a range of topics like water, energy, air, forest, biodiversity, climate, global warming, sustainable development, culture, current affairs pertaining to the environment, green skills and policies and practices laid out by world leaders.

Besides building capacity on the core issues of the environment, GREEN Olympiad is a stepping-stone for a journey of investigative education, knowledge enrichment and empowerment of the school community.

While promoting environment education in schools, GREEN Olympiad instils a sense of collective responsibility amongst students, teachers, and the school community to foster the planet. Through the programme, TERI reached out to approximately 1.5 lakh students in the age bracket of 9–18 years, creating awareness about green skills, environment, and Sustainable Development Goals. In 2023, the programme received support from the Ministry of Environment, Forest, and Climate Change (MoEFCC), and the Ministry of Education (MoE), and concepts on Mission LiFE led by the MoEFCC and NITI Aayog were popularized.

Students were taught about SDGs like sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and culture's contribution to sustainable development.

Cutting across boundaries

GREEN Olympiad caters to both public and private schools across boards and regional connections. The programme seeks involvement of researchers, academia, governments, and practitioners to channelize the appropriate know-how and pedagogy for students.

To devise strategies, a multi-stakeholders' meeting is organized every year. Some of the organizations, part of this effort are Kendriya Vidyalaya Sangathan, United Nations Educational, Scientific and Cultural Organization, National Council of Educational Research and Training, Central Board of Secondary Education, Ministry of Environment, Forests and Climate Change, Bharatiya Vidya Bhavan, National Council for Science and Technology Communication, Navodaya Vidyalaya Samiti, etc.

In 2021, GREEN Olympiad envisaged inclusion of an additional theme of 'Green Skills', which is essential for an overall growth and enhancement of employability of youth. A need is felt to mainstream green skills within the learning ecosystem of children from an early age.

The core activity of the GREEN Olympiad is a written examination to test students' knowledge, application, and analytical skills on the subjects. Students are prepared through a curriculum drawn for schools at the start of the session in April.

A series of workshops is organized for state-level educators, school teachers on environment, sustainable development and green skills covering all the states and union territories. The key focus of these workshops is to enhance an understanding of local specific issues. The idea is to encourage schools to register for the programme and learn to bring environmental awareness.

Sample papers are developed for students to be given as preparatory material before the examination. Also, a webinar is organized to orient students for the examination. There is a registration tutorial as well as a dedicated website for the programme.

The registration for the GREEN Olympiad Examination begins in the month of June every year held in the month of October / November. The examination is undertaken in four difficulty levels catering to standard 4–12. Results are published and shared with schools in the month of December.

GREEN Olympiad organizes a mega prize distribution ceremony on the platform of TERI's flagship event, World Sustainable Development Summit. Global rank holders are felicitated with certificates and book vouchers, while all registered participants receive certificates in the categories of distinction, merit, and participation.

Creating a network of youth

In its 25-year journey, GREEN Olympiad has evolved as an asset of immense academic potential in schools, as it rests on the vision to create an 'Environment Conscious Youth Network' facilitating achievement of the Global Agenda by 2030.

The programme is implemented annually in an academic cycle and, so far, has reached out to 3.5 million children across 32 countries.

As the world gears up to fight climate change, it needs programmes like GREEN Olympiad which prepares youngsters to take lead in environmental stewardship.

GREEN SCHOOL: PROMOTING ENVIRONMENTAL STEWARDSHIP

Environmental sustainability and climate action have become paramount concerns globally, necessitating a concerted effort from all quarters. In this regard, several initiatives have been launched to promote environmental education and awareness. For instance, the mission LIFE campaign emphasizes the adoption of eco-friendly ways of life, encouraging individuals to make sustainable choices in their daily lives.

The Sustainable Development Goals (SDGs), particularly Goal 4 (Quality Education) and Goal 13 (Climate Action), underscore the importance of awareness and behaviour change in achieving a sustainable future.

India's Intended Nationally Determined Contributions (INDC) outline the country's commitments to mitigating and adapting to climate change, highlighting the need for collective action.

Additionally, understanding the critical role that education plays in forming a more sustainable society, the National Education Policy (NEP) promotes the inclusion of environmental education in the curriculum.

These initiatives collectively emphasize the significance of education and awareness in promoting environmental responsibility and equipping individuals with the knowledge and skills necessary to address the pressing challenges of climate change and environmental degradation.

