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FROM THE DIRECTOR GENERAL'S DESK

Mahatma Gandhi's timeless words resonate deeply in our current environmental context: "There is a sufficiency in the world for man's need but not for man's greed." This profound statement holds a mirror to humanity's relationship with the environment, urging us to reflect on our consumption patterns and their consequences. It prompts us to reconsider our priorities and embrace a more sustainable way of living.

The unprecedented challenges and crises that the people and planet face today serves as a rallying cry—a call to action for collective preparation against potential future crises, charting a course towards a more stable and resilient world. The world stands at a critical juncture, with high stakes, depleting resources, escalating emissions, and increasingly

visible impacts of climate change and vulnerabilities. Yet, with a sense of optimism the global leaders, scientific communities, researchers, civil society and citizenry have united with a shared belief and commitment to build a resilient planet. Global climate summits like the United Nations Climate Conference and landmark agreements like the Paris Agreement are the testimony to this collective vision, where developing and developed nations arriving at a consensus to collectively promote a greener and liveable planet. With immense pride, I share that TERI stands at the forefront of action-oriented research in climate change, environment, energy, and sustainable development, playing a pivotal role in shaping energy conservation policies, executing grassroots initiatives and demonstrating energy-efficient solutions for small and



medium businesses in India. TERI's relentless research has impacted millions of lives. As we confront newer challenges ahead, TERI remains dedicated to fostering positive change through designing need based and innovative solutions.

The Energy Programme envisions overall socioeconomic development of India and other developing nations by promoting clean energy along a low-carbon trajectory. In the past fiscal year, over 100 projects were successfully undertaken across specific thematic domains, encompassing Industrial Energy Efficiency (IEE), Renewable Energy Technology (RET), and Electricity and Fuels (EF). These projects, spanning low carbon pathways, energy efficiency, promotion of renewable technologies, just transition, battery energy storage, e-mobility, RE integration, and capacity building, extended their impact not only across India but also globally.

The initiatives in the Energy sector created a long-lasting impact, establishing TERI as a catalyst for transformative change. By garnering support from Indian business leaders and securing CEO signatories for the Industry Charter, TERI has successfully set the stage for a collective commitment to achieving near-zero emissions by 2050.

An expansion of TERI's expertise in research, the Green Shipping initiative, strategically advances sustainable practices in ports, shipping, and waterways. Employing integrated sustainability frameworks, we evaluate the transformative impacts of energy transition and circular economy practices across pivotal sectors. In partnership with the Ministry of Ports, Shipping, and Waterways, our programme actively bolsters the National Centre of Excellence in Green Ports and Shipping (NCoEGPS). We persistently advocate sustainable methodologies through our research in areas of Advanced Biofuels and Resource Efficiency and Governance. Additionally, our Thermochemical Conversion Lab pioneers biofuel technologies, reinforcing TERI's influence in bioplastic research and bio-commodity policies, marked by patented technologies and continual advancements.

For over three decades, our work in the area of Earth Science and Climate Change (under the Climate Change and Air Quality Programme) has been a vanguard in global and local environmental research. Our focus is on delivering science-backed recommendations for climate change mitigation, adaptation, and enhanced air quality across critical sectors, ensuring informed action and implementation.

TERI's global impact is substantial, marked by participation in crucial initiatives such as IPCC special reports, AR6 assessments, and membership on the International Civil Aviation Organization's Technical Advisory Board for CORSIA implementation—a global mechanism for airline emission

reductions. Our active presence at COP events underscores our unwavering commitment towards the subject. The Multi-country Cooling Platform, in collaboration with the Embassy of France, fosters knowledge exchange for sustainable habitat and energy efficiency. Leading the preparation of the 'G20 Report on Actions Against Marine Plastic Litter, 2023' during the G20 India Presidency highlights TERI's influential role in shaping policies. Indo-Pacific region efforts provide critical insights for policymakers addressing the health response to climate change. At the national level, TERI significantly contributes to the National Action Plan on Climate Change, India's Cooling Action Plan, and the National State of Environment Report. We have also created an impact in the corporate actions that encompass a carbon pricing handbook, climate risk profiling, tailored climate products, and impact assessments for the oil and gas sector, promoting sustainable business practices.

Our Waste, Water, and Natural Resources (WWNR) Programme leads the way in developing transformative solutions for sustainable resource management. Aligned with Sustainable Development Goals (SDGs), the programme leads in waste management, circular economy practices, wastewater reuse, and resource efficiency, pioneering cutting-edge technologies for a harmonious coexistence between progress and nature.

Projects in the areas of Land Resources and Waste Management of the WWNR Programme significantly contribute to achieving eleven SDGs and support the NDC goal of establishing an extra carbon sink of 2.5–3 billion tonnes of CO₂ equivalent by 2030. In the past fiscal year, 45 projects were implemented. Notably, TERI Advanced Oxidation Technology (TADOX®) for wastewater treatment won the First prize in the 'Innovations in Water Technology' category at the FICCI Water Awards 2022. Our initiatives also focus on enhancing sustainable biodiversity and ecosystem services through carbon finance projects under REDD+ and ARR in forestry and agroforestry.

In response to the urgent need for sustainable infrastructure due to extensive urbanization, the Sustainable Infrastructure Programme (SIP) is dedicated to reducing urban carbon footprints by integrating sustainability principles into the built environment. In the fiscal year 2022–23, SIP executed 27 projects across India, contributing to low-carbon development pathways and the nation's potential for net-zero development.

With a significant impact, the work in Sustainable Buildings space has made a mark with Mahindra–TERI Centre of Excellence (MTCoe) offering vital building material testing services to industry, academia, and research laboratories



nationwide. These services focus on evaluating thermal performance, contributing to enhanced thermal comfort and energy efficiency in the building sector. A comprehensive study carried out on energy and cost savings in modern construction buildings, with a specific focus on the use of gypsum board drywall is worth mentioning.

Over a steadfast commitment to research and innovation spanning three decades, the Environmental and Industrial Biotechnology (EIB) Programme has been a key player in mitigating environmental contamination, advancing bio-based products, and promoting sustainable clean energy. Its extensive research initiatives have paved the way for the creation and commercialization of globally recognized technologies, such as 'Oilzapper,' a ground-breaking microbial consortium for oil spill bioremediation.

The transformative impact of 14 nationwide initiatives is exemplified by successful programmes such as the joint venture—ONGC TERI Biotech Ltd (OTBL), advancements in biologically-enhanced methane production from coal, innovative MEOR technology initiatives, and the development of the eco-friendly oil well drilling fluid XC Polymer (xanthan gum), marking inspirational strides in sustainability and technological innovation.

Our research, centred on sustainable agriculture, environment, and bioenergy, focuses on developing plant- and microbe-derived products to boost crop yields, reducing the carbon footprint in agriculture. These achievements reflect our commitment to innovative solutions in agriculture, environmental stewardship, and bioenergy.

With the successful implementation of drone technology-based field trials, the formulation of highly effective nano-copper and nano-sulphur fungicides, and the launch of an Advanced Mycorrhizal Biofertilizer product called "Uttam Superrhiza," TERI has not only demonstrated technological prowess but has also made a substantial impact in the realm of agricultural innovation and sustainability.

The initiatives in Social Transformation & CSR space are rooted in its unwavering belief that the sustainable utilization of natural resources, the effective management of energy, widespread adoption of renewable energy technologies, and the minimization of all forms of waste are integral elements driving the journey towards SDGs. This foundational philosophy underscores our commitment to fostering positive social transformation and corporate social responsibility.

TERI's initiatives in Social Transformation and CSR space had a profound impact by addressing energy access challenges, reducing CO2 emissions, and promoting environmental

sustainability. The targeted interventions improved rural living conditions and transformed lives.

Functioning as pivotal conduits for disseminating the organization's endeavours across the nation, our Regional Centres play a crucial role in laying a robust foundation for TERI's activities and projects at the grassroots level. These centres contribute significantly to the expansion and enrichment of our knowledge repository, thereby extending the scope and impact of the organization's operations.

Spread across the country, TERI centres in Bengaluru, Mukteshwar, Mumbai, Assam and Goa have been integral hubs for research, education, and implementation of sustainable practices. These centres actively contribute to advancing the field of sustainability by conducting groundbreaking research, offering educational programmes, and collaborating with stakeholders to address environmental challenges. Through their diverse initiatives, these centres play a crucial role in shaping policies, influencing public awareness, and driving positive change towards a more sustainable and resilient future. It gives me immense pleasure to proudly highlight the impactful role played by our Communication Outreach and Advocacy (COAU) Programme, serving as the organization's bedrock of support and a vital link that has effectively magnified TERI's initiatives through extensive outreach activities. One of the standout accomplishments among the COAU's initiatives is the internationally acclaimed annual flagship event, the World Sustainable Development Summit. Bringing together over 1200 world leaders representing 25 organizations, this Summit has served as a platform for meaningful deliberations on the overarching theme, 'Mainstreaming Sustainable Development and Climate Resilience for Collective Action.' Within our community-related initiatives, the programme featured 18 episodes of 'Swasthya Sankalp' aired on Kumaon Vani. Additionally, the release of two significant knowledge documents by COP27 Compass and coverage of two key domains under the SDG Charter were noteworthy highlights of our outreach efforts. Notably, the launch of Act 4Earth during the World Sustainable Development Summit marked a major milestone in our commitment to sustainable practices and initiatives.

In conclusion, this Annual Report encapsulates a year of unwavering commitment, transformative actions, and impactful initiatives undertaken by TERI across various programmes and thematic areas. Our journey towards sustainability, resilience, and positive social transformation is evident in the strides we have made in the realms of energy, environment, biotechnology, sustainable infrastructure, waste management, and corporate social responsibility. As we

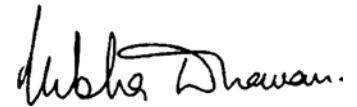


navigate the critical landscape of climate crisis, with depleting resources and escalating environmental risks, we reunite with a renewed belief and determination of inducing positive change through collective actions.

Last but not the least, I extend my gratitude to our dedicated team, partners, and stakeholders who have played a critical role in making these accomplishments a reality. Together, we

are charting a course towards a more sustainable, resilient, and harmonious world. As we move forward, TERI remains steadfast in its commitment to research, innovation, and advocacy for a future where humanity and the environment coexist.

Thank you for being a part of this remarkable journey and joining hands to co-create pathways for building a better tomorrow.



Vibha Dhawan
Director-General, TERI







WHO'S WHO AT TERI



TERI'S GOVERNING COUNCIL



Mr Nitin Desai
Chairman



Mr Vijai Sharma



Mr Nawshir H Mirza



Mr R Mukundan



Mr Mahendra Singhi



Mr M S Unnikrishnan



Dr Vibha Dhawan



Ms Ireena Vittal
(17/8/22)



THE MANAGEMENT TEAM



Dr Vibha Dhawan
Director General, TERI



Mr Girish Sethi
Energy



Mr Sanjay Sethi
Sustainable Habitat



Dr Banwari Lal
Environmental and Industrial
Biotechnology



Mr R R Rashmi
Resource Efficiency and Governance



Dr Vibha Dhawan
Sustainable Agriculture



Dr Jitendra Vir Sharma
Land Resources



Ms Suruchi Bhadwal
Earth Science and
Climate Change



Col. (Retd) Sanjai Joshi
Administrative Services
(till 31/8/2022)



Dr Dipankar Saharia
Agricultural and
Rural Extension



TERI'S DISTINGUISHED FELLOWS



Dr Prodipto Ghosh
Distinguished Fellow, Earth
Science and Climate Change



Mr K Ramanathan
Distinguished Fellow,
Electricity and Fuels Division



Mr Shri Prakash
Distinguished Fellow, Transport
and Urban Governance



Mr Ajai Malhotra
Distinguished Fellow and Senior
Advisor (Climate Change),
Director General's Office



Mr R R Rashmi
Distinguished Fellow and
Programme Director, Resource
Efficiency and Governance



Mr Ajay Shankar
Distinguished Fellow,
Director General's Office



**Air Commodore
(Retd) M M Joshi**
Distinguished Fellow,
Administrative Services



Mr S Vijay Kumar
Distinguished Fellow and
Lead, Food and Land Use
Coalition, India



Mr Dipak Dasgupta
Distinguished Fellow, Earth
Science and Climate Change



Mr Sanjay Mitra
Distinguished Fellow, Transport
and Urban Governance



Dr Syamal Kumar Sarkar
Distinguished Fellow,
Water Resources



Mr Manjeev Singh Puri
Distinguished Fellow, Earth
Science and Climate Change



Mr Amitava Bhattacharyya
Distinguished Fellow, Environmental
& Industrial Biotechnology



Dr Asha Ram Sihag
Distinguished Fellow, Resource
Efficiency & Governance





RESEARCH PROGRAMMES

- Energy
- Green Shipping
- Climate Change and Air Quality
- Waste, Water, and Natural Resources
- Sustainable Infrastructure
- Environmental and Industrial Biotechnology
- Sustainable Agriculture
- Social Transformation and CSR Division



ENERGY PROGRAMME



The Energy Programme promotes energy efficient and renewable energy-based technological solutions to help India and other developing economies achieve sustainable and resilient future through low-carbon pathways.



Themes and Commitments

Thematic focus

We focus on addressing key issues such as energy efficiency, cleaner technology options, renewable energy, and energy transitions, offering customized solutions to meet these challenges. Stakeholder engagement, in-depth analysis, field testing, demonstrations and a joint dialogue enable us in designing need-based solutions.

Initiatives across the following thematic domains help achieve the key motto of 'promoting energy efficient and low-carbon solutions':

- Industrial Energy Efficiency (IEE)
- Renewable Energy Technology
- Electricity and Fuels

Industrial Energy Efficiency (IEE)

- » Undertaking energy audits for Indian and international clients (large industries, power plants, commercial complexes, water pumping installations, including implementation support in selected cases).
- » Developing an evidence base to chart out a roadmap for decarbonization of Indian industry—particularly, hard-to-abate sectors such as iron & steel, cement, etc.
- » Promoting energy efficient technologies (EETs) and best operating practices (BOPs) in micro-, small- and medium-scale enterprises (MSMEs) sector (audits, implementation support, cluster studies, knowledge sharing, etc.)
- » Providing business advisory services and capacity building (sectoral studies, workshops/training programmes, technology assessments, etc.)

Renewable Energy Technology

- » Promoting RE technologies through in-depth research studies, testing, development & deployment:
 - Testing: Solar photovoltaic (PV) products such as modules, pumps, batteries, etc.
 - Thermal energy storage applications/product development
 - RE resource potential and RE integration in energy planning including solar rooftop applications
 - RE technology development support and assessments



► Green Hydrogen report launch

- » Facilitating bio-energy utilization through:
 - Resource studies
 - Gasifier marketing in Indian and overseas markets
 - Agro-waste conversion solutions
 - Kitchen waste conversion solutions (TEAM technology)
- » Consulting services for domestic and international clients across the range of renewable energy technologies covering solar PV, solar thermal, floating solar, wind, bioenergy, energy storage, hydrogen, etc.

Electricity & Fuels

- » Energy Transition: Promoting low-carbon pathways through:
 - Integrated demand-supply studies at the national and state levels to inform capacity and electricity generation mix scenarios in the medium- to long-term
 - Grid-scale storage solutions including battery energy storage
 - Smart distribution with storage
 - Electric vehicles adoption
- » Promoting demand side management: Energy efficiency and best operating practices
- » Policy and regulatory analysis, regulatory impact assessment
- » Carrying out studies on key thematic areas/issues such as future role of coal, oil & gas, and attendant issues & challenges
- » Just transition



» Capacity building

Larger goals and the context

Energy Programme endeavours to address primarily SDG 7 focussing on affordable and clean energy. The varied activities under this programme also touch upon SDGs 1, 7, 8, 9, 11, 12, 13, and 17.



The Energy Programme envisions overall socio-economic development of India being driven by clean energy along a low-carbon pathway. The Programme focusses on supporting the transformation of the nation's energy landscape by ensuring adequate, reliable, affordable and easily accessible supplies of clean and renewable energy, as well as by developing

and promoting energy-efficient technological solutions/ measures for end-users in diverse sectors of the economy.



Harmony with nature and a people-centric approach keeping in mind the diversities in the social and cultural milieu of the country including the changing behavioural patterns should be cornerstones of our energy planning policies.

K Ramanathan, Distinguished Fellow,
Electricity & Fuels Division, TERI



Approach and innovation

The Energy Programme promotes low-carbon solutions and clean energy pathways through its in-depth field research and demonstrations, simulations, and modelling. Industry-centric need and opportunity mapping, data gathering and analysis and co-designing sustainable solutions define our journey. We also facilitate multi-stakeholder dialogue around Just Energy Transition and disseminate proven ideas for large-scale adoption and mainstreaming of efficient and cleaner technologies.

Our accomplishments

More than 100 projects were executed covering low-carbon pathways, energy efficiency, promotion of renewable technologies and studies, just transition, battery energy storage, e-mobility, RE integration, and capacity building across India and beyond. A few examples:

- **World Bank supported hydrogen GIS mapping:** TERI conducted GIS-based mapping study for the identification of the potential zones for green hydrogen production and utilization in India.
- **Situational analysis and preparation of detailed project reports (DPRs) for three MSME clusters in Andhra Pradesh:** We conducted a comprehensive analysis of energy usage, manufacturing processes, and operating technologies within identified MSME clusters. Based on this analysis, we prepared and disseminated DPRs outlining the transition to energy-efficient technologies.
- Mapping of MSME sectors, specifically glass and refractory, was conducted from the energy perspective and in-depth study of existing energy consumption scenario (detailed energy audits of 10





► *Interaction with the villagers affected by coal mining activities*

units in 5 clusters) and identification of opportunities for energy/resource saving was done. A roadmap for energy efficiency in this sector would eventually be made.

- Mapping of MSMEs in the chemical sector was conducted from the energy perspective and in-depth study of existing energy consumption scenario (detailed energy audits of 10 units in 5 clusters) and identification of opportunities for energy/resource saving was done. A roadmap would be created to make the industry more energy efficient as well as resource efficient, and environmentally friendly.
- TERI serves as the primary energy auditing organization, actively facilitating the implementation of the Perform, Achieve and Trade (PAT) scheme by the Government of India's Bureau of Energy Efficiency (BEE). Our core responsibilities include conducting mandatory energy audits and verification audits, primarily within the cement, iron & steel, pulp & paper, power, and textile sectors. In addition, detailed energy audits were carried out in other sectors for large industries such as Bosch, Chemplast Sanmar, Cipla, Gujarat Heavy Chemicals Limited, Indorama, Greenlam, Stylam Industries, and Saint Gobain.
- **SME energy audits in the garment sector in Cambodia:** Energy audit studies were undertaken in 50 garment manufacturing units with the objective of promoting sustainable energy practices across garment manufacturing in Cambodia.
- **Accelerating net-zero transition of public transportation in Kolkata:** A study with the support of West Bengal Transport Corporation was carried out—(a) to assess electricity demand by buses, 3-wheelers, and ferries on the distribution network of the city, and (b) the city-level pollution and GHG emissions post their electrification.
- A joint project for the application of a cloud-based **digital twin technology** to the electrical distribution network was undertaken in collaboration with Panitek Power AG, Venios GmbH, and BRPL. The

digital twin technology replicates the operational characteristics of the utility assets and assists the DISCOMs in planning, monitoring, and management of distribution assets.

- **Energy Storage for Renewable Energy Integration in India (StoREin):** The project that focuses on identifying applications and implementation of Battery Energy Storage System (BESS) at distribution level as well as capacity building is joint collaboration between the Ministry of New and Renewable Energy (MNRE), Government of India and the Federal Ministry for Economic Affairs and Climate Action (BMWK), Germany. The other consortia partners are GIZ, TERI, IIT-Bombay, WRI, and Fraunhofer-IEE.
- **One Sun, One World, One Grid (OSOWOG):** The study to develop a long-term vision, roadmap and institutional framework to implement the OSOWOG is underway. The study in which TERI is a consortium partner is being led by EDF, France.
- **Provided technical assistance to the Government of the Republic of Guyana in the electricity sector:** TERI has also been playing the role of a project management unit (PMU) for distributing 30,000 solar PV home energy systems across 245 hinterland and riverine communities in Guyana.
- TERI conducted studies on municipal solid waste (MSW) characterization in approximately 25 cities. The findings revealed a substantial opportunity to establish approximately 55 compressed biogas (CBG) plants, with the capacity to generate around 825 tonnes of CBG per day. This initiative is projected to lead to an annual reduction of 1 million tonnes of CO₂ equivalent emissions.

Inspirational evidences

Success stories

- TERI is supporting Tata Steel Utilities and Infrastructure Services Limited in implementing their DSM Action Plan. The focus is on energy-efficient lighting, promoting energy-efficient appliances, developing a dedicated energy efficiency programme for industries, and undertaking employee awareness programmes.
- **AP-TRANSCO:** A capacity-building programme for 500 senior officials of Andhra Pradesh power utilities (AP TRANSCO, AP DISCOMs, and NREDCAP) was conducted through 10 online webinars during September 2022–March 2023 on power sector scenario, power markets, GIS implementation in power utilities, forecasting and unit commitment, security constrained economic dispatch, reactive power management, grid integration of renewable

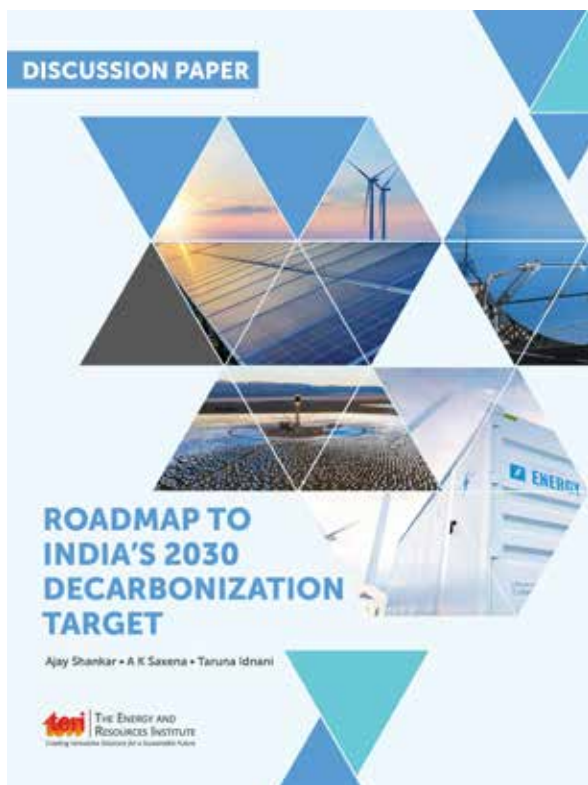


energy, emerging applications in power sector such as smart grid, electric vehicles, green hydrogen, etc. <https://www.youtube.com/supported_browsers?next_url=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DwLe9phbqc-l>

- In the third phase of the International Energy Agency (IEA) and TERI's collaboration on 'Collection and Estimation of data for IEA Energy Statistics and Balances', the focus was to understand the status of the Off-Grid and Decentralized Solar PV Applications Programme started by the MNRE in 1992 and Waste-to-Energy Programmes of the MNRE. TERI collated, analysed and documented the findings of the study in the form of two reports that were submitted to the IEA. The study and learnings were well received by the IEA.

Sustainable solutions promoted

- **Low-carbon growth of direct reduced iron (DRI) production in India:** The study explored the potential for hydrogen-based DRI production and recommended policy measures and next steps to accelerate the transition.
- **Roadmap to India's 2030 decarbonization targets for power sector:** A discussion paper examining the challenges and pathways to achieve the ambitious 2030 targets was released.



► TERI's discussion paper highlighting how India can achieve its 2030 targets announced at Glasgow

- **India's Electricity Transition Pathways to 2050:** The study to develop insights on contribution of clean energy in the supply mix to meet the anticipated demand, role of various technologies, impact on system cost, emissions, etc., was fine tuned.
- **Low-carbon pathways for the state of Madhya Pradesh:** A study to find out least cost investment in new-generation technologies and generation dispatch to meet the anticipated electricity demand in Madhya Pradesh in 2025 and 2030 was completed.
- Consultancy for provisions of technical services for development of investments in climate resilience and access to renewable energy technologies for Papua New Guinea.
- Carried out feasibility study supported by ABT Associates to assess the potential of biogas-based cold storage applications in rural Maharashtra. We conducted a biomethanization potential assessment study for a variety of wastes, including agro-residue, organic fraction of municipal solid waste (OFMSW), and industrial waste, across 25 cities in India.
- **Assessment of two-axis tracking solar photovoltaic system:** A third-party assessment was carried out of the system which was developed by Asun Solar Power Private Limited and supported by GMR.
- TERI conducted a market assessment study and developed a roadmap for the promotion of concentrated solar and photo-electrochemical device green hydrogen and oxygen generation technology developed by SoHHytec, a Swiss-based technology start-up.

Impact We Created

- **TERI's dialogue with the leaders of Indian business on industrial decarbonization and energy efficiency:** It led to on-boarding of Indian CEOs as signatories of the TERI's Industry Charter for Near-Zero Emissions Ambition by 2050.
- **Decarbonizing energy-intensive industries:** Global policies and best practices for industry transition—the study, which was conducted in cooperation with two international organizations, UNIDO and LeadIT, focussed on decarbonization of the steel and cement sectors. The key findings of the study were presented at the G20 Energy Transitions Working Group (ETWG) meetings held in Bengaluru and Mumbai.



- **Technical assistance to improve energy use efficiency to achieve PAT targets:** TERI continued to provide PAT-related technical services to Jindal Stainless Limited (JSL), Hissar, one of the Designated Consumers (DCs) of energy under the PAT scheme notified by the Ministry of Power.
- A 350 kg/h briquetting plant set up at Village Kulburchan, District Patiala, Punjab operated for more than 2000 hours to assess the field performance. With the use of advanced coating, the performance of the coated components has increased by 1.5–2.0 times. The average production of the plant with coated components has increased by 29% besides a substantial decrease in the specific power consumption, and plant downtime. The plant downtime has reduced from 34 hours per month to 21 hours per month. The briquette production cost was INR 7,537/- per tonne of briquettes during the baseline studies, which was reduced to INR 6,476/- per tonne of briquettes during the full-scale trials with coated components.



► *Field demonstration of a briquetting plant along with paddy straw storage at project*

- Just Transition research in coal sector enabled TERI to engage with stakeholders and capture multiple perspectives across top three coal-producing states in India—Jharkhand, Odisha, and Chhattisgarh—on implications of moving away from coal. This dialogue has essentially generated significant awareness at the grassroots level about how coal-based economy is likely to undergo change and how future is likely to unfold.

Knowledge building and dissemination

- TERI's participation in the 'Green and Digital Recovery—run-up to India's G20 Presidency dialogue' at Brussels was an opportunity for knowledge exchange.
- TERI's panel presentation on 'Glimpse of Indian national, legal, policy & regulatory framework on power' at IEEE PES (Power and Energy Society) General meeting at Denver, Colorado (USA) in July 2022 created a space for knowledge dialogue.
- A white paper on 'Distribution System Operator' was developed by TERI along with IIT- Delhi and IIT-Kanpur.
- The BEE has engaged TERI as a PMU for assisting in the work related to Global Energy Transition Index (GETI) and other international activities such as BRICS, ADEME since November 2020. The work continued during the year.
- In collaboration with Japanese experts, TERI promoted the dissemination of Japanese low-carbon and energy-efficient technologies among industries in India by conducting awareness seminars and feasibility studies in Pune and New Delhi.
- An 'India-Japan Environmental Week' was co-organized by TERI in New Delhi on January 12–13, 2023. The event was supported by Ministry of the Environment, Japan (MOE). More than 500 participants including a large number of experts from Japan and India participated in the conference.



► *India-Japan Environment Week*

- An awareness programme on 'Green Technologies and Practices for Foundry & Steel Re-Rolling Industries' was organized at Kolkata in July 2022.
- An awareness workshop on 'Green Technologies and Practices for MSMEs' was organized at Bokaro in May 2022.



- A training programme on, Energy Efficient Ceiling Fans, was organized for the MSME fan-manufacturing cluster at Kolkata in July 2022.
- TERI, in collaboration with BEE and other stakeholders, has established a collaborative platform called SAMEEEKSHA (www.sameeeksha.org). Four issues of the Sameeeksha newsletter were published and circulated among key stakeholders.
- Under the Just Transition project, TERI developed a website as well as a biannual newsletter called Vichar-Vimarsh which captures diverse voices and perspectives on the issue.
- Research and development in the field of smart grid, BESS, e-mobility, DSM & EE, mapping of demand & supply centres for potential green hydrogen opportunities in India, etc., helped gain insights and disseminate learning.
- Conducted knowledge sharing webinar/workshops on Just Transition, e-mobility, DSO, etc.
- TERI in collaboration with Responsible Energy Initiative which is a consortium of organizations, namely The Nature Conservancy, Vasudha Foundation, and the National Solar Energy Federation of India in support of Climate trends, organized the first-ever Responsible Renewable Energy Summit.
- TERI and WBTC organized a capacity building workshop on 'Accelerating Net Zero Transition of Public Transportation in Kolkata' on May 10, 2023 to develop a comprehensive understanding of charging infrastructure, technologies, financial models and administrative measures needed to implement the transition to EVs in public transportation.
- The 5th India-Japan workshop on Energy Transition 2023 brought together Indian and Japanese experts to discuss the strategies to realize the energy transition including clean energy and also to explore mutual cooperation in this field.
- A series of webinars were conducted to promote energy conservation across Small Island Developing States (SIDS), funded by the International Renewable Energy Agency (IRENA). (<https://islands.irena.org/-/media/Files/IRENA/Sids/Grenada-Energy-Management-and-Audit-Webinars>)
- TERI conducted an assessment of solar PV trainers in Timor-Leste. The existing training modules, training needs, and current challenges in installation and maintenance were captured. This activity was supported by Climate Technology Centre and Network (CTCN) and Green Climate Fund (GCF). A training of trainers (ToT) programme will be organized in the near future.

Contribution to knowledge building

- Seven publications
- Two international presentations

Partnerships and networks

Multiple projects in energy space could be carried out with generous support from varied donors such as UNEP, GIZ, MacArthur Foundation, DST, SSEF, BEE, Bloomberg Philanthropies, CIFF, ABT associates, IFC, CTCN, etc. Consultancy projects were secured from many domestic corporate players as well as international players such as GGGI, Government of Guyana, World Bank, etc., in the field of energy efficiency in countries such as Guyana, Grenada, Uzbekistan, Mexico, Cambodia, etc.



► Workshop with PV trainers in Timor-Leste





► *Performance evaluation of cooling towers to ensure water and energy savings potential*

A memorandum of understanding was signed between the Department of MSME and Textiles, Government of West Bengal, Shakti Sustainable Energy Foundation and TERI at the Bengal Global Business Summit 2022 held at Kolkata in April 2022. Additionally, TERI provided knowledge support to the Ministry of Steel for the development of Vision 2047 document and National Mission for Green Steel.

Furthermore, TERI is a core partner of the Responsible Energy Initiative, launched in 2021 in collaboration with World Resources Institute India (WRI India), Landesa, World Wildlife Fund for Nature India (WWF India), and Forum for the Future. It focusses on three key areas concerning finance and investments in renewable energy, sustainable and inclusive land use patterns, and circularity.

Details on Knowledge Building; Partnerships and Networks can be viewed via the following URLs:

- ¹ https://www.teriin.org/files/TERI_Annual_Report_Knowledge_Contributions.pdf
- ² https://www.teriin.org/files/TERI_Annual_Report_Partnerships_and_Networks.pdf



GREEN SHIPPING PROGRAMME



The Green Shipping programme aims at extending TERI research capabilities into the landscape of sustainable ports, shipping, and waterways transportation. They carry out comprehensive assessments using integrated sustainability frameworks and life cycle tools to evaluate the advantages of energy transition and circular economy practices in key sectors such as agriculture, shipping, automotive, packaging, and steel.

The programme assists the National Centre of Excellence in Green Ports and Shipping (NCoEGPS) set up by the Ministry of Ports, Shipping and Waterways (MoPSW), Government of India. The Programme functions through its two divisions—Advanced Biofuels and Resource Efficiency and Governance (REG).



Advanced Biofuels Division

Microbial Biofuels and Biochemical Area

Themes and Commitments

Thematic focus

With in-depth research explorations, Microbial Biofuel and Biochemical research group at TERI paved the way for development and demonstration bioprocesses for production of biofuels and biochemical and biocommodities from 1st generation as well as from low-cost 2nd and 3rd generation feedstock. With an aim to make these processes environment friendly and cost economical, end-to-end low-cost technologies were developed, in a biorefinery approach. This strategy helped to establish collaboration with industries for demonstration of technologies at higher Technology Readiness Level (TRL) scale, which is the key for commercialization.

Centre for Biofuels

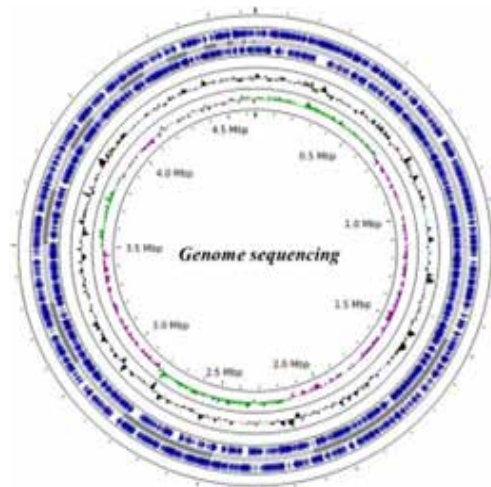
Research and development of this Area is primarily focused on microbial (using bacteria, yeast, algae as host) bioprocess development and demonstration for production of: (i) liquid biofuels, bioethanol, biobutanol, biojet fuel precursor, marine algae production for application in advanced biodiesel production, biofuels for adoption in shipping sector; (ii) gaseous biofuels; biohydrogen, biomethane. With an aim to overproduce these biomolecules using the select high product yielding microbial strains, research domain of these areas also spans synthetic biology approach using whole genome analysis as a tool for biosynthetic pathway elucidation for construction of recombinant hosts (GM strain).



► Pilot-scale demonstration of pilot-scale downstream recovery of liquid biofuel molecule(s) at TERI



► Marine algal cultivation in 100,000 litres (220 sq. m) production system (based on sunlight distribution and 6000 litres raceway pond inoculum system) for improvement and production of 3rd generation feedstock (to use as platform feed for biodiesel, bioethanol, biohydrogen, aquafeed, and animal feed) production.



► Whole genome sequencing of select high product yielding microbial strains for pathway elucidation and construction of GM strain

Centre for Biochemicals

Thematic research under this Area deals with technology development and demonstration for production of high value industry platform biochemicals (2,3 butane diol, 1,3 propane diol, lactic acid, acetoin, acetic acid, butyric acid, farnasene, beta carotene, gamma linolenic acid, and value-added biocommodities, aqua feed, animal feed, using low-cost feed including agriculture residues and algal biomass as feed.





▶ Beta-carotene producing algal cultivation in the Mumbai coast using 1000 litres raceway pond (the alga has changed colour from green to orange when beta-carotene production shift happened)



▶ Pilot-scale process demonstrated for downstream recovery of value added biomolecules



▶ 2,3 butanediol and ethanol production from 1st and next generation feed



▶ High-value carotenoid production from organic acid rich spent effluent by photosynthetic bacteria

Tata Chemicals Ltd. -TERI Centre of Excellence

Based on the TERI research leads developed for biochemical production from different low-cost feed, TERI team is exploring for demonstration of the aforementioned technologies at large scale (Higher TRL scale) though employment of novel, end-to-end technologies. These milestones are executed using the dedicated state-of-the-art upstream fermentation integrated with downstream recovery laboratory facility, established under this Centre at TERI GRAM.





- Bioprocess development for extraction of sugar from lipid-extracted algae biomass
- Marine algae production in 1000-litre scale for high-value beta carotene production
- Process development of onsite harvesting and beta carotene extraction from algae biomass.

High value industry platform chemical production

- Pilot-scale production of high-value biochemical, 2,3 butane diol production from 1st and 2nd generation (biomass) feed
- Demonstration of pilot-scale downstream recovery process for recovery of 2,3 butane diol from fermentation broth
- Bioprocess development for biomass treatment for sugar recovery
- Bioprocess developed for 1,3 propane diol production from glycerol
- Lactic acid production from low-cost sugar and biomass
- Lutein and beta carotene extraction from Chlorella and Spirulina biomass.

Microbial biofuel production

- Bioethanol production from algae biomass
- Adoption of biofuel in shipping sector
- Butanol production from low-cost feed
- Algal; biodiesel production.

Our accomplishments

- » Tata Chemicals Ltd. – TERI Centre of Excellence on platform biochemical production
- » Individual research projects
- » Execution of projects under National Centre of Excellence on Green Ports Shipping and Waterways.

Larger goals and the context

MBB's research endeavours cover 4 SDGs: SDG 7, SDG 9, SDG 14, and SDG 17.



Sustainable solutions promoted

Marine algal production used as feed for high value biomolecule production

- Marine algae cultivation in the coastal site in a 100,000-litre scale for lipid production

Pyrolytic Biofuel, Biochar and Green Chemicals (PBGC) Area

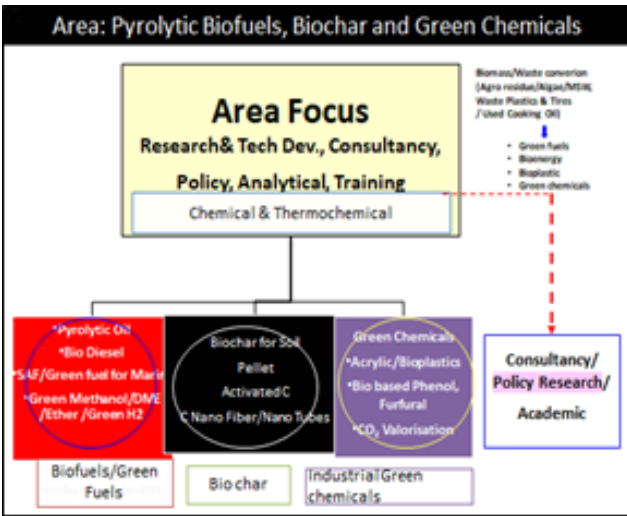
Thematic focus

The primary focus of the area "Pyrolytic Biofuels, Biochar, and Green Chemicals" (PBGC) is research and technology development, policy, and consultancy in sustainable low-carbon biofuels, green fuel bioenergy, and bioplastics. Within this area, research and technology development primarily revolve around thermochemical and catalytic conversion of agro-industrial biomass, waste residues, algae, waste/scrap plastics, and used cooking oil (UCO) into advanced biofuels such as SAF/bio-jet fuel, biodiesel, refinery-grade pyrolytic biocrude, and other by-products such as biochar and high-porosity activated carbons.





► TERI's Thermochemical Conversion Lab



Larger goals and the context

This area's research work majorly covers three SDGs, viz., 7, 9, and 14.



Expertise

- Technology development
 - Pyrolysis technology
 - Biofuel (Sustainable aviation fuel (SAF), biodiesel, green fuel for marine (green methanol, green H2/ green ammonia)
 - Biochar and activated carbon (soil, combustion application)
 - Co-pyrolysis oil to refinery grade oil
- Technology assessment

Our accomplishments

TERI maintains a Thermochemical Conversion Lab that conducts research in pyrolysis technology for production of biofuel (SAF, biodiesel, green methanol), biochar and activated carbon, and pyrolysis oil to refinery grade oil. This Area also works on bioplastic research and biofuel and bio-commodity policy domain.

To its credit, TERI has a few patented technologies in this field, and is currently engaged with development of some others. These include:

Pyrolysis Research (Patented Technology Developed (TRL: 5)

TERI Pyrolysis Technology: Gas Fired Augur



► TERI Pilot Pyrolyser (patented)



► Bio oil catalytic upgradation unit

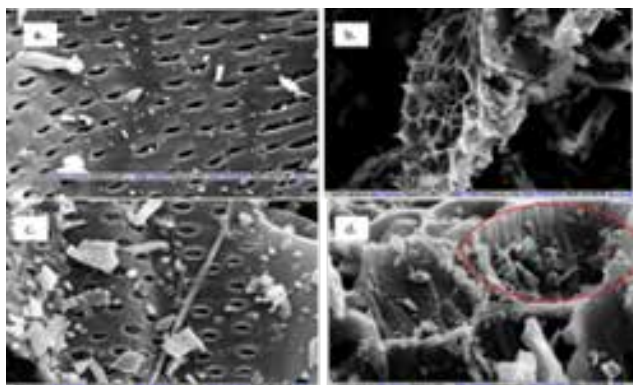


- Using TERI's patented pyrolysis technology, different biomass feedstocks/agro-industrial residues such as tea wastes, coffee wastes, mustard residues, paddy straw, cashew nut shell, cotton stalk, sugarcane bagasse, scrap bamboo, plastics, industrial spent biomass (L'OREAL) have been converted to pyrolytic biofuel and biochar.
- PBGC Area has performed intense research aimed at downstream catalytic upgradation of pyrolytic oil produced in pilot pyrolyser to further superior quality bio oil for refinery integration.
- Indigenous catalysts have been developed for downstream catalytic upgradation of pyrolytic bio-oil to refinery grade bio oil, aviation fuel components, speciality chemicals, and aromatics.

Biochar, Activated Carbon and Green Pellets



▶ TERI's pyrolytic char derived green pellets



▶ TERI's biochar derived activated carbon

TERI has been continuing technology development in making high-grade carbon products from pyrolytic biochar and its applications.

- High micro-porosity (BET Surface area 500–2400 m²/g) activated carbon (green carbon) is successfully made from agro-residues and de-oiled marine algal biomass-based pyrolytic
- Biochar through indigenously developed downstream activation process. The activation is accomplished using environmentally benign physical and chemical processes. Carbon materials with micro and nano porosities have been identified as highly suitable for CO₂ adsorption.

- TERI also has got good research leads in biochar soil fertility improvement in the pot experiment so far under controlled in-house conditions. TERI's Pyrolytic biochar made from mustard and rice stalk at different pyrolytic conditions is used for soil fertility experiments and growth of medicinal plants of *Centella asiatica* under a research exchange programme by Global Challenges Research Fund (GCRF), UKRI, United Kingdom.
- Under a sponsored research project, the PBGC Area has developed indigenous process for making green pellets using pyrolytic biomass-based biochar. The Comparative Analysis of Emission of Air Pollutants from Biochar Pellets against conventional Biomass Briquettes shows 61–93 % reduction of particulate matter (PM_{2.5} and PM₁₀) and VOC, respectively.

TERI's Technology has entered a stage where bio oil and biochar could be recognized as the building block for thermal biorefinery for co-production of fuels and chemicals.

Biodiesel (Technology Status TRL: 4)

- TERI has developed a two stage in-house acidic and basic ionic liquid (IL) catalysed process for production of biodiesel from renewable oil feedstocks such as CO and marine algal lipid which can be operated with renewable power (present scale of conversion 10 kg/h). The biodiesel conversion efficiency > 95 % is achieved.
- The Life cycle environmental impact of TERI's solar integrated biodiesel conversion process shows significant reduction for 14 impact categories. This is very crucial development w.r.t. biodiesel plant running with renewable energy using 2nd and 3rd generation feedstocks such as UCO and algal lipid.

Industrial Green Chemical (Pilot scale technology developed TRL 4)

- TERI has developed and patented a green process of making acrylic acid through allyl-alcohol pathway from renewable glycerol. The glycerol produced in TERI's in-house UCO-based biodiesel plant as well as glycerol procured from commercial biodiesel plant are used for making the allyl alcohol with a conversion efficiency of glycerol to allyl alcohol >80% higher than literature benchmark.
- The LCA and TEA of the process shows the economic and environmental sustainability and its upscaling potential.
- The oxidation of allyl alcohol to acrylic acid with benchmark efficiency of >70% and upscaling of glycerol to acrylic acid production to pilot scale is under development



SAF from Biomass Agro Residues and Marine Algal Lipid (TRL 3)

- The global aviation industry seeks to reduce its GHG emissions significantly, decoupling airline growth from carbon growth. The current cost of SAF is high, which needs to be cost-competitive.
- India still lacks viable processes for making SAF from surplus agro biomass residues, Municipal Solid Waste (MSW), and algal lipids.
- TERI has initiated work in converting both biomass pyrolysis oil and marine algal lipid to SAF. The pyrolytic biocrude has been downstream upgraded through catalytic intervention to bio-jet fuel range products including diesel fraction from a variety of agro residues as well as from de-oiled marine algal biomass.
- Upscaling of these processes and demonstration at minimum sustainable scale will lead to jet fuel range products from 2nd generation low-cost feedstocks and 3G marine algal feedstock is available in abundance in India.