Going beyond conventional education

Realizing the need to empower young minds as 'agents of change' and combat climate change through education, Tata Steel Foundation and TERI started a unique and major initiative—the Green School—in 2017 in Jharkhand and Odisha.

Stepping beyond the standard system, the partnership highlights the importance of education in producing leaders who care about the environment.

The project was implemented in Tata Steel Foundation's operational location schools in tribal remote villages of Odisha and Jharkhand which are rich


DRAWING COMPETITION

in mineral resources but also ecologically fragile. Global accords such as the Paris Agreement and Tata Steel Foundation's philosophy of giving back to society served as inspiration for the project's inception.

With the success of phase-I implementation in 10 schools across the two states, this initiative has extended to 20 additional schools across Jajpur, Jharia, Joda, Noamundi, Sukinda and West Bokaro locations in Jharkhand and Odisha. The project has grown every year, with the sixth phase completed in the last financial year.

By highlighting the significance of environmental consciousness, climate change awareness, and citizenship, the Green School aims to bridge the knowledge gap and give students from different educational boards (state boards, ICSE, and CBSE) the confidence to take initiative in the direction of sustainability by recognizing these important learning goals that fall outside the purview of the conventional educational system.

National education institutes like DAVs have forged this into their school routine, while also linking with New Education Policy (NEP) guidelines.

Four environmental themes interlinking with climate change and SDGs serve as the foundation for the green curriculum. The initiative had social and financial difficulties while it was being carried out. Nonetheless, the project was driven ahead by a common vision for an environmentally conscious society, enhanced community relations, and a dedication to sustainability.

Thriving amidst turmoil

The COVID-19 pandemic presented additional challenges for students. Nevertheless, despite their modest progress, they continue to flourish because of cooperation and perseverance.

Experts are invited to participate in a virtual celebration of various environmental-related days. Additionally, the sustainability week celebration provided a learning platform to learn from the experts from various sustainability fields during COVID.

By working together with educators and community members, students are driving social impact. They act as role models, overcoming stigma and other obstacles that often impede the development of distant areas. Their accomplishments give vulnerable adolescents hope and a sense of responsibility in bringing about change through their formally crafted 'Environment Management Committees'.

Apart from getting recognized at various international platforms, students are making their mark on the international scene. They were the youngest panellists at the World Sustainable Development Summit 2023. The community-based movement for environmental preservation exemplifies an incredible path from local awareness to international prominence.

Reverberations from the society

The stories told by the young people and community members highlight the significant influence of the Green School initiative. These experiences, which range from setting up water filtration systems to implementing sustainable practices at home, leave a lasting impact on the community, parents, and kids in Jharia.

Students in Sukinda demonstrated their dedication to sustainability by implementing an innovative bamboo drip irrigation scheme that not only conserved water from getting wasted but also raised awareness about alternate approaches.

At the World Sustainable Development Summit 2024, students and teachers shared their innovative projects that how they took up various actions and community impact projects including making paper bags, wealth out of waste, installing bird nests and bird feeders, setting up herbal and medicinal gardens to bring about change in society. They shared their learning with family members, peers, and society at large through various social media platforms to develop a sense of responsibility among the masses. The stories told by the young people and community members highlight their experiences, ranging from setting up water filtration systems to implementing sustainable practices at home, leaving a lasting impact on the community, parents or powerful biodiversity action initiative: Stop tree cutting and listen to the story of the tree involving several communities through an engaging *Nukkad Natak*. These grassroots projects also demonstrate the significant influence that neighbourhood initiatives can have on environmental preservation.

Growing impact

The Green School reached out to entire strength of students, teachers and related parents, and community members The effective Green School Buddy Programme and Environment Management Committees have raised environmental awareness, and improved students' critical thinking abilities and behaviour. The achievement of the initiative is further demonstrated by its appearance in local media and its acknowledgment on national and international stages.

The project has received a series of international recognition including it being recommended by the Indian National Commission for Cooperation with UNESCO (INCCU) for the Wenhui Award for Educational Innovation 2018. The Green School was also recognized as a replicable model for environment education in local communities and was shared by Think20 (T20) as a policy recommendation at the G20 Summit in November 2020.

The project was even selected by the Ministry of Environment, Forest, and Climate Change, Government of India, to present at the special session at the India pavilion at COP 24 and COP 25. The project was studied by the team of CAPS- Center for Philanthropy and Society and acquired a mention in their research paper named 'Building Back Greener: Addressing Climate Change in Asia'.

The Green School is an example of effective corporate and organizational cooperation in promoting environmental education. The project not only tackles current environmental issues in far flung areas but also establishes the groundwork for a resilient and sustainable future by fostering environmental leaders.

WORLD SUSTAINABLE DEVELOPMENT SUMMIT: DECADES OF SHAPING GLOBAL DISCOURSE

The World Sustainable Development Summit (WSDS) is the annual flagship multistakeholder initiative of TERI. Instituted in 2001 as Delhi Sustainable Development Summit (DSDS), the Summit plays a pivotal role in shaping the narrative of the Global South on sustainable development and climate commitments.

As the world grapples with complex challenges posed by climate change, environmental degradation, sliding back of the global Sustainable Development Goals and growing geo-political conflict, it becomes rather important to foster global collaboration, innovation, and commitments for building a future based on peaceful coexistence.

By uniting leaders and stakeholders, the Summit, with a legacy of over two decades, has become an influential platform for addressing pressing issues related to sustainable development and climate change.

Amplifying the voice of Global South

The agenda of sustainable development gained traction in the international discourse when it was formally recognized in the 1992 Rio Declaration at the Earth Summit.

Agenda 21 recognized the need for a global consensus and political commitment on development and environment cooperation to address the major challenges confronting the new century. For successful implementation, it was important that diverse global stakeholders made a concerted effort to realize the vision of a safe and sustainable world. The Global South, comprising nations facing unique socio-economic and environmental challenges, required a dedicated platform to articulate their perspectives and concerns.

Based on the idea of fostering leadership and discussion around the issue, the WSDS (erstwhile DSDS) was launched in 2001 as the only independently convened summit on sustainable development and environment, located in the Global South. The WSDS envisioned to revitalize global commitment to sustainable development as a shared future goal, particularly in relation to the decade since Rio. Since then, held as an annual event, the WSDS has engaged and fostered ties with Nobel laureates; political leaders; leading decision-makers from governments, bilateral, and multilaterals; business groups; high-level functionaries from the diplomatic corps; scientists; media persons; researchers; and representatives of non-governmental organizations from across the world.

By convening the WSDS, TERI not only facilitated dialogue but also served as a catalyst for collective action, leveraging its position to engage stakeholders and present the developmental needs of the Global South on a global stage.

The Summit series thus became a transformative force in fostering collaboration and driving initiatives that address the nuanced challenges faced by developing nations in their pursuit of sustainable development and climate resilience.

While the multilateral forums have addressed these emerging challenges at the global level, the ensuing politics around the consolidation of international commitments on countering climate change has also led to a slow progress in most cases. Moreover, many of the initiatives are also highly influenced by and located in the developed countries, highlighting the need for an autonomous platform curated to recognize the specific needs of the Global South.

Adapting and innovating through challenges

Over the course of two decades, the WSDS has encountered various challenges, the impact of the COVID-19 pandemic in 2021 being the notable one. During such times, the Summit had to adapt rapidly by transitioning to a virtual format. Despite the virtual setting, WSDS remained resolute in its mission to connect leaders and stakeholders, ultimately hosting an engaging and highly participatory summit.

In the recent years, the WSDS has continued to evolve, shifting from virtual to a physical event. This transition, while promising, presented its own set of challenges, particularly in terms of resource mobilization and the level of enthusiasm among stakeholders to attend and invest. However, the Summit has consistently managed to make a significant impact, staying true to its commitment to advancing sustainability and equity.

To uphold its legacy, the WSDS has demonstrated a remarkable ability to adapt and innovate. It has consistently introduced new themes and topics that address contemporary challenges and fulfil its commitments to sustainable development. Through these adaptations and a steadfast dedication to its mission, the WSDS has remained a vital platform for global dialogue and action on critical issues.

To address challenges and fulfil commitments, the WSDS showcased adaptability and innovation. New themes and topics were introduced to address contemporary challenges. The Summit played a constructivist role, launching Act4Earth during WSDS 2022 to create new knowledge outputs.