Impact We Created

- Pyrolytic bio-oil and biochar-based products for reducing GHG emission (by 60–95%) is associated with stubble burning.
- Agro-residue biomass to sustainable aviation fuel production pathway established, which could be employed for wider biomass feedstocks such as MSW and algal biomass.
- The ionic liquid (IL) catalyst-based green diesel process developed by TERI, has eliminated the water use for purification process.
- Conventional petroleum feedstock replaced by renewable feedstock (glycerol) for making green acrylic acid production through allyl alcohol pathway.
- Solar integrated IL catalysed biodiesel conversion led to low water and carbon footprint.

Invited Lecture/Co-Charing Session in International /National Conference

Delivered seven (7) invited keynote speech (5 international and 2 national) conferences and workshops and participated as panellist. Also attended 2 International and 2 national Webinars as Delegate.



► Participated as panellist at “Moving towards the circular economy” in 6th India Refining Summit 2023 ‘Towards a Net Zero Future’ organized by Messe Frankfurt Hotel Le Meridien, New Delhi on February 23, 2023



► Presentation at EU-INDIA Innovation Cooperation in the Biofuels Sector G2G and B2G Meeting on Advanced Biofuel from Biomass for Maritime and Aviation at Pandit Deendayal Energy University (PDEU), Gandhinagar, Gujarat on February 13, 2023





► Presentation in the Session "Industry 5.0 and Paradigm Shift: Emerging Challenges" on "Scientific Temper and Quality of Life" International Congress, SANMANTRANA-2023 organized by SVVV Indore and St. Cloud State University (Minnesota, USA) on February 2, 2023

TASK Force Member

- Sub-Group 'Bio-ATF' / "Biofuels-Feedstock" constituted under the chairmanship of Director (Bio-Refinery), MoPNG under the Working Group on Biofuels (Constituted under the National Policy on Biofuels-2018) – Concept note developed and Recommendations made for BIO-ATF Feedstocks as part of MOP&NG "Bio ATF" Taskforce (13th April 2022/9th Aug Submitted)
- BIS (Petroleum, Coal and Related Products Department) TASK Force (PCD 03 : 1 : P4) Panel Member to Formulate Indian Standard for Pyrolysis Oil and attended TASK Force meetings in 2023

Partnerships and networks

- Grants secured from the Ministry of Ports, Shipping and Waterways; Department of Biotechnology; Ministry of Science and Technology; Centre for High Technology (MoPNG), Government of India.
- Few grants received from private industries, national and MNCs such as Asian Clean Fuels Association, Singapore; and Global Challenges Research Fund UKIERI, European Commission.
- Long-term partnership with the Department of Biotechnology, Ministry of Science and Technology, Centre of High Technology (MoPNG), Government of India, is worth mentioning.

Way Forward

The PBGC Area is working towards developing strategic collaborative research partnership with Institutes and

industry of national and international importance, especially in technology upscaling of green fuels production, bioplastics/biodegradable polymers, and biochar-based products. TERI's PBGC Area has strength in green (including biofuel), biochar and bioplastic area, which could be leveraged to the genesis of full-fledged dedicated Centres with industrial partnership.

Resource Efficiency and Governance Division

Thematic focus

The Resource Efficiency and Governance (REG) division leads TERI's efforts around critical environmental policy issues such as circular economy, blue economy, agriculture policy, energy data management, energy transition, sustainability assessment, natural resource management, and climate change-based geopolitical analysis. The Division aims to promote the effective utilization of natural resources and energy through a combination of data, policy, economic analysis, and market instruments.

Larger goals and the context

The REG Division endeavours to address SDGs 2, 7, 12, 13, 14, and 16.



Our expertise

The Division's expertise include Life Cycle Assessment, Energy Data Management and Analysis, Agriculture Policy, Blue Economy, Natural Resources, Economic and Policy Analysis, Green Energy, and Ecosystem Evaluation.



Life Cycle Assessment (LCA)



Life Cycle Assessment (LCA)



Agriculture Policy



Blue Economy



Natural Resource Management



Economic and Policy Analysis



Green Energy



Ecosystem Evaluation

Our accomplishments

Over the last few years, the Division has been at the forefront of undertaking imperative and unique research projects, broadening the horizons of sustainable development across the industrial landscape, especially hard-to-abate sectors.

- The Division undertook a first-of-its-kind comparative LCA of different beverage packaging options available across the markets of India, Vietnam, and Thailand.
- The Division undertook a first-of-its-kind LCA project, comparing the sustainability levels of electric vehicles

against cars running on internal combustion engines for the Indian market.

- The Division undertook a first-of-its-kind research exercise for the defence sector wherein it assessed how the accelerated usage of simulators can help the Indian Armed Forces reduce their overall carbon emissions.
- The Division developed a strategic roadmap for the adoption of Sustainable Aviation Fuels for the Indian airline sector.
- As part of its research activities around energy transition, the Division was one of the first in India to robustly look at the implications of 'Just Transition' both from an economic and socio-economic standpoint.



Aggregate numbers

The Resource Efficiency and Governance is one of the most dynamic teams in TERI working across diverse disciplines. The Division currently has following keys projects to its credit:

1. India's first comprehensive environmental sustainability assessment of packaging sector:

Conducted the first comparative Life Cycle Assessment (LCA) study in the country across four popular beverage packaging options in the Indian market: glass bottle, PET bottle, aluminium can, and MLP Tetra Pak. The study was followed by dissemination activities in collaboration with several state governments and was supported by the Hon'ble Minister of Environment, Forest and Climate Change, Shri Bhupender Singh Yadav. The implementation phase of the project is ongoing where REG aims to partner with project client Ball Corporation, India and local recyclers for public campaigns and eventual



establishment of a Deposit Return System (DRS) in some states. The success of the project has enabled REG to bag similar projects for analysis in Vietnam and Thailand.



► Presentation of LCA study report to the Hon'ble Minister Shri Bhupender Singh Yadav



► Presentation of LCA study for Vietnam at Sustainable Packaging Solution workshop

2. India's first comparative LCA study of EVs and ICE vehicles:

The comparative LCA comparing 3Ws and 4Ws powertrain components of EVs and ICE vehicles have massive implications for the energy transition future of India. The finding highlights the advantages and disadvantages of EVs enabling policymakers to make the right decision during its promotion phase.

3. Assessing simulators' role in promoting sustainability in defence sector:

REG became the first division to establish a strong network with the Ministry of Defence (MoD), Government of India through its project of assessing the environmental and economic benefits of simulated army training over on-field training. The project has made inroads for REG Division as well as other divisions to collaborate with the MoD in the future.



► Report launch event of sustainability assessment of simulated defence training in the presence of ADG ADB Major General C S Mann on the occasion of World Environment Day

4. Establishing EDMU: REG with the Bureau of Energy Efficiency (BEE) has compiled and published India's entire energy data under its EDMU project.

5. Assessing alternative livelihood opportunities of coal mining workers in India's mining district:

REG has conducted a Needs Assessment to map the demand side of job opportunities for informal coal mining workers in three mining districts of India: Dhanbad, Jharkhand; Angul, Odisha; and Cuddalore, Tamil Nadu. The study also has a component of assessing the supply side by mapping alternate industries present in the region. During an eventual closure of coal mining in distant future, the study is a pre-emptive effort towards securing livelihoods during this transition.



► On field FGD with women whose husbands are working in coal mining industry

6. Sustainability assessment of biomass-based fuel for transportation sector:

A comprehensive environmental and social benefit study of using biomass-based fuel (CBG) for vehicular transportation.





► *Field survey to assess social benefits of CBG vehicles*

7. India-Australia research and industrial collaboration in reducing plastic waste (IACP):

Three organizations from India (TERI, DA, and CSIR-NEERI) and three from Australia (UNSW, ISF-UTS, and CSIRO) have come together for a comprehensive study on plastic economy of India across its entire value chain. The REG division has contributed to the data chapter and has updated the Indian plastic material flow across sectors and 7 polymer types by 20 years; the last one being done in 2006.



► *Agra municipal solid waste dump yard and 3 TPD recycling facility*

8. EU-REI: Sustainability Assessment in Textile clusters: Under the EU-Resource efficiency initiative, the Ludhiana textile cluster is chosen where the REG team in collaboration with CWM will conduct a resource efficiency assessment and recommend changes for improved performance.

9. FOLU-India: The two projects under the FOLU brand are looking to:

- Understand and establish the feasibility of sustainable agricultural practices and interventions in the rainfed region (Vikarabad District, Telangana) through adopting an integrated landscape approach.
- Develop a roadmap for the crop diversification of Punjab. The general approach adopted is to initiate a value chain-based gap analysis to identify the enabling conditions required to make the alternate crops economically lucrative to the farmers.

Approach and innovation

The approach of REG is not to limit itself to a few particular specializations but to consistently strive to expand the portfolio of sectors in which we undertake projects. The REG team is dynamic and multidisciplinary, with expertise in economics, environmental sciences, agricultural sciences, environmental impact assessment, public policy, and material sciences.

Impact We Created

The energy and resources industry is undergoing significant changes due to various factors such as decarbonization, digitization, financial constraints, and geopolitical instability. These forces are driving transformative shifts within the sector. The REG Division draws on its deep understanding of the sustainable industry landscape to help stakeholders tackle today's environmental challenges, and help the nation achieve its 2070 net zero target. Some of the impacts we have created in the current transitioning environment are:

- Success of Ball Corporation India LCA study has enabled us to bag similar studies from international companies recognizing TERI's capability in conducting life cycle assessments. Now that TERI has become a recognized and credible player for LCA studies with more and more private sector companies approaching us for LCA of their products. This will give a big boost to SDG 12 (Sustainable Consumption and Production) in the long run.



- Developing interactions with IDS office has hinted a scope for collaboration projects with the Defence ministry in the near future. Defence being a sector of national and strategic importance, environment considerations of defence operations in association with TERI will carry a good name for India in the international stage.
- Development of a framework at the end of demand and supply side needs assesment for informal coal mining workers. The framework can thus further be used as a toolkit to provide alternative livelihoods for any displaced community in the future.
- Successfully organized side events at Clean Energy Ministerial (CEM) 2023 in Goa where REG's development of EDMU led to the consensus that economy-wide energy efficiency targets are necessary for the country.
- The FOLU-India project as part of their implementation has created a positive impact on ground through various rural consultation processes. Several farmers have bought into the process and are now aligned with the implementation vision set out as part of the project.

Partnerships and networks

- Worked closely with CSIRO Australia, CSIR-NEERI, UNSW, UTS and DA on plastics circular economy of India. A long-term partnership has been formed with these research institutes for continuous knowledge exchange through the upcoming work.
- Collaboration with the Ministry of Defence and in discussion for collaboration projects.
- Knowledge and technical partner with the MoEFCC for circular economy segment for G20 India.
- Several private industry partnerships including Ball Corporation, Maruti Suzuki India Ltd, Samsung India, Tata Sons, etc.

Details on Knowledge Building; Partnerships and Networks can be viewed via the following URLs:

- ¹ https://www.teriin.org/files/TERI_Annual_Report_Knowledge_Contributions.pdf
- ² https://www.teriin.org/files/TERI_Annual_Report_Partnerships_and_Networks.pdf



CLIMATE CHANGE AND AIR QUALITY PROGRAMME



Earth Science and Climate Change Division has been conducting research on relevant global and local environmental issues, in both developed and developing countries, for more than three decades. Using an interdisciplinary approach, it focuses on undertaking path-breaking research in the fields of climate change and air quality.

Using heterogeneous approaches of research that comprise instrumentation, model-based assessments, and stakeholder-consultative processes, it seeks to bridge the gap between science, policy, and practice for informed action and implementation. It focuses on scientific and policy-relevant recommendations for climate change mitigation, adaptation and improving air quality and health by assessing various sectors including water, health, agriculture, energy, industry, transport, waste, buildings, and land use.



Themes and Commitments

Thematic focus

The Earth Science and Climate Change initiatives are centred on the following areas:

- Impacts, vulnerability and adaptation research for climate-sensitive sectors
- Climate risk and disaster management research
- Climate change and health challenges
- Climate mitigation, technology, and policy research
- Climate finance and market
- Return levels of climate extremes
- Regional down scale of climate models using dynamical and statistical methods
- Studies on ocean and atmospheric dynamics
- Climate modelling and monsoon research
- Air quality monitoring and emissions monitoring
- Air pollution and health effects
- Emission inventORIZATION and air quality modelling
- Linking air pollution with climate change
- Developing air quality management plans for urban and regional scales
- Urban indoor air quality assessment
- In-situ and ex-situ management of post-harvest crop residue
- Training and capacity building on various climate and environmental issues

Key accomplishments

- We are instrumental in developing research-informed evidence for policymaking, aiding government bodies in the formulation of National and Sub-National



► *Field work*



- Climate Action Plans for climate change, heat stress, health, and agriculture and water sector.
- We have also developed and supported the state of environment reports and environmental policies, GHG inventory development and mitigation measures to achieve GHG reduction goals at the city and regional scales, heat action plans, flood risk, and disaster management interventions, climate risk information that are recently adopted in various state government policies and work.
 - Under the ambit of the Montreal Protocol, TERI's research on sustainable cooling has added value to national policies.
 - A landmark in this direction is a study titled 'Public Procurement Policies for Refrigeration and Air-Conditioning Equipment using non-ODS based Refrigerants' carried out by the area in collaboration with the Ozone Cell, Ministry of Environment, Forest, and Climate Change (MoEFCC). Recognizing the findings of the study Government-E-Market (GeM) Place – a digital platform for public procurement has now integrated the servicing technician personnel practising good servicing practices in the refrigeration and air conditioning sector, into the existing GeM.
 - Recognizing our contribution in the field of climate change and sustainability, Ms Suruchi Bhadwal was counted amongst 10 Indians for Water Sheroes by the Principal Scientific Adviser, Government of India, Office of the Chief Science Advisor of Canada, The





► COP27 Outcomes presentation

- Royal Society of Canada (RSC), Office of the Deputy Representative UN Women and Red Dot Foundation.
- Every year TERI has a strong presence at the Conference of the Parties (COP) under the United Nations Framework Convention on Climate Change. The CCCR area is responsible for looking after the COP conference from TERI. In the 27th Conference of the Parties (COP27) from 6–18 November 2022 at the Sharm-el-Sheikh, Egypt. Like previous COPs, we were involved in several events as organizers, co-organizer, and panellists. These events focus on a wide range of issues including enhanced transparency, climate finance, decarbonization pathways, vulnerability and adaptation, technological change, and climate governance, and strengthen the narrative for better alignment with sustainable development goals.
 - To discuss some of the key outcomes of COP27, TERI organized a high-level panel discussion on ‘COP27 Outcomes: from the Perspective of Policy, Research & Business’ with the key members of the Indian delegation who shared their valuable insights on the outcomes and future road map to achieve the targets laid out by India.
 - In partnership with The Embassy of France in India, we organized cross-country knowledge exchange sessions under the flagship of TERI’s ‘Multi-Country Cooling Platform’ and as a part of project SHEETAL – Alliance for Sustainable Habitat, Energy Efficiency and Thermal Comfort for All. The sessions facilitated panel discussion, brought together policy and cooling industry experts from India and France around sustainable cooling across sectors such as building and cold chains.
 - We also focused on providing state-level policy recommendations through several source apportionment studies, which guided state-level regulatory authorities to develop local action plans to

control air pollution and its impacts.

- A new project was initiated with support from the Clean Air Fund and Bloomberg Philanthropies to strengthen systems for airshed management and contribute to implementation of priority measures to reduce air pollution as per the Uttar Pradesh Clean Air Action Plan. Under the project, TERI has established Strategic and Policy Advisory Unit nested within the Department of Environment, Government of Uttar Pradesh, to provide strategic guidance and technical assistance for effective funds utilization and results delivery of UP-CAMP.
- We are moving forward from the knowledge gained from the past project on SLCPs. TERI, with support from Vasudha Foundation is estimating the present SLCP concentration across the country which will aid the government in prioritizing the policies to get maximum co-benefits. Further we are working on a coupled model approach to quantify the impact of air pollutants on climate, which will make TERI one of the few organizations to be able to do that successfully in the country.
- The real-time source apportionment study, a joint venture of the Delhi Pollution Control Committee, IIT-Delhi, IIT-Kanpur and TERI launched the real-time source apportionment ‘supersite’ for sharing details of sources of pollution on an hourly basis as well as forecasting the air pollutants for the next three days. This will help the policymakers identify pollution hotspots and make targeted interventions. Under this project a website is launched <www.raasman.com> which provides real-time data on the sources of air pollution in the city and is expected to help the Government of Delhi frame effective policies to curb it.
- We developed a Framework for Monitoring and Evaluation of the National Action Plan for Climate Change and Human Health (NAPCCHH) and conducted the National-level Health Vulnerability Assessment for Climate Change.



► Field work



Projects

The ESCC has been executing a number of projects under various themes. In total, 70 projects were completed during the last financial year. Some of the notable projects executed during 2022/23 are tabulated below.

S. No.	Name of area	Project title	Principal investigator	Project sponsors
1	Centre for Climate Change Research	ECSWG during G20 India Presidency	Suruchi Bhadwal	The Boston Consulting Group (India) Private Limited
2	Centre for Climate Change Research	Developing Climate Change Resilience Plan	Neha Bharti	Tandon Urban Solutions Private Limited
3	Centre for Climate Change Research	Risk Assessment and Accounting for the Ecosystem Services	Prasoon Singh	WWF-India
4	Centre for Climate Change Research	Decarbonization of E-commerce	K Umamaheswaran	Amazon.com,Aakhya Media Services Private Limited
5	Centre for Climate Change Research	Development of a Transition Risk Management	Amlan Mishra	American Friends of EdelGive Foundation
6	Centre for Climate Change Research	Green Public Procurement Framework	K Umamaheswaran	Government e Marketplace (GeM)
7	Centre for Climate Change Research	Sub-project for Accelerating Net-zero Transition of Public Transportation	K Umamaheswaran	New Venture Fund
8	Centre for Climate Change Research	Climate Change and Health Review of Evidence for Indo-Pacific region	Smita Chakravarty	Foreign, Commonwealth and Development Office
9	Centre for Climate Change Research	ICAT-PHASE 2	Suruchi Bhadwal	United Nations Office for Project Services (UNOPS)
10	Centre for Climate Change Research	Eco-region Specific Climate Impact Assessment	Suruchi Bhadwal	The Norwegian Ministry of Foreign Affairs
11	Centre for Climate Change Research	Determination of Scope 3 Greenhouse Gas	K Umamaheswaran	ITC Limited
12	Centre for Climate Change Research	Activities for Dissemination of Findings on HFC-use and Phasedown	Shaurya Anand	Natural Resources Defence Council
13	Centre for Climate Change Research	Preparation of Revision Document of Jammu and Kashmir	Neha Bharti	Government of Jammu and Kashmir Department of Ecology, Environment and Remote Sensing
14	Centre for Climate Change Research	Due Diligence Service for CIP in Bihar	Gaurav Yadav	Climate Impact



15	Centre for Climate Change Research	GHG Estimation, Carbon Credit Calculation	Chempakassery P. Veena	Kerala Development and Innovation Strategic Council
16	Centre for Climate Change Research	Due Diligence Service for CIP in Satpura	Gaurav Yadav	Climate Impact
17	Centre for Climate Change Research	Due Diligence Service for CIP in Panna	Gaurav Yadav	Climate Impact
18	Centre for Climate Change Research	IGSD Event	Suruchi Bhadwal	Institute for Governance and Sustainable Development
19	Centre for Climate Change Research	Site Visit to TERI's R&D Centre, TERI Gram	Suruchi Bhadwal	Observer Research Foundation
20	Centre for Air Quality Research	Future Climate Leaders Programme	Vidhu Kapur	Joe Fenn (Evergreen Story Inc.)
21	Centre for Air Quality Research	Source Apportionment Study of Kaniha OCP	R. Suresh	Mahanadi Coalfields Limited
22	Centre for Air Quality Research	Air Quality Monitoring at Accenture, NOIDA	Prabhat Sharma	Accenture Solutions Private Limited
24	Centre for Air Quality Research	Air Pollution Source Apportionment Study for Kolkata and Howrah	Dr Arindam Datta	West Bengal Pollution Control Board
25	Centre for Air Quality Research	Study on Hyperlocal Air Quality Assessment	R. Suresh	Bihar State Pollution Control Board, Patna Municipal Corporation
26	Centre for Air Quality Research	Development of Climate Resilient Agriculture	Dr Arindam Datta	Deutsche Gesellschaft Fur Internationale Zusammenarbeit (GIZ) GmbH
27	Centre for Air Quality Research	Carrying Out Indoor and Ambient Air Quality of Accenture	Prabhat Sharma	Accenture Solutions Private Limited
28	Centre for Air Quality Research	Achieving Net Zero with Development and other Co-benefits	Nimish Singh	Vasudha Foundation USA
30	Centre for Air Quality Research	Consultancy Services to Design, Constitute and Operate a Community of Practice (CoP) for Air Quality Improvement in Indian cities	Dr Arindam Datta	Ricardo Energy and Environment
31	Centre for Air Quality Research	Scope and Role of Natural Gas in Mitigating Industrial Air Pollution	R. Suresh	FIPI
32	Centre for Air Quality Research	Emission Inventory and SA Study for Kashipur and Rishikesh	R. Suresh	Uttarakhand Pollution Control Board



33	Centre for Air Quality Research	Emission Inventory and SA Study for Vadodara	R. Suresh	Vadodara Municipal Corporation
34	Centre for Air Quality Research	Emission Inventory and SA Study for Faridabad	R. Suresh	Municipal Corporation of Faridabad
35	Centre for Air Quality Research	Air Pollutants Emission Inventory Around Monuments in India	R. Suresh	Environmental Defence Fund
36	Centre for Air Quality Research	Develop an Air Quality Progress Report (AQPR) for India	Nimish Singh	UNEP
37	Centre for Air Quality Research	Developing strategies for Control of Air Pollution in India and its Cities	Dr Anju Goel	Bloomberg Philanthropies
38	Centre for Air Quality Research	Clean Air Project in India (CAP India) -Phase I	Dr Anju Goel	SDC
39	Centre for Air Quality Research	Real-time Source Apportionment and Forecasting for Advance Air Pollution Management in Delhi	R. Suresh	IIT Kanpur
40	Centre for Climate Modelling	Climate Adaptation and Financing	Santosh Kumar Muriki	Deutsche Gesellschaft Fur Internationale Zusammenarbeit (GIZ) GmbH
41	Centre for Climate Modelling	A Pilot to Address Marine Litter and Facilitate Setting Up of a Collection Mechanism for Discarded Fishing Nets in Goa, India	Dr Ashwini Pai Panandiker	European Union – Resource Efficiency Initiative (EU-REI)
42	Centre for Climate Modelling	Developing Climate Change Resilience Plan and Upgrading City Infrastructure to Mitigate the Effects of Climate Change in Urban Systems	Santosh Kumar Muriki	Tandon Urban Solutions Private Limited
43	Centre for Climate Modelling	Sub-project for Eco-region-specific Climate Impact Assessment and Sustainable Agricultural Practices	Santosh Kumar Muriki	The Norwegian Ministry of Foreign Affairs

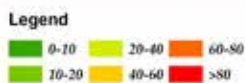
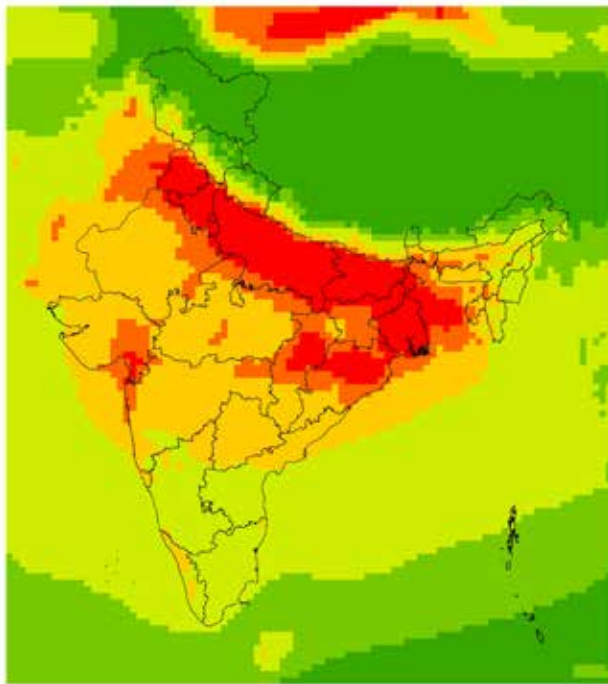
Innovation

- » Developed a Fully Automated Flood Early Warning System (FEWS) to provide inundation forecast.
- » Created TERI Climate Tool (TCT) with the goal of making it easier to integrate the results of climate modelling.
- » Adoption of AI/ML-based approach to assess climate risk for different sectors.
- » We conduct source apportionment studies through

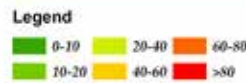
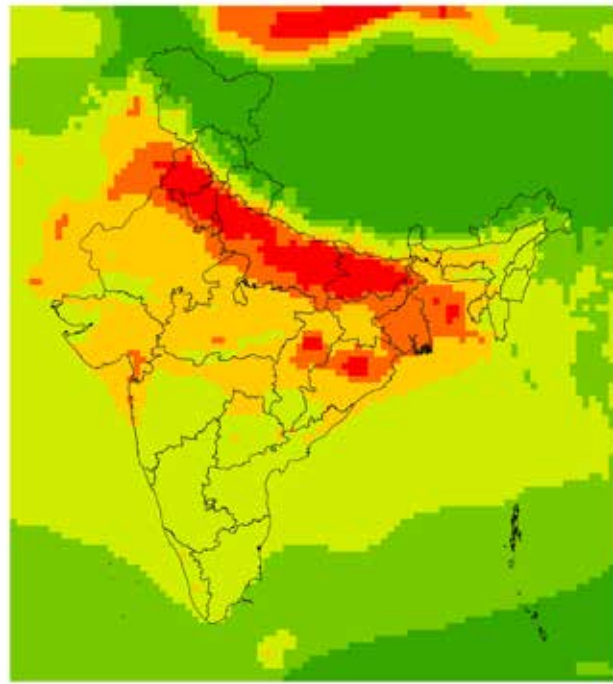
- different modelling approaches to become one of the key institutes across the country to carry out such scientific study. This has also led TERI to be in the list of Institute of Repute (IoR) for reviewing emission inventory, source apportionment studies and carrying capacity study as directed by the MoEFCC.
- » TERI-developed indigenous emission factor for emissions' estimation is entirely different from the followed conventional approach has added substantial value to our findings.



PM2.5 Concentrations (TERI 2019)



PM2.5 Concentrations (STEP 2030)



► *Climate modelling maps*

- » Additionally, our capacity to develop a national emission inventory, which a few institutes have already attempted, is another uniqueness of TERI.
- » Our research in the field of forecasting of air pollutants, which has already been tested and found comparable, can be adopted in other parts of the country.
- » TERI has already been a part of real-time source apportionment study, which helps in evaluating the effects of intervention measures on air quality on timely manner, is yet another feather in the cap amongst the researchers across the globe.

Inspirational Evidences

Demonstrations

- Camera installation for pollution source monitoring in Lucknow: Thirty-two cameras have been installed (16 by TERI and 16 by APAG) at different locations in Lucknow, and 7 cameras are connected with the Integrated Command and Control Centre and operationalized at ITMS Smart City.
- Establishment of model construction site: A construction manual has been prepared on dust mitigation measures at the construction site and one construction site at Lucknow and two at Kanpur were visited. Stakeholder consultations are being carried out on the measures listed in the construction manual.
- Retrofitting of old IC 2-w to EV (Pune): The methodology for retrofitting IC 2-w to EV has been finalized. Vehicles are retrofitted with batteries and the vehicle calibration with respect to the battery, tyres, etc. is currently in process. Battery-calibrated vehicles are dispatched to Dominos and field trials have been started.
- Integration of MRS audit with smart city portal in Lucknow: MRS App- Module in Smart city 311 app has been developed. Training for LMC staff on the App has also been done. Trial runs for drivers and supervisors are currently going on.
- TERI has been instrumental in developing research-informed evidence for policymaking aiding



government bodies for the formulation of state of environment reports and environmental policies, specifically in the field of air quality management.

- TERI has also been focused on providing state-level policy recommendations through several source apportionment studies, which guided state-level regulatory authorities to develop local action plans to control air pollution and its impacts.
- The capacity-building and training programmes for personnel involved in air pollution management for enhanced awareness and policy-making capacity in the relevant departments are being executed.
- TERI has established a Strategic and Policy Advisory Unit nested within the Department of Environment, Government of Uttar Pradesh, to provide strategic guidance and technical assistance for effective funds utilization and results delivery of UP-CAMP.

Impact We Created

Global contribution

- Contributed to the IPCC special reports and assessment report AR6
- Member of Technical Advisory Board of the International Civil Aviation Organization (ICAO) to provide research and advisory for the implementation of CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) a global market mechanism for emission reductions by international airline operators
- Every year TERI has strong presence at Conference of the Parties (COP) under the United Nations Framework Convention on Climate Change
- Multi-country Cooling Platform in partnership with The Embassy of France in India to facilitate cross country knowledge exchange for Sustainable Habitat, Energy Efficiency and Thermal Comfort for All
- Under the ECSWG during G20 India Presidency, TERI took the lead in preparing the 'G20 Report on Actions Against Marine Plastic Litter, 2023'
- TERI has provided policy relevant evidence and highlighted the gaps to inform policymakers regarding the health response to climate change in Indo-Pacific region.

National policy

- Involved in the preparation of National Action Plan on Climate Change
- India's Cooling Action Plan
- Involved in the preparation of National State of

Environment Report (NSOER)

- One of the national host institutes to carry out source apportionment studies, emission inventory studies and carrying capacity studies.
- As directed by CPCB, TERI is identified as Institute of Repute (IoR) for providing technical inputs to emissions inventory, source apportionment and carrying-capacity reports for all concerned million plus cities/ non-attainment cities and provide guidance to concerned cities for preparation of micro action plan.
- Development of National-level Emission Inventory
- Notable participation in air quality progress report for India
- TERI has provided policy relevant science to inform policymakers to push for improvements in standards and made policy submissions to highest levels in the government in the field of air quality management.
- The training and capacity building programmes for the officials of state pollution control boards and Central Pollution Control Boards across the country has helped to bridge the gap and build the capacity within pollution control board officials.

Sub-national policy

- Prepared and revised SAPCCs for Indian states/UTs such as Uttarakhand, Puducherry, Maharashtra, Gujarat, Assam, Chandigarh and Jammu and Kashmir
- Developed State of Environment Report (SOER) for Punjab and Chandigarh
- Contributed towards Heat Action Plan for Odisha
- Sectoral GHG inventory and abatement options
- Our recommendation through source apportionment studies guided state-level regulatory authorities to develop local action plans for control of air pollution and its impacts. This has helped the implementing authorities to prioritize their actions, which in turn helps in achieving the interim target (20–30% reduction in air pollutant concentrations by 2024 for all the non-attainment cities) set by NCAP for different cities.
- TERI is moving forward from the knowledge gained from the accomplished projects, outlining the present SLCP concentration across the country, and aiding the government in prioritizing the policies to accrue maximum



benefits. Further we are working on a coupled model approach to quantify the impact of air pollutants on climate. This will make TERI as one of the few organizations to be able to do this successfully in the country.

Corporate actions

- Carbon pricing handbook for corporates
- Climate risk and disaster profiling for risk free and sustainable business operations
- Produced custom-tailored climate products at a granular scale for various stakeholders
- Climate change impact and vulnerability assessment for the oil and gas sector in India

Fund (EDF), UNEP, VITO Belgium, GIZ, RICARDO, Clean Air Fund (CAF), Vasudha Foundation, University of Aberdeen, EPFL, IIASA, PSI, University of Bern, Pure Earth, Evergreen Story Inc., European Commission

Partnerships and Networks

Centre for Air Quality Research

Government

Municipal corporations, state pollution control boards, Central Pollution Control Board (CPCB), Delhi Pollution Control Committee (DPCC), Ministry of Environment, Forest and Climate Change (MoEF&CC), Department of Environment, CSIR NEERI, Punjab Council for Science and Technology (PSCST), Environmental Management and Policy Research Institute (EMPRI), Mahanadi Coal Fields, RITES.

Non-governmental and Academic

Automotive Research Association of India (ARAI), Federation of Indian Petroleum Industry (FIPI), Indian Institute of Technology Delhi, Indian Institute of Technology Kanpur, Accenture, Calcutta University

International

Swiss Agency for Development and Cooperation (SDC), Bloomberg Philanthropies, Environmental Defense



► *Field work*



► *Our Publication*



Centre for Climate Modelling

International

NORCE Research Center-Norway, BCCR-Norway, MPI-Germany, University of Reading, British Antarctic Survey-UK, Potsdam Institute for Climate Impact Research (PIK)-Germany

National

Ministry of Earth Sciences, Indian Institute of Tropical Meteorology (IITM)-Pune, Indian Meteorological Department (IMD), INCOIS, NRSC-ISRO, Andhra Pradesh State Development Planning Society, KL University, NIT-Warangal, SV University, Andhra University, Indian National Centre for Ocean Information Services (INCOS).

Details on Knowledge Building; Partnerships and Networks can be viewed via the following URLs:

- ¹ https://www.teriin.org/files/TERI_Annual_Report_Knowledge_Contributions.pdf
- ² https://www.teriin.org/files/TERI_Annual_Report_Partnerships_and_Networks.pdf



WASTE, WATER, AND NATURAL RESOURCES PROGRAMME



Waste, Water, and Natural Resources (WWNR) Programme's mission is to spearhead transformative solutions for sustainable resource management. We are setting a new standard for environmental stewardship by generation of carbon credits through nature-based solutions, unlocking nature's potential by valuing ecosystem services, and rehabilitating degraded lands. Using Sustainable Development Goals (SDGs) as way-posts, we develop innovative strategies for biodiversity conservation to strive for a harmonious coexistence between progress and nature. As both pioneers and providers of cutting-edge technologies, we are at the forefront of revolutionizing waste management, circular economy practices, wastewater reuse, and resource efficiency.



Themes and Commitments

Thematic focus

Waste, Water, and Natural Resources Programme consists of two broad divisions:

- **Land Resources Division**
- **Environment and Waste Management Division**

Land Resources Division focusses on promoting sustainable forest and biodiversity management, providing solutions towards generating finance through carbon mechanisms for forests, and supporting the livelihood of forest-dependent communities. The Division operates through five areas, which are as follows:

- **Centre for Forest Management and Governance** focusses on research and implementation in the areas of forest management, governance, and policy.
- **Centre for Sustainable Land Management** tackles the challenges in the areas of land degradation, rehabilitation and resettlement, mine reclamation, training and capacity building on climate change, forestry, and policy.
- **Centre for Biodiversity and Ecosystem Services** is primarily focussed on sustainable management of forest ecosystem and biodiversity conservation and developing effective strategies for environmental restoration and community development through REDD+ (Reducing Emission from Deforestation and Forest Degradation) and ARR (Afforestation, Reforestation, and Revegetation) based carbon finance projects.
- **Nutritional Security** is engaged in implementing health and nutrition-related projects.
- **Sustainable Services Management** deals with research on land use change and ecosystem services, evaluation and impact studies of development programmes, and watershed development projects.

Environment and Waste Management Division works towards application research on policies, regulation, governance, technology deployment and capacity building on solid waste and wastewater management issues, assessment of resource efficient cleaner production (RECP) potential in micro-, small- and medium-scale enterprises (MSMEs) and solutions for holistic waste management and resource optimization.

The Division operates through four areas, which are as follows:

1. **Centre for Waste Management (CWM) Area** is creating technologies (biomethanation) and solutions to minimize waste generation and convert waste into energy/useful products.
2. **The Resource Efficient Technologies (RET) Area** provides resource efficiency, circular economy, and sustainable consumption and production (SCP) consulting and implementation support in central and south Asia for small and medium enterprises (SMEs).
3. **Biowaste Technologies (BWT) Area** evaluates diverse biowaste samples collected from municipal solid waste (MSW), agricultural residue, industrial waste, and energy crops, to test the biomethane yield and identify the best suitable feedstock for biogas plants.
4. **NMCG-TERI Centre of Excellence on Water Reuse (NTCoE)** jointly established by National Mission for Clean Ganga (NMCG), Ministry of Jal Shakti (MoJS), Gol and TERI has an objective to create platform for supporting targeted research and innovation to develop clean, green, cost- and resource-effective wastewater treatment technologies for reuse of treated water.

Larger goals and the context

Our projects within the WWNR Programme contribute significantly to the attainment of eleven SDGs. Besides, our efforts contribute to realizing the NDC goal of establishing an extra carbon sink of 2.5–3 billion tonnes of CO₂ equivalent by 2030 through the expansion of forest and tree cover.





Our accomplishments

- The WWNR Programme has been executing various projects under different themes. About 45 projects have been implemented during the last financial year.

- At present, Land Resources Division is implementing about 28 ARR and REDD+ carbon finance projects in AFOLU (agriculture, forestry, and other land use) sector that promote biodiversity conservation and enable local communities to enhance their skills to use natural resources sustainably.
- We have provided livelihood support to over 2 lakh farmers and forest-dependent communities through carbon finance projects.
- We have been regularly organizing training workshops for officers of Indian Forest Services. Since 1991, about 40 training workshops, sponsored by the Ministry of Environment, Forest, and Climate Change and attended by about 1500 IFS officers have been organized.
- Our work has led to savings of energy, water, and materials along with minimized waste in SMEs from various sectors, leading to development of low-cost products from waste contributing to circular economy.
- We have collaborated with ABT Associates for providing technical, analytical, and capacity-building support to promote methane mitigation activities and project development to reduce methane emissions from India's agriculture and MSW sector.
- Our analysis of physical and proximate characterization and biomethane potential in the MSW generated from 17 Indian cities is helping developers to set up compressed biogas (CBG) projects.
- We are working on techno-economic analysis (TEA) of CBG under the SATAT and GOBARDhan scheme.
- Our patented Advanced Oxidation (TADOX®) Technology for wastewater treatment and reuse has received great recognition at the national level by receiving the first prize under the 'Innovations in Water Technology' category in the prestigious FICCI Water Awards 2022.

Aggregate numbers

- Currently, we are executing REDD+ and ARR projects all across India, which include ARR projects for agroforestry plantations in selected districts of Gujarat, Uttar Pradesh, Punjab, Haryana and Uttarakhand and REDD+ projects in Van Panchayats of Ranikhet and Nainital as well as in tiger reserves such as Dudhwa, Periyar, Pench (Maharashtra), Pench (Madhya Pradesh), Sundarbans, Manas, Kaziranga, Kanha, and Community Conserved Areas of Nagaland and Assam.
- Presently, we are working on an assignment that is aimed at developing the natural wealth accounting system for Bangladesh and identifying Payment for



Environment Services (PES) schemes for conservation and preservation of natural resources.

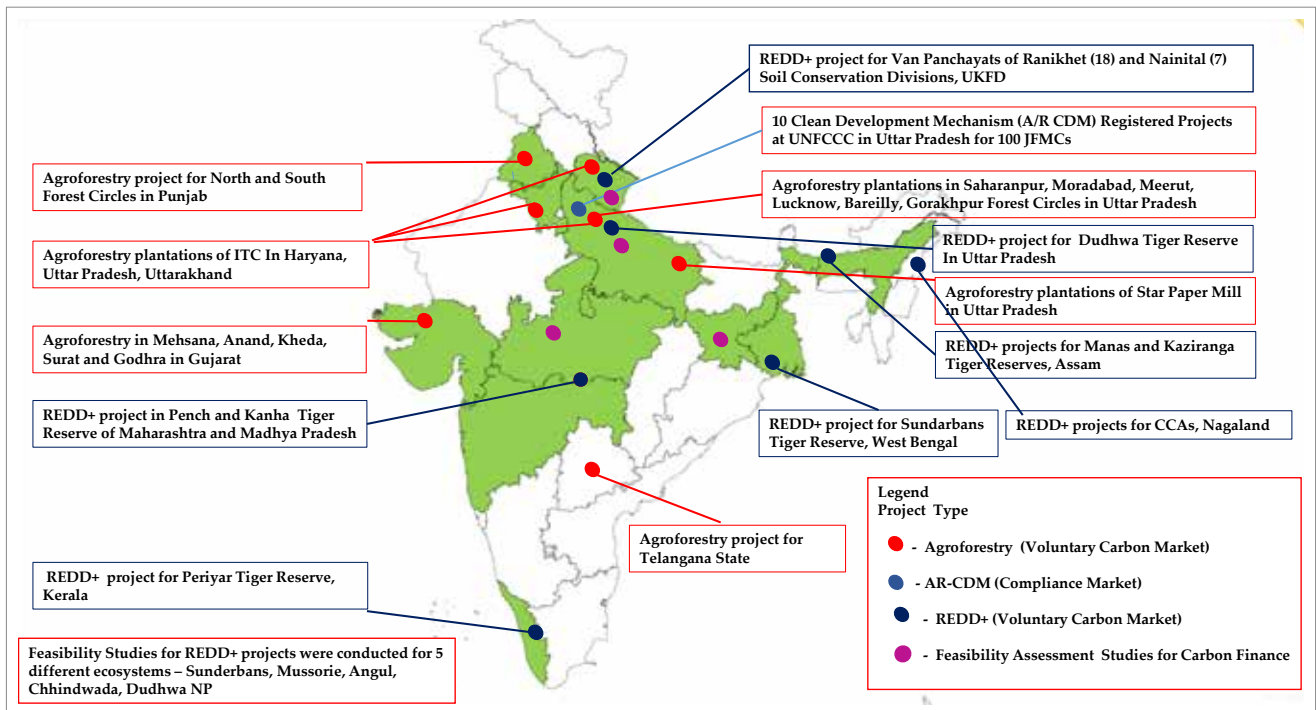
- Completed a project in Sariska Tiger Reserve where we have developed PES Scheme and a mechanism for obtaining carbon finance from Voluntary Market.
- Completed a project of HINDALCO red mud dump site restoration by converting the alkaline inhospitable red mud deposits to a substrate, which allows vegetative growth to develop green cover.
- Our projects at CWM are addressing critical environmental and sustainability challenges across various sectors ranging from combating plastic pollution in marine ecosystems and enhancing resource efficiency to assessing the state of the environment and accelerating industrial decarbonization. Donors, including organizations such as GIZ, CSIRO, and the Children's Investment Fund Foundation, provide crucial support for these endeavours.
- We are working closely with National Mission for Clean Ganga (NMCG) on pilot demonstration of TADOX® technology in textile CETP cluster, Rooma Kanpur. We are also working on a World Bank project with Bangalore Water Supply and Sewerage Board

(BWSSB) to assess advance treatment options, recovery and utilization of biogas, bio-solids and reusable water in the expanded Bengaluru area.

- RET Area is targeting 300 agri food SMEs in Uzbekistan and Tajikistan, 100 enterprises in tourism sector in Kerala, 100 enterprises from plastic value chain in Sri Lanka, 17 Business Development Service providers through Circular Economy Enterprise Incubation Training of Trainers (ToT), and 18 participants in Circular Economy Catalyst replicator workshop.

Approach and innovation

Our initiatives focus on improving the sustainable management of biodiversity and ecosystem services through forestry and agroforestry-based carbon finance projects under REDD+ and ARR. The REDD+ projects in India are local projects being implemented in collaboration with Forest Department, EDCs, and local communities. The project addresses issues such as income generation, biodiversity conservation, and alternate sustainable livelihoods. We have also provided technologies and solutions to minimize waste generation and convert waste into useful products.