Shaping the international narrative

Engagement between countries through Track 1.5 and Track 2 diplomacy has the potential of smoothening the process of policy deliberations on traditionally sensitive areas and allows for deeper understanding of positions and perceptions of stakeholders.

The WSDS has been an instrumental channel for multistakeholder diplomacy and shaping international narrative since the past two decades by engaging with state as well as non-state actors on issues of global relevance. The platform has had impactful deliberations on a variety of issues ranging from climate resilience and adaptation, climate finance, energy transitions, sustainable development, and climate action, with the latest being the initiative to internationalize Lifestyle for Environment.

The outcome documents over the years have been instrumental in informing constructive decision making and sustainable policies at the national level to achieve global climate goals. The Summit's engagement with diverse set of stakeholders also has had a positive impact on expanding the scope of discussion around sustainable development.

Over the years, the WSDS marked participation of 56 Heads of State and Government, 126 Ministers, 13 Nobel Laureates, 1932 Business Leaders, 3,023 Speakers, and 39,483 Delegates.

By reinforcing commitments at all levels, translating words into concrete actions, and fostering collaboration, the WSDS has contributed to creating a more sustainable and equitable world for present and future generations.

KUMAON VANI: SPREADING GREEN WAVES THROUGH 90.4 MHZ

Far from clamour of big cities, several rural areas in India find their voice through community radio. Covering 10 to 15 km radius, these radio stations connect various village communities, and are an effective medium to keep the ethnic languages and cultures alive.

Despite the growing popularity of social media, community radios' transformative role in fringe areas remains unrivalled. Engaging listeners through audio storytelling and raising awareness about a range of issues such as best agricultural practices, health, education, gender equality, and disaster management, these radio stations not only relay information relevant to a community but also bring to surface the challenges faced by them.

Moreover, the communities living in the hilly terrain have limited access to vital information on critical issues like agriculture, health, sanitation, education, employment, tourism, art & culture, and other government welfare schemes.

Feeling the pulse of Kumaonis

While working with the local farming community, TERI, too, realized there was a lack of access to information, especially in the remote parts of the mountain region. It was a big roadblock in promoting sustainable development. This sowed the seeds for starting a community radio. In March 2010, Kumaon Vani was set up in the Supi village, Nainital district of Uttarakhand. Riding at 90.4 MHz, it strives to bring

together communities across several villages in the Kumaon region and promotes sustainable development among the local farming community.

Today, Kumaon Vani is operated, owned, and driven by the local community in Mukteshwar. A team of four full-time producers, including the station manager, forms the core group that manages the daily operations of the station. This is supported by a team of 7-8 freelance reporters who have been trained to report from the field and produce radio programmes in different formats.

The creative team of reporters and technicians are youths from the local community. The team is primarily responsible for grassroots engagement with the community by collecting ideas, feedback, and voices from different parts of the Kumaon region. According to a baseline survey report, radio listenership in the community is very high since it is accessible on the move, in the field and costs less.

Conversing with the locals

The radio programmes of Kumaon Vani focus on improving farmers' livelihoods by providing them information and knowledge on sustainable agriculture, water and sanitation, forestry and biodiversity, delivery of government welfare programmes, and accountability in local governance. It spreads awareness on science, health, gender, and education, and provides impetus to Kumaoni language, art, and culture.

Kumaon Vani also works on collaborative projects and campaigns with several stakeholders including ministries, state departments, academic institutions, NGOs, advertisement agencies, Information and Public Relation Department Uttarakhand and the Nainital district administration.

Located at an altitude of more than 2286 m, it reaches out to nearly 500 villages in Nainital, Almora, Ranikhet, Kausani, Champawat, Devidhura, Pithoragarh, Betalghat, Sheetlakhet, Kausani, Gwaldham and Bagheshwar. It covers a population of nearly 350,000 people, which is pre-dominantly an agricultural community.

Reinforcing the power of voice

Kumaon Vani broadcasting has played a significant role at the grassroots level for addressing rural development, issues of poverty, agriculture, gender inequality, education, social problems, among others.

Khushhal Singh, Sunkiya village, could instantly connect to the programmes broadcasted by Kumaon Vani. "I can flip through 100 TV channels and find nothing that concerns my life. Kumaon Vani talks about my life and my problems," he says.

Tara Singh, a certified artist from Akashvani, Almora, found a way to reach out to people through Kumaon Vani.