► List of ongoing and completed projects under WWNR Programme in 2022/23



TERI's patented technology, TADOX® (TERI's Advanced Oxidation Technology) treats municipal and highly polluted industrial wastewater having issues of high colour, high COD, BOD and dissolved organics.

Inspirational evidences

- Our Voluntary Carbon Market Projects in Tiger Reserves of India are enhancing carbon sequestration, forest cover, and generate additional income to the dwellers of forest fringe villages.
- Our voluntary carbon market projects for agroforestry plantations in Uttarakhand, Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, and Gujarat are generating additional income to the farmers and restoring agrarian ecosystem.
- We have conducted Study on Estimation of Carbon Stocks in Biodiversity Conservation Plots promoted under ITC's Mission Sunehra Kal Programme.
- Under India-Norway cooperation, we have worked on building knowledge and capacity to tackle plastic and chemical pollution from important sources within key industries, public sector, and civil society.
- We are developing research-informed evidences for policymaking, aiding government bodies in the

formulation of state of environment reports and environmental policies.

Impact We Created

- Carbon finance projects are benefiting over 35,000 farmers across five states in India by generating an additional income of approximately INR 115 crore.
- REDD+ projects have been benefiting around 700 EDCs/forest-dependent villages, generating an incentive of around INR 29.5 crore.
- The mine reclamation work is converting the red mud dump sites into usable form.
- Waste management studies, supported by GIZ, are contributing to Reduce, Reuse, and Recycle concept of an integrated circular-economy waste management system in the solid waste sector in cities such as Panjim and Varanasi.
- Based on our research findings, a developer is installing the CBG plants in Bhopal, Delhi, and Ludhiana.





Knowledge building and dissemination

Under the WWNR Programme, continuous efforts have been made to consolidate learnings from various projects, build capacity of stakeholders, and disseminate achievements and key insights.

- Last year, four training workshops were organized for capacity building of over 160 frontline staff of forest departments and 14 stakeholder consultations under ARR and REDD+ projects were conducted where over 1000 participants were sensitized for natural resource conservation.
- Two Refresher Training Workshops on Forest and Climate Change: Opportunities and Challenges of Adaptation and Mitigation, and on the significance and Scope of REDD /REDD+ for India's Forests were organized.
- Conducted International training on 'Risk Analysis Checklist and Anaerobic Digestion Screening Tool for Biogas Projects', supported by ABT Associates, USEPA, and the MNRE.
- It is worth mentioning that the WWNR Programme produced approximately 28 publications during the year 2022/23.

Partnerships and networks

The WWNR Programme maintains a close and collaborative partnership with state departments across India, as well as with key ministries within the Central Government, including the MoEFCC, MoTA, MoRD,

Ministry of Water Resources, MoUD, and others. This extensive network actively engages in shaping national-level policymaking. Additionally, the Programme collaborates with numerous corporate entities, academic institutions, community-based organizations, and multilateral and bilateral organizations on a national and international scale.

Details on Knowledge Building; Partnerships and Networks can be viewed via the following URLs:

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SUSTAINABLE INFRASTRUCTURE PROGRAMME



With extensive and rapid urbanization, the need for sustainable infrastructure has become much more pronounced than ever. In this regard, the Sustainable Infrastructure Programme dedicates itself towards reducing urban carbon footprints through utilization of the principles of sustainability in the built environment.



Themes and Commitments

The principal objective of the Sustainable Infrastructure Programme is to promote sustainability in the built environment by suitably addressing the challenges of the rapid urbanization, at the same time, integrating sustainable practices in the areas pertaining to buildings, mobility, planning, governance, and water resources. The Programme also aims at creating innovative solutions for building low-carbon resilient cities and infrastructure and thus enabling India to achieve carbon neutrality by 2070. The Programme streamlines its core responsibilities amongst its following four key divisions:

1. Sustainable Buildings Division (SBD): Provides innovative, integrated, and cost-effective solutions to mainstream the principles of sustainability in the building sector with the aim of stimulating low-carbon development pathways, leading to increased resilience and mitigation potential.

2. Transport and Urban Governance Division (TUGD): Works towards creating sustainable, resilient, and smarter cities. Since its inception, the Division has been providing technical support and policy advisory to multiple cities across the country for effective planning of sustainable and smart urban development. This includes preparation of smart city proposals, policy briefs on mobility-related aspects, and implementing innovative approaches such as the urban living labs (ULLs). The TUGD also conducts modelling and geospatial assessments on energy-environment-related aspects and explores climate change implications vis-à-vis urban growth, associated demands and challenges in India.

3. GRIHA Council: Committed to fostering sustainability and resilience in the built environment, GRIHA Council advances the development of sustainable habitats for all. The Council promotes adoption of sustainable building practices and facilitates the implementation of GRIHA ratings and certifications. Recognized as the national rating system for green buildings in India, GRIHA aims at holistic evaluation of environmental performance of the built environment thereby, providing a definitive standard for sustainable habitats.

4. Water Resources Division (WRD): This division provides services in the quantitative and qualitative assessment of water resources, water audit, water

foot printing, watershed management, urban water demand management, groundwater management, glacier research, hydrological assessments, rural water supply and sanitation sector, water quality and pollution studies, wastewater treatment recycle and reuse strategies, and policy analysis. The Division comprises two work areas—Water Resources and Policy Management and Centre for Himalayan Ecology.

Addressing Sustainable Development Goals

We facilitate innovation in infrastructure, while ensuring that the process involved aligns with global commitments and addresses the associated Sustainable Development Goals (SDGs) such as 3, 6, 7, 9, 11, 12, 13, 15, and 17.





“ In the past five decades, we have come a long way in stimulating low-carbon development pathways with the aspirations of moving towards net-zero. As a nation we have tremendous potential to decarbonize the economic growth and become the prime mover in net-zero development. Seeing this as a great opportunity, we at the Sustainable Infrastructure Programme of TERI, work towards creating innovative solutions for a sustainable future to mitigate climate change and create a sustainable and resilient built environment.

Mr Shri Prakash, (Distinguished Fellow, TERI)

Our accomplishments

In 2022/23 overall, 27 projects were executed across India by SBD, belonging to the following genres:

- Environmental design consultancy projects for green buildings (15)
- Research projects (8)
- Project management cells created for implementation of energy efficiency in buildings (3)
- Training and capacity-building projects (1)

Last year, TUGD accomplished 20 projects of national significance in collaboration with various stakeholders including national and international governments, bilateral and multilateral agencies, foundations, research institutes, corporates, non-governmental organizations (NGOs), civil society, academia, and practitioners. The following are the principal areas under which majority of the projects were executed:

- Policy research (8)
- Energy and environment analysis (3)
- Capacity building (4)
- Knowledge creation and dissemination (5)

Geographical reach of projects under TUGD



Regional centres

To promote sustainability, facilitate adoption of sustainable building practices, and create resilient and smart cities across India, regional centres have been established in Delhi, Guwahati, Bengaluru, and Mumbai. These regional centres strengthen Sustainable Infrastructure Programme’s outreach, implementation, and communication with the clientele for seamless project execution. The centres have made a marked contribution in developing a strong network of stakeholders and collaborations including but not limited to government agencies, corporates, and bilateral organizations.

In 2022/23 GRIHA Council successfully carried out several projects. Some of the worth-noting details are given below:

- 1262 projects were registered with GRIHA Council under various GRIHA variants.





India being a developing nation, the transport needs are growing fourfold, and decarbonization of road transport is crucial for sustainable mobility for meeting near zero carbon targets. To decarbonize road transport and reduce our dependence on fossil fuels, there are different technology options. Careful analysis is required considering the local usage and environmental conditions to get the best.

Mr IV Rao, (Distinguished Fellow, TERI)



- 77 projects were rated. These projects were evaluated under various environmental parameters and based on their performance they were awarded with appropriate star rating.
- Thirteen trainings and capacity-building programmes were conducted with diverse stakeholder groups, 1938 participants were trained under these programmes.
- 182 new products were enlisted on GRIHA Product Catalogue. These products have been included in the GRIHA Product Catalogue based on their adherence to GRIHA benchmarks.
- 3 GRIHA certifications—Zero Waste Certification, Energy Positive Certification, and Water Positive Certification—were launched towards realization of net-zero national goals.

The Water Resources Division provides services in core areas, such as applied research, training and capacity building, policy advocacy, demonstration, and implementation. Last year, WRD executed the following 11 projects in different parts of the country in collaboration with various stakeholders including national and state governments, bilateral and multilateral agencies, research institutes, corporates, NGOs, civil society, academia, and practitioners.

- 6 research projects
- 1 demonstration and implementation project
- 4 training and capacity-building programmes

Training programmes

- The training programmes were conducted in both online and offline modes for various stakeholders to provide accessibility regardless of location and physical presence. This approach has not only enhanced the participation and accessibility of the awareness and training programmes but has also played a pivotal role in reducing the carbon footprint associated with the logistics.

- As an empanelled training agency with the Ministry of Housing and Urban Affairs (MoHUA), TUGD conducted training programmes and stakeholder engagement workshops for implementation of various urban schemes and missions of the Government of India on sustainable urban solutions and promotion of decarbonization of the transport sector.
- Conducted regional and global knowledge exchange and programmes with corporates like Aramco Asia, GIZ, Energy systems Catapult, Coca-Cola, GFA Consulting group, SHAKTI, etc.
- Capacity-building workshops for bi-lateral and multilateral agencies, including the European Union International Urban and Regional Cooperation (IURC), Rockefeller Foundation’s Asian Cities Climate Change Resilience Network (ACCCRN), CIFF, USAID’s Climate Resilient Infrastructure Services programme (CRIS) and ‘CAPABLE’ programme funded by the Asia Pacific Network (APN) for Global Change
- Capacity-building programmes: 13 training programmes via both online and offline modes were conducted for stakeholders on GRIHA V.2019, GRIHA CATALYST Membership Programme, Water Management, GRIHA Existing Buildings, SVAGRIHA, Motor and Transformer Assessment Tool, Drywell Construction Technique, etc.
- E-course: GRIHA Council developed an e-course on GRIHA V.2019 for which 140 subscriptions have been received.
- Examinations: GRIHA Professional Exams were conducted for professionals from the fields of architecture, engineering, and urban planning wherein total 211 candidates appeared for GRIHA-certified Professional and GRIHA Evaluator Exams.
- As an empanelled Key Resource Centre (KRC) with the Jal Jeevan Mission of Ministry of Jal Shakti, WRD organized training programmes for Level 1 (chief engineers, etc.) and Level 2 (superintending engineers, etc.) officers engaged in implementation of Har Ghar Jal scheme.



► Online training programme with Planning Insights on GRIHA V.2019





▶ Two-day training programme on GRIHA Variants, University Institute of Architecture, Chandigarh



▶ One-day training by IIA Northern Chapter in partnership with GRIHA Council

- » Level 1 training: Transforming Institutions for Functioning as Utility—planning and strategy for improved service delivery, 13 chief engineers across the country were trained on aspects related to utility reforms.



- » Level 2 training: Under Rainwater Harvesting, Climate Change and Sustainable Management of Groundwater, 30 officers from different districts of Bundelkhand region participated in the training programme.



▶ Another training programme

- The WRD organized a training programme titled, 'Integrated Water Resources Modelling under a Changing Climate in the Indian Himalayas', November 21-24, 2022, at National Institute of Hydrology (NIH), Roorkee. Relevant stakeholders from Garhwal and Kumaon regions of Uttarakhand were imparted training on latest modelling techniques for strengthening comprehension of the impacts of climate change on glacier melting and river runoffs.



▶ Another training programme

- TERI with EU partners organized a workshop, 'Minimizing Occupational Risks in Wastewater Treatment: the role of technology-based wastewater safety planning' during the IWA Conference on water reclamation and reuse in Chennai on January 15, 2023. This workshop was dedicated to international occupational safety and health guidelines for wastewater treatment workers and introduced technology-based wastewater safety planning as an occupational risk management approach.

Approach and innovation

The research projects carried out by the Sustainable Infrastructure Programme are unique in their requirements considering the wide range of subjects such as byelaws modification, inclusion of building resilience, energy efficiency in design and selection of suitable building materials or technologies. The diverse nature of the projects requires unique approaches. In this regard, implementation of the projects, line mainstreaming of energy-conservation building codes, and building technologies in the states depend heavily on local expertise and knowledge available with the stakeholders in the states and fine-tuning is done to meet the requirements.

The uniqueness and value addition of TUGD lies in its holistic approach, focus on sustainability and innovation, stakeholder engagement, performance monitoring, and resilience building. By integrating these aspects into work, the Division contributes to the development of well-governed, efficient, future-ready transportation, and governance systems that support



sustainable urban development and improve the quality of life of the involved citizens.

Going by the principle—what gets measured gets managed—GRIHA Council both facilitates and administers GRIHA rating tool. In the rating process, GRIHA Council conducts orientation workshops and regular site visits for handholding and enabling the projects to minimize a building's resource consumption, waste generation, assess the overall ecological impact, and promote sustainable building practices. Conforming with the Pradhan Mantri Awas Yojana (PMAY), a unique certification known as JAN (Jan Awas Nirman) GRIHA Certification was launched. This certification caters to the small, low-cost residential buildings in India with an aim to spread the idea of sustainability at grassroots level and encourage adoption of modifications to lower their carbon footprint.

The WRD is engaged in research projects related to the development of integrated and strategic solutions for achieving water security. The Division's goal is to contribute to enhance water-use efficiency; promote water conservation IWRM; abating and managing water pollution and wastewater management. The WRD also carries out extensive research towards facilitating understanding of the impacts of climate change on the melt response of Himalayan glaciers and its repercussions on the livelihood of mountain communities at large.

Inspirational evidence

1. Panel Discussion on Thermal Comfort in Affordable Housing

TERI, in association with SHEETAL Alliance organized a half-day panel discussion on June 20, 2022 at New Delhi to address the existing challenges for mainstreaming thermal comfort in affordable housing with an overarching framework of the built environment.



► Thermal Comfort in Affordable Housing

2. Inauguration of Model Demo Habitat at Teri Gram, Gwal Pahari, Gurugram

TERI inaugurated Model Demo Habitat on July 13, 2022 developed under the Habitat Model for Efficiency

and Comfort project supported by the Department of Science and Technology (DST). The project consists of two tasks, wherein the first task aims at providing the Indian building market with cost-effective movable and smart external shading products, reducing direct solar heat gain inside a building by more than 75% while allowing natural daylight. The second task is focused on designing and demonstrating the potential of low-energy radiant slab cooling, integrated with natural heat sinks, and establishing their operational mechanism for optimum comfort and energy efficiency.



► Inauguration of Model Demo Habitat at TERI Gram

3. Launch Event for Sky Modelling Report and CIE Sky-type Finder Tool

The Mahindra-TERI Centre of Excellence (CoE) released a technical report, guidebook, and online toolkit (Sky-type Finder) for defining sky luminance across various sky conditions for Delhi and NCR.



► Launch event for Sky Modelling Report and CIE Sky-type Finder Tool

4. Release of An Assessment of Avoided CO₂ Emissions During Construction, Maintenance, and Operation of National Highways

TERI released a report titled *An Assessment of Avoided CO₂ Emissions During Construction, Maintenance, and Operation of National Highways* in partnership with Central Road Research Institute (CRRI), Indian Institute of Petroleum (IIP), IORA Ecological Solutions during its annual flagship event, World Sustainable Development Summit 2023.



The detailed guidance of estimating tonnes of CO₂ avoided per km of national highways presented in this report can form the basis for tracking CO₂ emitted or avoided.

The report was released by Shri Bhupender Yadav, Union Minister for Environment, Forest and Climate Change. The event took place in the presence of Dr Bharrat Jagdeo, Vice President of Guyana, Dr Sultan Al Jaber, Special Envoy on Climate Change and COP28 President, UAE, and Dr Vibha Dhawan, Director General, TERI.



► TERI released a report titled 'An Assessment of Avoided CO₂ Emissions During Construction, Maintenance, and Operation of National Highways' during WSDS 2023

Release of TERI, CSIR-CRRI, IORA, CSIR-IIP report— *An Assessment of Avoided CO₂ Emissions During Construction, Maintenance and Operation of National Highways*

More information on this report could accessed via: <https://www.teriin.org/policy-brief/assessment-avoided-co2-emissions-during-construction-maintenance-and-operation>

5. Needs Assessment Workshop Conducted

TERI conducted its first phase of 'needs assessment' as part of the German Government supported project 'Transformative Climate Action' using participatory data-driven decision-making platform (T-CAP) in Visakhapatnam during January 4-6, 2023.

The project aims to bolster climate-informed decision making through a living lab approach that will



► Stakeholder interaction during Needs Assessment Workshop

accelerate participation at the local level using digital means. The lighthouse city of Visakhapatnam will be projected as an inspiring case example to other cities around the globe.

During the first round of assessment, different line departments of Greater Visakhapatnam Municipal Corporation (GVMC) were interviewed. This was followed by a 'focus group discussion' that assimilated the technical know-hows and understanding of the municipality under the three broad pillars of the project—(i) climate action, (ii) participation, and (iii) digitalization.

6. TERI's Participation in a Three-day Orientation Programme in Lucknow

TERI participated in a three-day orientation programme from February 14-16, 2023 in Lucknow, hosted by the Department of Environment, Forest, and Climate Change (DoEF&CC), Government of Uttar Pradesh. The DoEF&CC has nominated TERI to provide project management unit support for Uttar Pradesh-Clean Air Management Project (UP-CAMP) preparation and implementation.



► Three-day orientation programme in Lucknow

7. TERI Participates in Uddheshya: mainstreaming gender from ideas to action

TERI took part in Uddheshya: mainstreaming gender from ideas to action, organized by World Resources Institute (WRI) India at India Habitat Centre, New Delhi. TERI, was amongst the panellists, highlighting the possible opportunities for implementing gender-inclusive mobility in the country and achieving equitable and inclusive transport.



► Uddheshya: mainstreaming gender from ideas to action by WRI India



8. Facilitation of Decarbonizing Transport Sector Capacity Building Programme, Institute for Human Settlements

TERI facilitated a session on decarbonizing transport sector, organized by Indian Institute for Human Settlements (IHS), Bengaluru on February 21, 2023.

TERI experts gave their insights on emission reduction, and efficiency improvement and on vehicle scrappage.

9. Participation of TERI as Knowledge Partner in EVOLVE 2023, Kerala

TERI participated as a knowledge partner in EVOLVE 2023, International Conference and Expo on E-Mobility and Alternative Fuels on January 19–21, 2023, organized by the Motor Vehicle Department, Government of Kerala.

TERI moderated the session on Alternate Fuel in Maritime, Freight, and Multi-Modal Transport along with speakers Mr Deepu Surendran, Cochin Shipyard, Mr Praveen Thomas Joseph, DP World, and Prof. Rajesh R Nair, IIT Madras.



► TERI as knowledge partner in EVOLVE 2023, Kerala

10. TERI's Contribution to the Panel Discussion Conference on Decarbonising Construction—building a low carbon future by the FICCI Federation House

TERI contributed to a panel discussion in the proceedings at the conference on Decarbonising Construction—building a low carbon future on January 13, 2023 at FICCI Federation House, New Delhi.

TERI moderated the panel discussion on decarbonizing road construction to aid India's net-zero journey. The



► Conference on Decarbonising Construction—building a low carbon future

session focused on the design, construction, ownership, and operation of facilities targeted for reduced or neutral impact on the environment with respect to carbon footprint.

11. TERI Attended the Regional Planning meeting of Urban Act in Bangkok: integrated urban climate action for low-carbon and resilient cities

TERI team participated in the Urban Act Regional Planning Workshop from March 20 to 24, 2023 in Bangkok, Thailand. The regional workshop was part of the project—Integrated Urban Climate Action for Low Carbon, and Resilient Cities (Urban-Act), which aims to support a transformation towards carbon and resilient urban development in five countries—India, the Philippines, Thailand, China, and Indonesia. TERI is one of the implementing partners in India, along with GIZ India and the National Institute of Urban Affairs (NIUA). The team participated in intensive brainstorming sessions to discuss the project strategy and interventions, ensuring alignment among country teams, national representatives, and international consortium partners.

12. The Flagship Event—14th GRIHA Summit

The event held on December 15-16, 2022 was graced by eminent personalities—Ms Leena Nandan, IAS, Secretary, MoEF&CC, Government of India; H.E. Mr



► Urban Act Regional Planning Workshop, Bangkok, Thailand



Freddy Svane, Ambassador, Royal Danish Embassy, New Delhi; Mr Sonam Wangchuk, Founding Director, Himalayan Institute of Alternatives, Ladakh (HIAL); Mr Sharman Joshi, renowned Indian film actor. The Summit was developed around the theme of Towards Net Positive Habitats which was centred around taking action to achieve India's COP26 commitments. More details on the Summit can be accessed at: <<https://www.grihaindia.org/grihasummit/#hero>>. Along with this, the JAN GRIHA Manual was launched and 3 star and 4 star-rated projects were awarded their rating plaques.



► 14th GRIHA Summit, 14-16 December 2022

13. Prelude Events of the 14th GRIHA Summit

A *nukkad natak* competition was organized to involve children, who are the future decision-makers and consumers of services, to spread awareness and instill environmental consciousness in young minds. Other events were predominantly of technical nature and organized in collaboration with USGKnauf and One Click LCA. A site visit to a GRIHA registered project—Atal Akshaya Urja Bhawan, New Delhi—was also arranged to

give the participants a hands-on understanding of the upcoming green buildings.



► Prelude events of the 14th GRIHA Summit

14. Significant Projects of 2022/23

GRIHA Council has included an international airport project—Hanimaadhoo International Airport in the Republic of Maldives, Parliament Building, Central Vista Project—amongst its key projects. Through this association, GRIHA Council looks forward to fostering partnerships towards sustainable and climate-smart development.

15. Rating for Ladakh

By administering GRIHA Rating in Ladakh, GRIHA Council is facilitating carbon-neutral Ladakh vision by achieving energy efficiency and carbon neutrality.

16. JAN GRIHA Certification

After the launch of JAN GRIHA certification, out of 258 registered projects, 196 have been certified.

17. Assisting National Water Mission

TERI is assisting the National Water Mission in improving industrial water-use efficiency, by developing potential benchmarks for industrial water use in four of the most water-intensive sectors, namely thermal power plants, textile, steel, and pulp and paper industry.

18. Development and Release of Comic Book on Water Conservation

The Water Resources Division signed a memorandum of understanding (MoU) with Diamond Toons to sensitize children on the merits of water conservation. Signing of the MoU was followed by the release of the first comic book of its kind, Chacha Chaudhary: Water – Our Right, as part of the World Water Day celebrations in March 2023.



19. Second Water Sustainability Awards 2022-23

The Water Resources Division organized the second edition of the Water Sustainability Awards on March 21, 2023. More than 100 applicants registered their nominations for awards under different categories. The Water Champion Award was conferred to Sadhguru for his exemplary contribution in disseminating the message of water conservation.

Transport and Urban Governance Division

- » **Rail Freight Study:** Multiple policy inputs incorporated in railway policies and analyses included in their vision documents.
- » **Urban Freight Study:** 200 EVs deployed by SLMG-Coca-Cola in Lucknow
- » **E-certificate Course on Mainstreaming Urban Climate Action:** Capacity building of more than 300 city and state officials, sector experts, and other urban practitioners on climate action aspects at the city level.
- » **Urban Living Lab in Panaji:**
 - ✓ Scaling up the living lab approach for climate actions to other cities such as Visakhapatnam, Shimla, and Coimbatore
 - ✓ Capacity building of city officials and other urban experts on climate-resilient project preparation and implementation through toolkits

GRIHA Council

- **Registered projects:** Currently, GRIHA Council has more than 3700 registered projects across the country with a combined footprint spanning more than 630 million square feet.
- **Rated projects:** More than 890 buildings have already been rated, under which 533 MWp of renewable energy systems are installed that could save 29,700 gigawatt hours of energy and prevent 8393 gigatonnes of carbon dioxide from being released into the atmosphere every year.
GRIHA-rated projects have contributed to water savings of 103,624 megalitre/annum. More than 2,66,770 new trees have been planted while 28,000 trees have been preserved.

Impact We Created

Sustainable Buildings Division

- The building material testing services of Mahindra-TERI Centre of Excellence (MTCoE) is helping industry, academia, and research

laboratories across the country in evaluating thermal performance of building materials, thereby promoting thermal comfort and energy efficiency in the building sector.

- Gypsum plasters have been revolutionary in creating mass awareness on using gypsum boards as a miracle building material. TERI and Energy Conservation Building Code (Energy Conservation Building Code) cells are undertaking large-scale training and capacity building for the government officials for the effective implementation of Energy Conservation Building Codes and Eco Niwas Samhita in Ladakh and Odisha.
- Study on energy and cost savings in modern construction buildings using gypsum board drywall.

Water Resources Division

- The WRD works extensively towards building the capacity of the stakeholders including water users and managers on various aspects of water management such as water conservation, water management, water quality, etc.
- The Division successfully tested and recommended a prototype micro-irrigation system that further enhances its efficiency and is advantageous for undulating and hilly terrains as it ensures uniform distribution of irrigation water, thereby enhancing use efficiency.

Knowledge building and dissemination

In 2022/23 Sustainable Infrastructure Programme brought out several knowledge and information-dissemination publications under the following broad categories:

- 2 green booklets
- 5 manuals
- 1 report
- 2 brochures and magazines
- 13 research papers
- 26 articles
- 1 policy brief

Details on Knowledge Building; Partnerships and Networks can be viewed via the following URLs:

- 1 https://www.teriin.org/files/TERI_Annual_Report_Knowledge_Contributions.pdf
- 2 https://www.teriin.org/files/TERI_Annual_Report_Partnerships_and_Networks.pdf



ENVIRONMENTAL AND INDUSTRIAL BIOTECHNOLOGY PROGRAMME



Implementation of microbial enhanced methane production technology in coalbed methane (CBM) well in Raniganj, Durgapur

The Environmental and Industrial Biotechnology (EIB) Programme is committed to protecting the environment and developing cutting-edge green sustainable solutions for wider application in rapidly expanding Indian economy.



Themes and Commitments

Thematic focus

With an unceasing effort of research and innovation over three decades, the Environmental and Industrial Biotechnology (EIB) Programme played a key role in decontamination of polluted environment, development of bio-based products, and production of clean energy. Extensive research explorations paved the way for development and commercialization of indigenous technologies, such as 'Oilzapper' (globally acknowledged technology and defined as microbial consortium, for bioremediation of oil spill sites and treatment of oily sludge generated by oil refineries), 'MEOR' (Microbial Enhanced Oil Recovery from matured oil wells), and PDB (paraffin degrading bacteria) for prevention of paraffin deposition in oil well tubing. These technologies got commercialized through a joint venture—ONGC TERI Biotech Ltd (OTBL). (www.otbl.co.in)

Microbial biotechnology

The areas of research in microbial biotechnology primarily explore microbes for development of sustainable solutions having commercial value. One such example is the successful demonstration of enhanced methane production from coalbed methane (CBM) wells. Further, for production of commodity chemicals we utilize carbon dioxide in fermentation process.



► Demonstration of enhanced methane production by application of microbes at Raniganj CBM well

Bioremediation

The ongoing work in bioremediation space involves large-scale implementation of microbial technologies; particularly bioremediation of oil spill sites in oilfields, as well as sites contaminated by pesticides and other organic pollutants. Additionally, we also carry out environmental quality assessment of soil, water, and vegetation.

Fermentation Technology Research Centre

TERI carries out in-depth research on fermentation technology and has created a state-of-the-art bioreactor facility, Fermentation Technology Research Centre (FTRC), at TERI Gram. The Centre is equipped with bioreactors that could execute a wide range of capacities, notably 3.2, 15, 30, 100, 200, 1500, and 15,000 litres.

The facility is also used to develop the bio-based products/technologies such as XC polymer (xanthan gum) and carboxymethyl hydroxypropyl guar (CMHPG) used in hydro-fracturing of oil reservoir rocks. These have huge potential for industrial applications in oil well drilling and food items.



► Fermenter (15,000 litre capacity) at FTRC, TERI Gram





“The EIB Programme is focused on the development of environmentally benign and economically viable bio-based solutions for industrial applications. For the past 20 years, the EIB Programme has developed many green solutions that are being used by the corporate sector. Moving forward, EIB research may be aligned with India’s Net-Zero ambition.”

Amitava Bhattacharyya (Retd IAS)

Larger goals and the context

- Four SDGs are covered by EIB research projects: SDGs 7, 9, 13, and 17. Currently, the Programme is committed to finding a sustainable solution to issues pertaining to industry and environment in collaboration with government and corporate sectors.

Approach and innovation

The EIB Programme primarily deals with basic and applied research as well as explores cutting-edge solutions, and promotes technology innovation in oil and gas industry.

Our accomplishments

There are currently 14 projects underway across the nation, which are funded by the Department of Biotechnology (Government of India), the Department of Science and Technology, Oil and Natural Gas Corporation Ltd, Oil India Ltd, and some lead public

and private entities such as Essar Oil & Gas Exploration & Production Ltd (EOGEP), Vedanta Ltd, and Reliance Industries Ltd.

The Programme has successfully produced technologies at a large scale using the cutting-edge bioreactor facility.

Other key accomplishments include the following:

- Microbial enhanced coalbed methane processes are being developed for non-producing CBM wells with poor to marginal prospects and where no biogenic methane has been reported. After detailed laboratory investigations, the developed processes are demonstrated in CBM wells of Bokaro field. Naturally occurring native microbes decompose coal into methane through a series of reactions. In this context, methanogenic bacterial consortia have been designed specifically to stimulate the microbial community in selected CBM wells. This technology may also be useful to recover energy from deeper and unminable coal seams whereas on an average only 15–20% of the coal is recoverable.
- TERI took an initiative and carried out laboratory studies to evaluate the potential to convert carbon dioxide (produced in the coalbed methane wells) into methane gas by application of methanogenic bacteria. Microbial consortia developed and tested in the laboratory under the coal reservoir conditions consist of hydrogenotrophic methanogens, which will be tested in the CBM wells of Bokaro field where the carbon dioxide level ranges between 5% and 20%.
- Under the EIB Programme, we have also developed anaerobic fermentation process to convert carbon dioxide to commodity chemicals, majorly succinic acid, targeting in food, chemical, and pharmaceutical industries as a precursor to generate many chemicals, such as solvents, perfumes, lacquers, plasticizer, dyes, and photographic chemicals.

Role in reducing carbon footprint

- Bioconversion of CO₂ into methane helped provide an alternative to conventional coal-based energy sources and consequently it contributed to the reduction of CO₂ in coal seams. This technology can convert 5-20% of carbon dioxide into methane under reservoir conditions.
- Carbon-neutral commodity chemicals produced by utilizing carbon dioxide, such as succinic acid and calcium carbonate.

Sustainable solutions for oil industries

- Enhancing oil recovery from stripper or abandoned oil wells
- Viscosity reduction of heavy oil in flow line
- Bioremediation by customized microbial and sustainable solutions for oil and gas, pharmaceuticals, and pesticides industries



- Reduction of environmental risk resulting from industrial operations

Bioremediation of oil-contaminated site using 'Oilzapper' technology

In 2022/23, 435.5 tonnes of Oilzapper was produced and used for treatment of oil spills/oil-contaminated soils mainly in the oil fields of oil-producing companies.



► Oil-contaminated site at farmer's field in Gujarat

Biologically-enhanced methane production

- Use of methane-generating bacteria that can act on coal seams to produce biogas; consisting mainly of methane and carbon dioxide.
- Enhancing methane production for commercial use with the aim of phasing out other coal-based non-renewable energy sources.

Bioconversion of carbon dioxide to methane

The conversion of carbon dioxide to biogenic methane in petroleum or CBM reservoirs is a desirable and viable strategy for reducing greenhouse gas emissions and facilitating energy recovery to meet societal energy

needs. The lab data demonstrates the effectiveness of the bioconversion of carbon dioxide to biomethane in the range of 30–40%, which offers a potential valuable opportunity for clean bioenergy recovery from CBM field.

Control of microbial-induced corrosion

Initiatives have been conducted by Microbial Biotechnology to 'safeguard the oil and gas pipelines' from microbial-induced corrosion. For the purpose of assessing the risk of microbiologically-influenced corrosion, TERI created an improved biomonitoring testing standard.

Production of D (-) Lactic acid using membrane integrated bioreactor

TERI's team has collaborated with IIT, Guwahati, for the integrated biofermentative production of D (-) Lactic acid at low cost. The intent was to develop a techno-economic solution for effective valorization of whey to D (-) Lactic acid—for additional revenue generation and mitigation of environmental pollution. Notably, D (-) Lactic acid is used in leather, textile, and tanning industries. It is also used as a plasticizer.

Inspirational evidences

Success stories

- **Enhanced biological methanation at the Raniganj CBM block**

For the enhancement of methanation processes beneath subterranean coal layers, TERI has pioneered a biological approach known as 'enhanced biological methanation'. The outcomes from the demonstration conducted at the Essar Oil & Gas Exploration & Production Ltd (EOGEPL) Raniganj CBM block in five poor to marginal CBM wells demonstrate a twofold increase in methane production.



► In situ stimulation job for enhanced coalbed methane production at EOGEPL well site

- **Microbial enhanced oil recovery (MEOR)**

Together with the Institute of Reservoir Studies, ONGC, a technology for improving oil recovery from oil wells with abundant or dead oil has been developed. Regarding the process, three patents



have been granted: one each in India, Canada, and the USA. A specialized biological solution created in collaboration with Glori Oil for US oilfields was applied to oil wells in Texas, USA.

- **Prevention of paraffin deposition in surface flow lines**

Through a collaborative effort with the Institute of Reservoir Studies at ONGC, a methodology has been devised to address paraffin deposition resulting from microbial activity in surface flow lines. Ongoing efforts are aimed at securing a patent for this innovative solution.

- **Development of hexachlorocyclohexane (HCH) degrading bacterial formulation and field trial demonstration**

Biostimulation and bioaugmentation techniques used in our research proved feasible for decontaminating HCH, as was seen during the field demonstration at the HCH dumpsite in Uttar Pradesh's Umari village of the Barabanki district. With complementary skills, the University of Delhi, TERI, CSIR-NBRI, and CSIR-IITR teamed up to demonstrate the remediation of a sizable HCH dumpsite. Bacterial formulation and specially formulated nutrition mixture developed by TERI were used in the field. The field trials were successful and the site got restored.

- **Assessment of the quality of the terrestrial and aquatic environment around Baghjan Well No. 5 (BGN#5) in the oilfield of Oil India Ltd at Assam, and bioremediation to clean oily soil and contaminated waterbodies near well BGN#5.**

At BGN#5 in the Baghjan oilfield of Oil India Ltd in Assam, a gas well blowout occurred on May 27, 2020 and condensate gas leakage was followed by a roaring fire. In the study, environmental quality of soil, water (surface and groundwater), and vegetation was examined in order to gauge the potential environmental harm caused by the blowout event at BGN#5. Oil-degrading microorganisms produced at TERI fermentation facility have been used in bioremediation to clean oily soil and contaminated waterbodies that were caused by the blowout of gas-producing BGN#5, Baghjan and subsequently the site was restored.



► Sampling during environment assessment at Baghjan site in Assam



► Bioremediation work at Baghjan, (farmer's land), Oil India Ltd, Assam

Impact We Created

- The joint venture – ONGC TERI Biotech Ltd (OTBL) helped provide 'green' technology services to the oil and gas sector on large scale and using this technology more than 7 lakh metric tonnes of contaminated soil/oily sludge was treated and restored.

- **Biologically-enhanced methane production from coal**

At Jharia, Bokaro, TERI and OEC have developed and demonstrated a microbial process aimed at enhancing gas quality in CBM wells. Field tests conducted in Jharia and Bokaro have conclusively shown a substantial increase in methane gas production. This has opened the door for future scale-up for broader application in collaboration with other CBM operators nationwide.

- **New initiative using MEOR technology**

The Programme has created a highly effective bio-based technology for reducing heavy oil viscosity in flow lines and is currently carrying on MEOR activities with heavy oilfields. The joint venture OTBL, established by ONGC and TERI, is actively commercializing and implementing the developed technology in stripper wells. More than 7000 stripper oil wells in India have been identified for increased oil output utilizing MEOR technology. A new initiative has been taken up for organic oil recovery in collaboration with the Institute of Reservoir Studies (IRS), ONGC. An MoU has been signed for 10 years for joint research.



- **Microbial treatment of paraffin deposition in surface flow lines**

Paraffin degrading microbes helped achieve an average scrapping-free period of 5-6 months compared to daily/alternate day/ weekly scrapping. Paraffin mitigation jobs that were implemented and monitored had an 84% success rate.

- **Development of eco-friendly oil well drilling fluid: XC Polymer (xanthan gum)**

In 2015, TERI initiated research to develop bio-based XC polymer at TERI Fermentation Technology Research Centre with a view to provide an eco-friendly technology to oil industry. This XC Polymer is produced for the first time in India through fermentation technology which is used as drilling fluid/ viscosifier and has been successfully field-trialled during oilwell drilling at Ahmedabad, Gujarat. This has huge replication value and will eventually reduce the import of XC polymer.

Knowledge building and dissemination

- 7 publications
- 10 patents
- Collaborations with various educational institutes from India and overseas for research work.
- Research collaborations with Delhi University, IIT Delhi, IIT Bombay, CSIR-NEERI, CSIR-NIO, CSIR-IITR, CSIR-NBRI, Assam University, DST-IASST, IISER Bhopal, ICAR-IISR in the area of Bioresources and Biotechnology.

Details on Knowledge Building; Partnerships and Networks can be viewed via the following URLs:

¹ https://www.teriin.org/files/TERI_Annual_Report_Knowledge_Contributions.pdf

² https://www.teriin.org/files/TERI_Annual_Report_Partnerships_and_Networks.pdf



SUSTAINABLE AGRICULTURE PROGRAMME



The Sustainable Agriculture Programme dedicates itself towards creating innovative solutions and developing new opportunities for profitable farming and livelihoods while conserving natural resources.



Themes and Commitments

Thematic focus

Our research focuses on sustainable agriculture, environment, and bioenergy by developing plant- and microbe-derived products to substantially improve crop yields, thereby reducing carbon footprint in agriculture.

We extensively work on key areas aimed towards improving plant and soil health that include plant- and nano-biotechnology to develop green products such as nano- and biofertilizers, superfoods, algal-based bioenergy, bioremediation, and resilient crop plants to biotic and abiotic constraints, besides enhancing their nutritional profile.



Key Areas

Centre for Agrinotechnology

Precision Agriculture and Reduction in GHG Emission

Nanobiotechnology Centre

Nano, Microbial, and Biotechnology

This theme addresses challenges in agriculture and environment through innovative and interdisciplinary nanobiotechnology and nature-based solutions utilizing microbiomes, microbes, and plants. Key aspects include microbiome-based advanced bio/organic formulations,

delivery of nutrients and agrochemicals, and nano-sensors for use in agriculture, etc. Such products would enhance productivity in agriculture and reduce risk to human health and environment.

Centre for Mycorrhizal Research

Mycorrhiza for Soil and Plant Health



The nutrient-tapping capacity of this symbiotic system has been effectively translated through research on mycorrhiza, and a method that will ultimately manufacture mycorrhizae-based biofertilizer has been created. The facility encourages the use of in vitro mass production techniques to generate high-quality, genetically uncontaminated, and healthy mycorrhizal propagules for use in agricultural applications. For more details, please visit <http://mycorrhizae.org.in/cmcc/>

Community Farming and Livelihood

Capacity Building

In Uttarakhand, efforts are being made to encourage innovative farming projects and sustainable farming methods that lead to better lives and less migration. Community farming is primarily focused on boosting native vegetation, such as medicinal, horticultural, and aromatic crops. It also offers training and acts as a



resource hub for goods with added value, particularly for women and tribal farmers. Through community farming projects, some landless households who were formerly employed as bonded labourers are now able to grow their own harvest. These programmes are currently being implemented in neighbouring areas as well.

Micropropagation Technology Park

Tissue Culture

Micropropagation Technology Park (MTP) has emerged as a pioneering initiative on using tissue culture for mass propagation of economically important crops including ornamental foliage, medicinal plants, cash crops, aromatic, fruit crops and forest plants. This is also linked to creating livelihoods through proactive market linkages and business development.



► Tissue culture at MTP

Larger goals and the context

Our work on sustainable agriculture aligns with the major United Nations Sustainable Development Goals (UNSDGs).



We are actively developing interdisciplinary tools and technologies to ensure sustainability in agricultural practices by improving soil quality and health while enriching soil biodiversity, using a rich microbial germplasm bank to develop biofertilizers and nano-agri inputs. Our team is also working with multiple microbial systems to develop natural products, pigments, and alternative sources of energy and food supplements. Active efforts are also being made to study the effects of carbon sequestration in soil and life cycle assessment of agri inputs being developed by our team. Our work encompasses UNSDGs 2, 3, 6, 7, 12, 13, 14, 15, and 17.

Sustainable solutions promoted

New formulations of mycorrhizal biofertilizer:

Harnessing the mycorrhizal-microbiome and isolating many synergistic, agriculturally relevant bacteria is an important component of the Programme. Three new formulations are being developed, tested in-house and are now being tested on large scale by industries and large farm holders not only in India and but also other countries including Jordan. The initial results have shown that apart from chemical fertilizers, irrigation water consumption has been decreased significantly.

Nano-nutrients and nanofertilizers: Development of nano-products as an alternative of conventional chemical fertilizers is a major need of our country and hence it is an important highlight of the Sustainable





Agriculture Programme. In-house research and biologically synthesized nano-agriproducts including macronutrients, micronutrients, weedicides and pesticides have been developed to achieve higher gains from limited agricultural resources. Three major nanofertilizer products have successfully completed bio-efficacy test using drone technology in 10 agro-climatic zones in India and 100 acres of field in Guyana.

Tissue culture: Developed commercial micropropagation protocols for >75 economically important and elite germplasm of various plant species based on market demand. Achieved production of disease-free planting material through meristem and shoot tip culture.

Microencapsulation technology: Next-generation microencapsulation technology for nodulating rhizobacteria (non-sporulating bacteria) species using natural polysaccharides with the desired size of microspheres loaded with microbes for seed coating applications with higher shelf life has been developed.

Microalgal farming: Ecology-inspired solutions by growing algal consortia increased algal productivity and supported in crop protection. Developed a tool to track nutrient stress in real-time algal cultivation system for successful cultivation of marine microalgae.

Microbial products: The development of microbial pigments as natural and sustainable sources of colourants for food, cosmetics, and textile applications is actively being pursued.

Reclamation of wastelands: Successful examples of sites reclaimed using beneficial microorganisms include fly ash overburdens, alkali chlor-laden sites, distillery effluent discharge sites, phosphor-gypsum ponds, coal mines, red mud, saline, and arid sites.

Plant biotechnology: Development of rice with enhanced photosynthesis for obtaining higher yields under elevated carbon dioxide conditions. The bioengineered rice capable of synthesizing its own nitrogen with no adverse effect on climate has been developed.

Our accomplishments

Number and nature of projects

Research and development, consultancy, technology transfer, product development, implementation, skill development and research networking are the key focus areas of our ongoing projects. Our funding is sourced from government, industry, corporate social responsibility, and bilateral projects.

- Partnering with our Sustainable Agriculture Programme, Chambal Fertilizers and Chemicals Limited (CFCL) launched their first Mycorrhiza Product in the Mycorrhiza category of biofertilizers in July 2022. The Advanced Mycorrhizal Biofertilizer product—'UTTAM SUPERRHIZA'—has been impacting the biofertilizers market since July 2022 with ~1900 tonnes being sold in the market. Climate-responsive mycorrhizal biofertilizers have superior field performance with improved plant and soil health (physico-chemical and biological).
- **New formulations of mycorrhizal biofertilizer:** Harnessing the mycorrhizal-microbiome and isolating many synergistic, agriculturally relevant bacteria is an important component of the Programme. Three new formulations were developed, tested in house and are now being tested on large scale by industries and large farm holders, not only in India but in other parts of the globe including Middle East and the USA. The initial results have shown that apart from reduction in chemical fertilizer input, irrigation water consumption can also be decreased significantly while showing positive impacts on plant development.
- **Role in reducing GHG emissions:** It is achieved through development of next-generation mycorrhizal biofertilizers and nanofertilizers using biological approach leading to minimal generation of chemical waste. This also supports the reduction of indiscriminate/overuse of chemical fertilizers.