Bhawana Bist, from Katramal village, got electricity in her house by airing her problem. "I ran around for many years to get an electricity connection. When I shared my problem on Kumaon Vani, I was immediately given a connection under the Rajiv Gandhi Vidyutikaran Yojana," she says.

For numerous village folks like these, Kumaon Vani became a window to the outside world. On an average, the radio station receives 40-50 phone calls/ week, WhatsApp messages, and comments on social media platforms like YouTube, Facebook, and Twitter.

During its 14 years, Kumaon Vani succeeded in establishing a strong connection with the local community by discussing common issues about their lives and livelihoods. Crucially, it gave a voice to those who invariably go unheard.

Health and Nutrition

- ENVIRONMENT FRIENDLY BIO-TOILET IN NORTHEAST INDIA SCHOOLS: A GREEN INITIATIVE
- DNA CLUBS: MENTORING THE SCHOOLS OF NORTHEAST

ENVIRONMENT FRIENDLY BIO-TOILET IN NORTHEAST INDIA SCHOOLS: A GREEN INITIATIVE

In terms of sanitation, the awareness on discharging the human waste is still low among public. Thereby, most of the houses, buildings, institutions are being constructed with conventional septic tank which uses conventional technologies—threatening the mother earth with harmful sewage. Bio-toilet system helps to prevent environmental pollution caused by pollutants from human waste and untreated wastewater. It also saves energy, conserves water, and produces energy in the form of biogas. It has been established that most hazardous and harmful pollution is sewage generated from human waste which may pollute the environment including groundwater. In order to address this issue, bio-toilet is a solution for bioconversion of human waste through microbial formulation.

Bringing school students for environment protection: bio-toilets initiative in northeast India

Bio-toilets installation programme in schools of northeast India was initiated in 2018 with the support of Department of Biotechnology, Government of India. Sanitation infrastructure like superstructure with 2 FRP (fibre-reinforced polymers) cabins, substructure with anaerobic digester capacity 2 m^3 having vertical and horizontal flow through two-partition chamber, with or without reedbed and soak pits was developed. Demonstration and evaluation of anaerobic digester, reedbed and biogas production as clean energy were carried out. Bio-toilet operation manual, short film on bio-toilet and bio-toilet charts were developed and distributed among students for promoting behavioural change and inculcate the habit of maintaining good hygiene.

The main objectives of the initiatives were to promote behavioural change among school children for good hygiene through installation of bio-toilet infrastructure in schools of eight northeastern states of India, bench-top demonstration of anaerobic digester for biogas generation, operationalization of bio-toilets and feasibility study for utilization of generated biogas as clean energy. The focus was on sanitation, water conservation through superstructure designing and bioenergy harvesting from the digester. Capacity building and community mobilization programmes were organized as needed considering the sustainability aspect of the project.


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Biotoilets in School

Under the project, 100 bio-toilet units were installed in 66 school campuses and 16 boy's and 18 girl's hostels of a few schools in Assam (35), Arunachal Pradesh (5), Manipur (10), Mizoram (10), Meghalaya (15), Nagaland (5), Sikkim (5), and Tripura (15) schools, covering 25 districts. The anaerobic digesters were charged by 20% microbial consortia as inoculum and appropriate volume of water-soluble growth stimulant formulations. The digester harboured microbial growth for feeding on human waste, thereby reducing the sludge and contaminants. Moreover, low-cost natural materials were also used to reduce the cost of the bio-toilets.

Sanitation and hygiene

The school students were aware on maintenance of proper sanitation and hygiene and importance of bio-toilet for reduction of environmental pollution. They were also made aware on preservation of groundwater and protection of soil, water and other natural resources for sustainable development.

TERI developed a bio-augmentation formulation that helped in human sludge degradation, resulting in substantial reduction of regular cleaning and sludge removal. Moreover, the superstructure with 30-degree slope ceramic rural pan with 4-inch P-trap and 3-inch outlet to digester helped in saving water by 40% per flash getting wasted during flushing. Designing and installation of subsurface horizontal flow reedbed attachment could also reduce pollutants before releasing to soak pit and environment. In addition, low-cost toilet superstructure made up of bamboo, MS rectangles truss, GI roof and cement plastering gave attractive look and enhanced durability of superstructure at a lower cost as compared to FRP or concrete structure.

Awareness programmes and knowledge dissemination initiatives promoted behavioural change among schoolchildren for good hygiene.

DNA CLUBS: MENTORING THE SCHOOLS OF NORTHEAST

The Department of Biotechnology's Natural Resources Awareness (DNA) Clubs, a programme launched by National Bioresource Development Board (NBDB) under Department of Biotechnology (DBT) was initiated to promote deeper awareness on issues concerning biodiversity and bioresources amongst schoolchildren and their sustainable utilization through biotechnology in selected schools in each state across India including northeast India. Given the vastness of the country and large number of schools in targeted cities, the regional resource agencies (RRAs) were also established at different locations in the country to facilitate the DNA Clubs' activities. Empowering the younger generation with knowledge of resources in their surrounding and updating contemporary research and paving way for future development and career advancement, The TERI's Northeastern Regional Centre initiated a mentoring programme in 2007 under which the DNA Clubs were started in 361 schools of 8 northeastern states with the objective to promote deeper awareness about bioresources and to enthuse students about the role of biotechnology in their sustainable utilization.

Benefitting school student

The main objectives of the DNA Clubs projects were to generate awareness among schoolchildren for contemporary biotechnology and bioresources and to bring fun, interactive classroom films and viewing exercises for the children in order to spread and diffuse knowledge about bioresources, enhance understanding about the immense value of biological diversity, the importance of locally available bioresources, their sustainable use and conservation, equip school students with laboratory, provide experimental learning opportunity, familiarize with scientific and technological issues related to biotechnology, create opportunities for hands on experiences, facilitate interaction with leading experts in diverse field of science, and stimulate interest in pursuing carriers in science and technology.

Wide-scale impact

DNA Clubs acted as a model for emerging avenues and careers in the fields of biodiversity, bioresources, and biotechnology. The DNA Clubs project facilitated to disseminate knowledge for deeper understanding in bioresource conservation and prospects of biotechnology among school students of NE India. A total of 361 secondary schools of 8 northeastern states, namely, Arunachal Pradesh (10 schools), Assam (191 schools), Manipur (57 schools), Meghalaya (20 schools), Mizoram (18 schools), Nagaland (13 schools), Sikkim (35 schools), and Tripura (17 schools) were covered under the theme 'DNA Club'. Along with establishment of school laboratory with equipment, the project activities included 6,498 audio-visual shows, 21,660 hands-on activities and lab experiments on 60 themes, 6,498 guest lectures on 137 topics by resource persons of 40 different professions such as academician, physician, environmental activist, state officials of agriculture, sericulture, forest, horticulture, etc. along with 1,083 institutions and 1,083 field exposure visits for knowledge sharing. The DNA Clubs has also conducted yearly vacation training programmes (VTP) where a selected group of 10th class students in their summer vacation had a camp for 20 days to get-hands on exposure training on advance biotechnological tools and techniques for bioresource conservation. Since its inception around 75,810 students of selected schools of 8 northeastern states have been directly benefitted from the DNA Clubs. Success of the project is well indicated by the utilization of the scientific laboratories by the students and maintenance of the herbal gardens developed in the school campus for better understanding of natural resources of nearby areas of the schools. This has also increased the scientific temper among students for opting science as their carrier. The activities in DNA Club have been able to impart enthusiasm among school students in keenly observing nature.

CREATING IMPACTS, TRANSFORMING LIVES

SUCCESS STORIES FROM TERI

Creating Impacts, Transforming Lives encapsulates the pathbreaking work of The Energy and Resources Institute (TERI) since its inception in 1974. From modest beginnings, TERI was conceptualized as an energy institute by its visionary founders, Mr Darbari Seth and Mr JRD Tata. Under the leadership of Dr RK Pachauri, its charismatic Director General, the institute rose in stature, became a leading global institution working for sustainable development.

Written lucidly, this collection of stories describes the journey of TERI's remarkable enterprises and how they contributed to the common good and made a material difference towards sustainability. It is this pursuit of securing a better environment for future generations, which not only made TERI a dependable voice on climate change, but also mainstreamed sustainable development.

This book strings together TERI's exceptional work of five decades, which is compelling as well as inspirational.

THE ENERGY AND RESOURCES INSTITUTE
Creating Innovative Solutions for a Sustainable Future