Research and field-scale programmes in these efforts were launched with the support of Shell India Markets.

- TERI, TERI-SAS and DEAKIN UNIVERSITY entered into a tripartite agreement for launching the TERI Deakin Centre for Excellence in Agriculture and Environment as TERI entered the 4th Phase of its Collaborative Relationship with Deakin University, Australia beginning in 2023.
- **Capacity building of DBT-TDNBC-DEAKIN - Research Network Across continents for learning and innovation (DTD-RNA):** Considering the importance and relevance of joint research platform, TERI-Deakin Nanobiotechnology Centre (TDNBC), Gurugram, India and Deakin University, Australia, in association with the Department of Biotechnology (DBT), Government of India, has created “DBT-TDNBC-DEAKIN - Research Network Across continents for learning and innovation (DTD-RNA)”. This is a unique network with the vision to contribute to a better world through nanotechnology. For more information, please visit <https://tdnbc.teriin.org/index.php>

Approach and innovation

The major work challenge is to bring sustainability in agricultural practices through reduced use of chemical fertilizers while substantially improving crop yields. Progress is being made in nanofertilizers, super foods, renewable energy-based agricultural solutions and algal-based bioenergy.

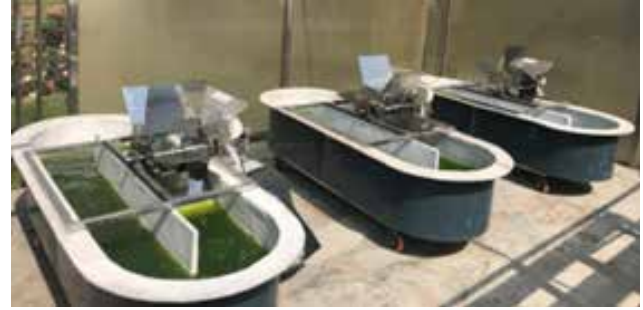
To derive more value, efforts are being made to reach potential stakeholders and disseminate proof of concepts and knowledge through public-private partnerships for making agriculture sustainable in India.

- TERI's 'PEG' or Performance Enhancing Green Biologicals Technology is a unique combination of TERI's in vitro mass production technology which also encompasses the naturally associated bacteria with the growing mycorrhiza in vitro conditions. These combinations which have multiple benefits to plants and soils are only available with TERI at a Mass Production level.
- Maintaining long-term, stable, and productive algal biomass production is the key barrier to any algal product commercialization. Outdoor algal cultivation systems experience threats from weeds, pests, and pathogens. Our early detection technology of algal pests helped to prevent pond crashes. Further, ecology-inspired solutions by growing algal consortia increased algal productivity and supported in crop protection.

Inspirational evidences

Efforts made to transfer products to private sectors and enhancing the capacity and awareness on the respective technologies.

- Our Advanced Mycorrhizal Biofertilizer product launched by Chambal Fertilizers and Chemicals Limited (CFCL) - 'UTTAM SUPERRHIZA' has been impacting the biofertilizers market since July 2022 with ~1900 tonnes being sold in the market.



- ▶ *Advanced Mycorrhizal Biofertilizer product launched by Chambal Fertilizers and Chemicals Limited (CFCL) - 'UTTAM SUPERRHIZA'*

- Harnessing the power of the soil microbiome to make climate-resilient and responsive bioformulations for maximizing plant impact and improvement of soil health and physicochemical properties.





► *Increased grain filling in pearl millet*

- Developed an efficient silica-based nano-biocatalysts for concentrating omega-3 fatty acids in algal oil, which demonstrated 2.5-fold enrichment in eicosapentaenoic acid (EPA) in algal oil.
- Replenishment of industrial wastelands of companies such as TCL and HZL with biological interventions such as Mycorrhiza while creating green cover of native and beneficial plant species.
- For more information on licensed technologies and services, please visit <https://terismartagrisolutions.com/>

Success stories

- Successful drone technology-based field trial was conducted with ICAR institutes of major nanofertilizers (Nano Urea, Nano P, Nano DAP) resulting in significant increase in yield and improvement in soil and plant health.



► *Field evaluation of TERI Nano Urea formulation following drone-based supplemental spray on the paddy crop at Davangere, Karnataka during Kharif 2022. This resulted in enhanced yield of up to 17.1%.*

- Three new advanced mycorrhizal biofertilizer formulations have been developed and tested by industries.
- World Economic Forum recognized TERI's reclamation technology as one of the innovative technologies working to conserve and restore India's forest landscapes.

- Developed effective formulations of nano-copper and nano-sulphur fungicides, which would reduce the dosage of application by 15–50 times on common fungal diseases such as early blight in tomato and potato, and powdery mildew in okra.
- Launched an Advanced Mycorrhizal Biofertilizer product 'Uttam Superrhiza' a unique granular product that is powered by TERI's in vitro PEG Technology of Performance Enhancing Green Biologicals. This is an exceptional growth promoter technology providing native biological inputs that complement mycorrhiza performance for synergistic effects and superior field performance.



Impact We Created

- Sold ~1900 tonnes of Uttam Superrhiza product formulation to CFCL for the Indian Biofertilizer Market.
- Two additional new mycorrhizal formulations ready to be supplied to Indian fertilizer Companies and additional formulations being tested in Middle East and Germany.
- Successfully cultivated marine microalgae over the year for the production of omega-3 fatty acids. The average annual productivity of biomass was 25 g/m²/day with the lipid. The relative content of omega-3 fatty acids was 24% in the extracted algal oil.





- Grants received from fertilizer industries for research and product development to support SDG2, PMPRANAM scheme by developing alternatives for chemical fertilizers.
- Research grants secured from the Department of Biotechnology; Department of Science and Technology; Science and Engineering Research Board, and Indian Council of Agricultural Research.
- Few grants received from private industries, MNCs.
- Long-term partnership with the Deakin University, Australia has led to effective collaborations and leading to the next phase.
- The DBT supported the DTD RNA, which is leading to effective community of practices and networking of diverse stakeholders.

Knowledge building and dissemination

Knowledge sharing sessions on 'UTTAM SUPERRHIZA' was undertaken by TERI SA Programme and CFCL where the Scientific Team of TERI explained the 'Performance Enhancing Green Biologicals' mycorrhizal technology to farmers and marketing representatives associated with CFCL during a series of events from July 2022–September 2022 across different states of India.

- SA Programme contributed to the WSDS Special Issue of TerraGreen released in March 2023 with two Innovation Showcases on:
 - i. Enhancement of Conscious Consumerism by Mehak Kaur and Mayurika Goel
 - ii. Mycorrhiza and Bacteria-Enriched Microbiomes by Mandira Kochar
 - iii. Services

The work carried out under different areas of SA Programme enables TERI in developing effective partnerships with various stakeholders such as public organizations, private, NGO, industries for research and development required for product translation and dissemination of best practices.

Partnerships and networks

- Research Grant secured from Shell under its Nature based Solutions programme. The project focuses on developing a combination-fertilizer package, with a mix of conventional bio-nanofertilizers, that would help in enhancing soil health—reducing GHG emission and supporting yield in a sustainable manner.

Details on Knowledge Building; Partnerships and Networks can be viewed via the following URLs:

- 1 https://www.teriin.org/files/TERI_Annual_Report_Knowledge_Contributions.pdf
- 2 https://www.teriin.org/files/TERI_Annual_Report_Partnerships_and_Networks.pdf





SOCIAL TRANSFORMATION AND CSR DIVISION



The genesis of Social Transformation & CSR Division's activities lies in its firm belief that sustainable use of natural resources, efficient utilization of energy, large-scale adoption of renewable energy technologies, and reduction of all forms of waste would move the process of development towards the goal of sustainability.



Themes and Commitments

Thematic focus

In Social Transformation & CSR (ST & CSR) Division, TERI addresses a wide spectrum of technosocial dimensions such as:

- Technology design and customization
- Training and skilling
- Action research
- Business model development for livelihood opportunities
- Renewable energy-based solutions for quality and reliable power
- Livelihoods, health, and education

The corporate social responsibility (CSR) concept at TERI is driven by 'Gandhian' thought of Trusteeship model, benefitting the most needy and vulnerable segments of the society. The CSR work at TERI is governed by Companies Act, 2013, as per Section 135 and focusing on Schedule VII's thematic activities. Interweaving elements of gender and social inclusion at every stage of design and implementation of all its interventions have been the cornerstone of TERI's endeavours. With its focus on clean and rational use of energy, TERI continues to strive for a climate-resilient and Atmanirbhar rural India.

Larger goals and the context

ST & CSR initiatives encompassing clean energy solutions and sustainable capacity building, envision helping India achieve its Net Zero targets by 2070. In the process, it addresses 10 out of the 17 SDGs, i.e., SDGs 3, 5, 6, 7, 8, 9, 10, 12, 13, and 17.



In this context, some of the key projects undertaken include development of clean and reliable solar-based power infrastructures to improve the operational reliability of power, Integrated Model Village Development, etc.



Sustainable solutions promoted

Developing green skills of rural India is a key intangible sustainable solution actively advocated by TERI. On the other hand, some of the tangible sustainable solutions promoted are as follows:

- Off-shore wind floating energy platform
- Solar-based solutions—irrigation pumps, home lighting system, LED street lights and DC fan, portable solar-powered cold storage and boats, solar water pumps for drinking water supply, etc.
- Hybrid solar charging units for power looms
- Clean biomass cookstoves
- Large-scale village adoption programmes for community development

Our accomplishments

Number and nature of projects

Till date, more than 200 projects have been executed across India and with the objective of 'social transformation', several grassroots initiatives are still ongoing. In the year 2022–23, 25 projects have been executed. These projects involve research, CSR project design and implementation, baseline studies and impact assessment, policy advocacy, demonstration, consultancy, etc. The projects touch lives of a diverse range of communities such as farmers, micro and small entrepreneurs, fishermen, school students, women-led SHGs, coastal and tribal communities, etc.

Role in reducing carbon footprint

- A special focus on CO₂ emissions' mitigation is placed in all the projects undertaken by ST & CSR.
- 150 units of Hybrid Solar Charging Units (HSCUs) for Power Looms were installed in Varanasi that helped reduce emission of 484.81 metric tonnes of CO₂ per year. (<https://www.teriin.org/project/energy-access-livelihood-promotion-and-other-basic-energy-needs>)
- Clean cookstoves promoted through rural disseminations mitigated 30–35% of indoor air pollution (per unit).

Approach and innovation

Sustainable and customer-centred ST & CSR initiatives helped develop clean energy technologies that are shared through open source platforms. Implementation methodologies are being adapted to changing context to increase process efficiencies and to reinforce best practices through policy advocacy and capacity building.

Relentless efforts made in creating sustainable market-led value chains that align commercial and social objectives of stakeholders. This has led to developing customized technology options, responsive service

mechanisms, localized and inclusive entrepreneurial business models, generating awareness and livelihood opportunities at the grassroots level.

Inspirational evidences

Demonstrations

Various holistic village and school development programmes with CSR funding on the theme of natural resource management have been implemented majorly in Haryana, Jharkhand, and other parts of India. The on-ground factors that manifest positive changes, transformation, greater adoption of clean energy practices and behavioural changes in the rural communities have been captured through some audiovisuals listed below:

Films & Videos		
S. No.	Film / Video	YouTube link
1.	Weaving in the Sunshine: A film on hybrid solar charging unit for power loom	https://youtu.be/2oQEHmjIMdU
2.	Solar Flow in Mandakini: A film on battery-powered boat	https://youtu.be/bj2N50_S5jA
3.	Anjora: The light	https://www.youtube.com/watch?v=WNTk-Qx6Nmc
4.	Solar Chandna: A documentary on solar micro grids	https://www.youtube.com/watch?v=_N63ERilrEE
5.	New Bloom on the Loom (short film on solar loom)	https://www.youtube.com/watch?v=aw30zHEujkg
6.	Solar Flow in Mandakini: A film on battery powered boat	https://www.youtube.com/watch?v=bj2N50_S5jA
7.	Weaving in the Sunshine: A film on hybrid solar charging unit for power loom	https://www.youtube.com/watch?v=2oQEHmjIMdU

Success stories

We took lead in providing infrastructure for reliable energy in remote schools to ensure quality education for the children. The initiative integrated renewable



energy with quality learning and local economy imaginatively. More than 380 students were imparted training in solar energy-related skills by leveraging 'Green Skill Development Programme' of the Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India. About 50% have been placed in different industries and few of them have started their career in green entrepreneurship.

As a part of a major project with World Bank Group, we successfully established 25 women-led Uttam Urja Shops and disseminated 4,000 clean cookstoves in Bihar. The main stepping stone for pan-India penetration is TERI's flagship initiative for clean energy access— 'Lighting a Billion Lives' (<http://labl.teriin.org/>).



▶ Training on ketchup-making to SHG members



▶ Training on bari-making to SHG members



▶ Promoting solar-powered solutions for rural India



▶ Implementation of solar-based projects



▶ Water conservation through pond rejuvenation as a CSR initiative

Impact We Created

- Owing to prevailing problems of energy access, reliability of energy supply, poor operation and maintenance there was wastage of 3–4 working hours due to power cut, sound pollution and CO₂ emission due to diesel generators, disruption of household chores and livelihood activities, etc. Interventions targeting these issues benefitted the rural population, which resulted into regular power supply, reduced electricity bill, no disruption of livelihood activities, greater time saving, reduced CO₂ emission, sound pollution, and indoor air pollution.
- The initiative on ensuring reliability energy supply to remote schools helped promote green jobs, enhanced career and entrepreneurial opportunities.



Knowledge building and dissemination

Consolidation of learning from diverse projects aimed at promoting sustainable energy, social inclusion, and gender equity has enabled TERI to share innovative and proven ideas, on-the-ground insights, and policy perspectives at various levels—local (village and state), national, and international—through active participation in knowledge exchange events.

Various publications based on action research and other innovations helped in reaching out to researchers, practitioners, policymakers, and other actors. Major contributions made by ST & CSR Division came in the following forms:

- 80 publications
- 1 patent and 4 other patents have been filed

Partnerships and networks

TERI constantly strives to draw synergies with national and state-level government programmes to integrate the scope of energy access into other related sectors such as livelihoods, health, education, and women's empowerment. Working in conjunction with government schemes, programmes and a range of rural development initiatives TERI has successfully reached the remotest of areas in providing energy poor communities the access to clean technologies for basic and productive use. To create a cadre of socially conscious youth, contributing towards a better and brighter future and facilitate progress towards the achievement of the Sustainable Development Goals (SDGs), TERI incorporates students and young professionals in the rural energy access framework.



▶ Best overall Excellence in CSR Award by ET Ascent

Awards and recognition

1. Mahatma Award for best CSR project in Environment category for Coal India Project
2. Best CSR project in Rural Development category for Coal India Project
3. Indo–French Award for CONCOR CSR Project
4. MCA Award for PFC CSR Project
5. Best CSR Initiative by IIT and DPE
6. Award for best Swacchata Project
7. Woodpecker Award for CONCOR CSR Project
8. Best overall Excellence in CSR under the Organizational Award by ET Ascent

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REGIONAL CENTRES



Serving as bridges to propagate the organization's work throughout the nation, Regional Centres help establish a strong base for TERI's activities and projects at the grassroots level. They help in further diversifying and broadening the knowledge repository as well as the scope of the organization's operations.



TERI Southern Regional Centre, Bengaluru

TERI's Southern Regional Centre (SRC) was set up to promote the rational use of energy when the country's economic liberalization was initiated in 1991. After 1991, the economic benefits of reducing costs and the environmental benefits of cutting pollution have become the primary drivers for economic growth. As the electricity grid becomes more complex with new clean energy technologies coming on board every day, energy efficiency is a cross-cutting solution. Thus, we need to make the clean energy transition to be reliable, affordable, and equitable. If supply becomes more variable, efficiency will make demand more flexible. If energy prices go up, efficiency will help to bring down the energy costs. As the energy sector changes, efficiency will create opportunities such as jobs and economic development.

Industrial Energy Group (IEG) is helping prominent clients to achieve their sustainability, climate, and equity goals. The Group amplifies ideas and innovations to design new pathways towards the future. Perform, Achieve, and Trade (PAT) scheme is a flagship initiative of the Bureau of Energy Efficiency (BEE) and the Ministry of Power (MoP), Government of India. The Group extends its services to designated consumers in implementing the PAT scheme during the current financial year, mainly thermal power plants. Energy efficiency studies were conducted across chemical, pharmaceutical, mining and commercial buildings during the year 2022–23.

The IEG refocused institutional international collaborative activities to effectively promote energy efficiency as a crucial near-term solution for meeting global energy needs and addressing climate change, providing technical assistance to the Government of the Republic of Guyana, especially in implementing renewable energy projects. Resource efficient programmes were executed for Cambodia, Indonesia, Tajikistan, and Uzbekistan industries.

The exponential growth of solar photovoltaic (PV) aggregation was advancing due to the rapidly decreasing cost of PV systems. Office buildings integrate solar rooftop PV systems through public procurement as a transition towards sustainable energy use. Union Bank of India nominated TERI as a project consultant for establishing an on-grid solar power plant for the Mangalore corporate head office. Finland has funded the solarization of Primary Health Care (PHC) services for marginalized and tribal communities in Hanur Taluk, Chamarajanagar District of Karnataka state through the EKOenergy ecolabel. The project has been successfully executed, benefiting five PHC services.



► *EKOenergy project—TERI handing over solar PV systems to the District Health Officer, Chamarajanagar*

Despite their ubiquitous nature, plastics are becoming a threat to the ecosystem. Littered plastic waste on land and aquatic environments finds its way into the water-bodies, affecting marine ecosystems. Single-use plastic (SUP) items form a significant portion of the littered waste. In March 2021, the Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India, introduced a draft amendment to the Plastic Waste Management (Amendment) Rules, 2018. Tamil Nadu State Pollution Control Board (TNPCB) engaged TERI to conduct a statewide survey and compile the directory of manufacturers and distributors of eco-alternative materials for SUPs.





- ▶ 'Directory of Manufacturers & Suppliers of Eco-alternative Materials for Single-use plastics in Tamil Nadu' prepared by TERI



- ▶ EKOenergy project -Solarizing of PHC in Bandalli, Hanur taluk, Chamarajanagar District, Karnataka

TERI has been engaged by the Watershed Development Department (WDD), Government of Karnataka, Bengaluru, as a "Process Monitoring Agency (PMA) for Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD)". The project comprises 21 districts of Karnataka State, which is being developed under the Watershed project covering an area of about 19 lakh hectares.



- ▶ Release of TERI prepared 'Directory of Manufacturers & Suppliers of Eco-alternative Materials for Single-use plastics in Tamil Nadu' by Chairperson and Additional Chief Secretary of Tamil Nadu Pollution Control Board (TNPCB) at Chennai



Northern Regional Centre – Mukteshwar

About TRISHA

TRISHA (TERI's Research Initiative at Supi for Himalayan Advancement) came into being in 2003 at Supi village, Mukteshwar in Nainital district of Uttarakhand. Since agriculture is the principal occupation of the hill inhabitants, research and extension have been largely undertaken to uplift the livelihoods of the local farmers who are largely marginalized. As a viable approach, the aim was to develop crop value chains for providing financial security to the marginal farmers of the Himalayan villages.

The following list gives a glimpse of the thrust areas of the Himalayan agriculture:

- Fragmented and marginal land holding
- Rainfed agriculture
- Infestation of wild animals
- Unsustainable farming practices
- Less marketing facilities

Available facilities

TRISHA, situated at height of 7,500 feet, is a distinct venture towards sustainable development. The centre houses a number of state-of-the-art facilities. Some of the facilities of significance include Supi bio farm's vermicomposting units, polyhouses, glasshouses, solar greenhouses, oil distillation unit, solar dryers, mechanical dryers, grinders, pulverizers, ovens, herbal garden of medicinal and aromatic crops, rainwater harvesting models, knowledge-cum-training centre, and a resource centre of various value-added products.

TERI-TRISHA approach

Realization of enhancement of land and crop productivity through utilization of sustainable and organic biotechnological approaches and harmonizing modern technologies and traditional knowledge are amongst our core areas. Our initiatives have



benefitted the local farmers, especially to look beyond their conventional farming system and bring about successful diversification of crops through organic inputs. The farmers of the area have been able to overcome the adverse impact of climate change by adopting cultivation of medicinal and aromatic herbs that require minimal amount of water and thereby have an assured source of income round the year. It has also strengthened their village-based micro-enterprise capability, leading to improvement in their economic condition. With its initiatives, TERI has touched lives of more than 5,000 households spread across many villages of the country. With the approach aimed at improving the socio-economic status of the farming community, TERI has not only provided farmers with high-quality planting material but has also entered into buyback arrangement for ensuring to provide them with assured market and better returns. Our efforts have successfully created an enduring platform for facilitating assuring economic returns by eliminating intermediaries and thus created a win-win situation for both farmers and clients.



TERI DeraGreen—Himalayan Centre

TERI DeraGreen is nestled in Mukteshwar, a secluded hill station located 350 km from Delhi and 46 km from Nainital. Mukteshwar is situated about 7,500 feet above sea level. The weather here ranges from pleasant to cold, which makes it an ideal year-round destination. It's a self-sustainable retreat that runs on solar energy and a rainwater harvesting system—perfect structure to save resources and nurture Mother Nature. The nearest railway station is at Kathgodam, 56 km from Mukteshwar.

TERI Eco-Tourism Programme is inclusive of two camps:

TERI Leadership Camp

TERI presents a dynamic and one-of-its-kind leadership camp that significantly interests young minds, looking forward to assume leadership roles in near future and contributing towards the common good. Through these camps, we not just offer a chance to get close to the wilderness and nature at our Himalayan Centre, but also facilitate comprehension of sustainability on the participants' end, effectively strengthening their leadership skills through various action-oriented activities and sessions.



TERI's Eco-Adventure Camp: a cool way to learn and care for the Mother Earth

TERI DeraGreen (Himalayan Centre) at Mukteshwar offers its visitors an adventure-filled holiday in the lap of nature—right from watching butterflies to witnessing kingfishers flit. If one cares for the Mother Nature, Eco-Tourism will prove as the perfect destination. At DeraGreen, we encourage close connectedness with the nature and village lifestyle. A stay at DeraGreen is aimed at instilling a sense of preserving nature's bounties for the future.



Highlights of the Eco-Tourism Programme

- Learning without textbooks; thereby linking the activities to the curriculum.
- Visit to TERI's bio-farm, Trisha, where one can see and learn about a variety of plants and herbs, rainwater harvesting and solar energy.
- Visiting Kumaon Vani radio station.
- A day in village: learning village lifestyle and other issues of villagers daily life.
- Adventure sports at Chauli ki Jali, rock climbing, rappelling, flying fox, archery, trekking.

Kumaon Vani 90.4 FM

- Kumaon Vani is Uttarakhand's first community radio station located in Supi village. It was established in 2010 by TERI. Kumaon Vani radio aims towards bringing together communities across several villages in the Kumaon region. It was established to use radio as a tool to promote sustainable development amongst the local farming community. It broadcasts content that is relevant to the people of the area and is often overlooked by the commercial media. The radio station is run by youth from the local community, under TERI's supervision.



Western Regional Centre – Mumbai

The Western Regional Centre (WRC), Mumbai is involved in planning, strategizing, and successfully implementing multi-thematic projects by adopting a multi-pronged approach. These projects revolve around the themes of environment resource mapping and reporting, nutrition security, and sustainable development. In the year 2022–23, the areas of project implementation particularly included the urban area of the Mumbai Metropolitan Region (MMR) and tribal areas of the Palghar district. The Centre successfully completed projects for national as well as international sponsors as part of its long-term commitments to create a positive impact on local communities and the environment. Important aspects of these projects included designing and implementing project activities in order to address specific Sustainable Development Goals (SDGs). In this path, the Centre has always ensured the involvement of local stakeholders through training and capacity building to create mass-level awareness and sustainability of the project activities.

Key activities carried out

Long-term plastic flux monitoring and river assessment in the Panvel Creek – Phase 2

Under the research collaboration with the Netherlands-based not-for-profit organization—The Ocean Cleanup (TOC)—this project is implemented in order to estimate the load of riverine plastic waste.

As a part of the project, solar-powered time-lapse cameras were installed at four river locations in the Navi Mumbai region. The photographs of the water channels are clicked after every set period of time for about 12 months in order to get season-wise data about the river behaviour, navigation frequencies, tidal flow and amount of plastic waste in the water channel.

Further, an AI tool developed by TOC would enable the estimate of the level of plastic waste pollution by

analysing the photographic data. Based on this, the most feasible blockage technology shall be suggested as the next phase of this research study.

Set-up of Biofloc technology at Mokhada, Palghar

This project was initiated with the objective of introducing a protein source into the diet and encouraging tribal women and youth to take up aquaculture as a means of alternate livelihood.

TERI successfully set a demonstration unit of Biofloc system at Arts, Commerce and Science College, Mokhada.

With the help of a knowledge partner (Centre of Fisheries and Education), TERI conducted a series of Training Trainers (ToT) sessions to build a team of local tribal stakeholders to implement and continue the project in the future.

In March 2023, TERI handed over the set-up to the Mokhada College after getting a successful first harvest of Tilapia fish from these units.



Through this intervention, a continuous supply of protein in the diet of tribal students is secured as well as an opportunity for locals is made available to have a hands-on experience through the continuity of this facility in the future.



Environment reporting

The Centre has prepared an annual Environmental Status Report (ESR) for the Navi Mumbai Municipal Corporation (NMMC) as well as an Air and Water Quality Status Report 2021-22 for the state of Maharashtra, funded by the Maharashtra Pollution Control Board (MPCB).

Available in the public domain, these annual reports help maintain the database of the status of locally available natural resources and monitor the levels of pollutants. It also helps decision-makers/policymakers to take timely implementation/mitigative measures to address a particular issue potentially detrimental to human health and the environment.

- Water Quality Status of Maharashtra 2021-22. [https://www.mpcb.gov.in/sites/default/files/water-quality/Water%20Quality%20Report%202021-22%20\(1\).pdf](https://www.mpcb.gov.in/sites/default/files/water-quality/Water%20Quality%20Report%202021-22%20(1).pdf)
- Environmental Status Report of Maharashtra 2021-22 for the Navi Mumbai Municipal Corporation. <https://nmmc-ecocity.org/assets/pdf/NMMC%20English%20ESR%202021-22.pdf>

Our achievements

The release of the Air Quality Status Report of Maharashtra 2021-22 at the hands of Hon'ble Chief Minister of Maharashtra Shri Eknath Shinde and Hon'ble Deputy Chief Minister Shri Devendra Fadnavis on the occasion of 'Sumangalam - Panchmahabhoot Lokotsav' at Shri Siddhagiri Mahasansthan, Kanheri Math, Kolhapur dated February 20, 2023.



North-Eastern Regional Centre – Assam

Thematic focus

The work of TERI North-Eastern Regional Centre focuses on agriculture, medicinal plants, sericulture, wastewater treatment, waste management, water quality improvement, livelihood enhancement, integrated watershed development programme, preparation of village development plan, production of quality planting materials, capacity building and rural extension, etc. The multi-pronged efforts of the Centre are aimed at improving the production base, livelihood, cleaner environment, and capacity building of various stakeholders.

Inventorization, molecular identification and characterization of *Garcinia* species from north-east India for isolation of polyisoprenylated benzophenones as taxol mimics

The R&D project carried out in collaboration with ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand and M S University of Baroda focused on exploration of species diversity and DNA barcoding for confirmation of species. Under the project, 13 species and 4 varieties of *Garcinia* were recorded from Assam,



Mizoram, Arunachal Pradesh, and Meghalaya and DNA barcoding of 13 species were carried out.

Water quality improvement of Dighalipukhuri, Guwahati

Two-pronged strategies, viz., reduction of external nutrient load from septic tank effluent and surface run-off and reduction of internal nutrient build-up due to microbial metabolism of nuisance microbes have been adopted to enhance oxygenation and nutrient remedial process. The scientifically-designed formulation has been applied to restore the polluted aquatic ecosystems. Sub-surface horizontal constructed wetland was designed, created, operationalized, and maintained to reduce organic inflow to the waterbodies from septic discharge and surface run-off. Artificial floating islands (AFIs) have been designed to oxygenate the water column upto 1 m depth from surface and to harbour microbial biofilm on the surface of the root system.

Raj Bhavan Assam—a zero-waste campus in partnership with TERI, North-Eastern Regional Centre

The project focused on holistic assessment of solid and liquid waste generation, present state of waste management, gap analysis and formulation and implementation of standard waste management procedure for achieving a zero-waste campus in Raj Bhavan, Assam. Under this project, a Material Recovery Facility (MRF) and reed beds have been developed to convert organic waste into compost and treat grey water, respectively.

Preparation of Vision Plan on community development activities

Preparation of vision document for the villages in and around the units of Dalmia Cement (Bharat)





Limited in Jagiroad, Lanka and Umrangshu in Assam and Thangskai in Meghalaya has been undertaken. Participatory approaches have been adopted to collect primary data on socio-economic status, geographic and demographic features, cropping system, seasonal calendar, livelihood options, resource availability and problem to arrive at a decision for preparing the context appropriate vision plan.

Promotion of organic cultivation

Department of Biotechnology sponsored Biotech-Krishi Innovation Science Application Network (Biotech-KISAN) project that has been undertaken for promotion of scientific cultivation of vegetables for livelihood enhancement. Under this project, capacity-building programmes and demonstration of crops and methods have been done in two districts of Assam, viz., Kamrup (M) and Kamrup (R). In the first phase of the project 50 beneficiaries have been covered under capacity building and demonstration activities and 15.53 acres of land have been brought under vegetable cultivation.

Our accomplishments

Research and development, consultancy, project implementation, capacity building and research networking are the key focus areas of the Centre. Funding sourced from government, corporate social responsibility, etc., is utilized to implement the project activities.

<p>Inventorization and taxonomic assessment of <i>Garcinia</i> species</p> <p>Inventorization and taxonomic assessment of <i>Garcinia</i> species from northeastern India and their molecular identification through DNA barcoding was implemented by TERI, North-Eastern Regional Centre. Under this project, 10 species and</p>	<p>Water quality improvement</p> <p>The project focused on enhancing oxygenation and nutrient remediation processes to reduce external nutrient loads and internal nutrient build-up. Additionally, a reed bed was developed for effluent treatment, and an artificial floating island was created to oxygenate the water</p>
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<p>four varieties of <i>Garcinia</i> were explored from 14 districts of Assam and two districts of Meghalaya and isolated genomic DNAs from 13 species.</p>	<p>column, trap suspended solids, remove dissolved nutrients, and enhance microbial activity in the root zone water column.</p>
<p>Zero-waste campus in Raj Bhavan, Assam</p> <p>The Centre has been implementing a project called Raj Bhavan Assam—a zero-waste campus in partnership with TERI, North-Eastern Regional Centre. The project focused on assessment of solid and liquid waste generation, gap analysis and formulation and implementation of standard waste management procedure for achieving a zero-waste campus in Raj Bhavan, Assam. Under the project, development of reed beds for black and grey water treatment, MRF for recycling of materials and production of compost from the kitchen and garden wastes have been done.</p>	<p>Biotech-Krishi Innovation Science Application Network (Biotech-KISAN)</p> <p>This project is being undertaken for the promotion of scientific cultivation of vegetables for livelihood enhancement. Under this project, capacity-building programmes and demonstration of crops and methods have been done in two districts of Assam, viz., Kamrup (M) and Kamrup (R). In the first phase of the project 50 beneficiaries have been covered under capacity-building and demonstration activities and 15.53 acres of land have been brought under vegetable cultivation.</p>

Approach and innovation

The TERI-NERC through its innovative research offers scientific solutions for wastewater treatment, waste management, water quality improvement, and natural resource management.

- We installed and commissioned MRF and reed bed system for solid and liquid management and





provided solutions to regulate and minimize waste generation and convert waste into useful products.

- We conducted scientific cultivation of vegetables with hand-holding capacity building and technical support.
- Our R&D work focuses on exploration of processes and solutions for sectoral problems.
- We tried to create uniqueness of works to make special and visible impact that determine the project's originality and authenticity.

Other activities of our projects that have created some uniqueness are as follows:

- A Food Testing Laboratory, partially funded by the Ministry of Food Processing Industries (MoFPI), Government of India, has been set up at the Centre to cater to the food safety concerns of consumers and to regulate the quality of food products from the producers, sellers, and entrepreneurs from across the eight northeastern states. The NABL-accredited Food Testing Laboratory is functional and currently maintaining its facilities for commercial testing of the samples of Packaged Drinking Water (As per IS: 14543) in the six accredited parameters. The Lab is also equipped for testing of samples for other chemical parameters, e.g., crude fibre, total ash content, alkalinity of water-soluble ash, acid insoluble ash, water-soluble ash and water-soluble extractive in tea, acid insoluble ash, total ash, moisture content in turmeric and alkalinity in packaged drinking water. The Lab is also continuously putting efforts by standardizing of newer parameters for commercial testing and NABL accreditation in chemical and microbiological parameters.

Inspirational evidences

- Solved the morphological identification problem in *Garcinia* species through DNA barcoding tools.
- Ten species and four varieties of *Garcinia* have been recorded from Assam and Meghalaya during the year and isolated genomic DNAs from 13 species for identification of the species.

Impact We Created

Inventorization and taxonomic assessment of *Garcinia* species

Tangible: Thirteen species and four varieties were recorded from four states of northeastern India and DNA bar coding were carried out for 13 species

Intangible: Identification problem of morphologically diverse species was solved

Zero-waste campus in Raj Bhavan, Assam

- **Tangible:** Treatment of black and grey water, the project achieved the treatment efficiency for biochemical oxygen demand (71%), ammonia removal efficiency (85%), chemical oxygen demand (61%), total dissolved solids (74%), total suspended solids (44%), total volatile solids (71%), and fecal coliform (77%).
- **Intangible:** Maintaining cleanliness inside the campus indirectly helps in minimizing the population of harmful microbes resulting in a healthy environment for human beings.

Water quality improvement of Dighalipukhuri, Guwahati

- **Tangible:** Application of scientifically-designed formulation for restoration of polluted water-body to eliminate toxic cyanobacterial blooms for improvement of quality in terms of dissolved oxygen (DO), reduction in BOD, COD, odour, and colour was done. There are corrections in pH of the water body (8.2), odour (odourless), DO (6 mg/l), COD (16.0 mg/l), total alkalinity (76.0 mg/l) and values of sulphate, nitrate, ammonia are lower than the CPCB standard range and BIS 10500.
- **Intangible:** Improvement in water quality and flora and fauna of the pond ecosystem.

Partnerships and networks

- TERI NE collaborated with different government departments, Krishi Vikash Kendra (KVK), Department of Sericulture, Government of Assam; ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand; M S University of Baroda; North-Eastern Hill University, Tura, Meghalaya; Bio-Resources Development Centre (BRDC), Government of Meghalaya, etc., for implementation of the projects and collaborative proposal development.



Western Regional Centre – Goa

The Coastal Ecology and Marine Resources Centre (CEMRC) works at influencing policy and strengthening the institutional support required for better management of coastal resources. Conserving coastal ecosystems through sustainable development and community-based resource management programmes has been the expertise of CEMRC. The Centre is also engaged in research that focuses on a variety of sectors such as biodiversity, coastal resource management, aquaculture and training, impact and vulnerability assessment of water resources to climate change, and studies at the interface of environment and development. The Centre has also developed the TERI Coastal Education Hub, bringing attention to our priceless coastal habitats and resources, for student education, entrepreneurship training and development, woman empowerment, and creating awareness among the public at large. In addition to participation in research projects that are local, national and international in scale, the Centre actively contributes to local thinking and provides intellectual inputs on

sustainable development issues through organization and participation in seminars, training programmes, and workshops.

Available facilities

The Centre is home to multiple aquaculture set-ups in conjunction with the Centre of Excellence project to design fish feed. Other facilities include the solar dryer, grinder-feed pelletizer, Kitchen garden, and TERI Coastal Education Hub. The Hub is a platform for disseminating ecological knowledge especially on the conservation of our coastal ecosystems and resources to schools/ colleges and youth across state and at national levels. <https://www.teriin.org/project/teri-coastal-education-hub>.

The thrust areas of the CEMRC include the following:

- Coastal Resources & Ecosystem Management
- Biodiversity Mapping
- Blue Economy
- Aquaculture and Training

Our accomplishments and impacts created

Project	Key Focus	Client/Funder	Outcomes/Impacts
Microbial indicators of metal stress in the mangrove ecosystems of Goa	The objective was to measure the presence of microbial bio-indicators to commonly occurring heavy metals originating from inland mining sources through a comparative study of pristine and stressed area of mangrove ecosystem.	Department of Science and Technology, Government of India	Monitoring of the environmental state of Goa's coastal ecosystems such as the Khazan/ mangrove ecosystem. Project results can be extrapolated to other stressed coastal areas.



International Indo-German conference and partnering meeting on sustainable energy and environmental technologies	This stakeholder meeting was aimed at bringing together experts, researchers, and industrial stakeholders, which intended to establish a joint Indo-German Agri-Marine Energy Centre in Goa.	Physikalisch-Technische Bundesanstalt (PTB), Germany	On two separate occasions, under the umbrella of the project, a stakeholder meeting was held with participation from Indo-German Science and Technology Centre (IGSTC) and State Government Departments for a discussion on opportunities, challenges, issues and policy strategy towards sustainable solutions. Further, TERI Goa and PTB Braunschweig organized a Core Partnering Meet on 'Indo-German Joint Initiatives for Sustainable Energy and Environmental Technologies'.
Development of aquafeed from de-oiled algae	Under this project, the development of artificial fish feed using de-oiled algae has been initiated and tested.	TERI-DBT Centre of Excellence	The project has established that local ingredients in conjunction with de-oiled algae constitute superior feed ingredients to form an effective fish feed, which compositional analyses have shown to be protein-rich, a factor essential for fish growth. Our prepared fish feed product 'AquDalgae' is in the process of being registered with the Coastal Aquaculture Authority (CAA) for subsequent commercialization.
TERI Coastal Education Hub	Dissemination of education on Goa's coastal habitats and traditional coastal occupations for students and the general public. The Hub also aims to create opportunities for entrepreneurship development and livelihood diversification.	Multiple funding agencies	Training courses for entrepreneurship development and women empowerment are undertaken at the TERI Coastal Education Hub for diversification and development of new pathways in livelihood generation.

Knowledge building and dissemination

On the basis of the ongoing research and innovations, the team made an effort to consolidate the learning, shared key findings and accumulated knowledge through publications and presentations in public fora.



Microbial indicators of metal stress in the mangrove ecosystems of Goa





Indo-German Partnering Meeting on Sustainable Energy (biofuels) and Environmental Technologies

Water Technology Area

Thematic focus

We address issues pertaining to water resource management with focus on water remediation technologies and watershed development projects. Primarily, we provide sustainable and cost-efficient solutions aligned with the needs of the stakeholders, based on scientific measurements, in-depth analysis, field and laboratory testing and pilot-scale demonstrations in collaboration with our national and international collaborators. The varied activities under this programme also touch upon SDG 6 and SDG 15 and primarily focus on affordable and clean water supply solutions.

Being driven by the broad intent of promoting cost-efficient and sustainable solutions, the water technology encompasses the following thematic domains:

- River Bank Filtration (RBF) technology
- Watershed management
- Groundwater exploration studies
- Hydrogeological investigations

Our accomplishments

- We undertake water treatment projects. TERI has successfully implemented riverbank filtration (RBF) installations along several major rivers, including the Kali, Krishna, and Tungabhadra Rivers in Karnataka and the Sal River in Goa, demonstrating feasibility of the RBF treatment approach in Southern India.
- Our RBF rural systems implemented are designed for rural communities of about 2,000 to 5,000 people. However, larger systems are also feasible.
- We provide access to RBF technology, which improves the health of villagers who switch from

consuming untreated surface water to cleaner RBF water.

- TERI along with consortium partners from India and Europe has strengthened the cooperation in education, research and innovation between Germany and India in sustainable water resources management
- We implement watershed projects that help conserve natural resources, increase crop productivity and generate alternate livelihood options thereby focusing on ecology, economy, and equity.
- The projects that we accomplished have created livelihood opportunities and helped in providing sustainable water supply scheme across various rural settings and assured the efficient use of water.
- We conduct projects on traditional ecological knowledge of local communities.
- We deal with a diverse range of issues related to socio-economic, institutional, policy, and technical aspects of India's water resources and rural development.



Aggregate numbers

Overall nine projects were executed across India, out of which seven were RBF implementation projects to provide clean and sustainable water supply for meeting drinking, domestic and irrigation needs for community particularly in south India. One pan-India project is on Indo-German Competence Centre for Riverbank Filtration where 14 partners from EU and India have collaborated to strengthen educational and research cooperation between Germany and India in the field of water management. Two projects on watershed development and one on Science Technology and Innovation hub will be implemented in the rural village of Goa. We work with a diverse range of organizations, including nodal ministries/departments, PSUs, corporates, academia and international development agencies.



Approach and innovation

We have a unique approach because a suitable water treatment technology like RBF for small-scale farmers, particularly when combined with drip irrigation and powered by solar energy provides advantages in most pronounced geographic regions with prolonged dry



periods and depleting groundwater resources. This combination of RBF and alternative power sources conserves water, increases agricultural productivity, and thus generates higher income per unit of farmland for small-scale farmers in developing countries.

Inspirational evidences

TERI successfully implemented the project 'Off the grid sensor-controlled irrigation using bank filtration technology' in collaboration with National Institute of Technology (NIT), Goa sponsored by the Department of Science and Technology, Government of India, under the umbrella of Demand Driven Mission - Water Technology Initiative. The aim of the project was to provide clean water to farmers for irrigation through RBF technology coupled with sensor-controlled irrigation system which is the first-of-its-kind in the region. We installed affordable RBF wells for the treatment of polluted water from Sal River near Navelim and Nauta Lake at Cortalim, Goa, powered by renewable energy source (solar-powered pumps) to provide clean water to farmers in off-the-grid areas. Water, with improved quality parameters such as reduced turbidity and bacterial load, supplied through systematic pipeline system helped farmers to obtain better crop produce.



Impact We Created

The projects that we worked on present a model of sustainability for educating rural local bodies and farming communities with small land holdings. For example, the implementation of RBF technology offers a cost-effective means to remove substantial quantities of contaminants, including suspended particles, and reduces microbial presence. This technology essentially improves water quality for drinking water supplies to rural communities. These communities often rely on untreated surface water sources such as rivers. Similarly, it benefits farmer communities who depend on polluted river stretches and lakes for their irrigation needs.

We collaborated with partners to implement sensor-based irrigation system controlled via Web/Mobile app, which allowed farmers to monitor the irrigation process from home. A water use efficiency model was demonstrated that prevented water loss and maintained the soil quality throughout the field. Daily wage farmers could use the time saved for watering the crops to sell their harvest in the market. Over time, this system will help farmers financially as well as reduce their labour work and help to reduce ecological loss.

Knowledge building and dissemination

TERI, in collaboration with the National Institute of Technology (NIT), Goa, and University of Rhode Island, USA has devised an irrigation system that is sensor-based and uses RBF technology for not just saving water but also providing contamination-free water to farmers in the coastal state. <https://dst.gov.in/sensor-based-irrigation-system-using-bank-filtration-saves-water-increases-farmers-income>

Details on Knowledge Building; Partnerships and Networks can be viewed via the following URLs:

- ¹ https://www.teriin.org/files/TERI_Annual_Report_Knowledge_Contributions.pdf
- ² https://www.teriin.org/files/TERI_Annual_Report_Partnerships_and_Networks.pdf





COMMUNICATION OUTREACH AND ADVOCACY



The Communication Outreach and Advocacy (COAU) Programme serves as the organization's pillar of support and the crucial link for all its outreach activities. Its primary focus is to ensure that TERI as a whole evolves to cater to multiple stakeholders that enable the establishment of resilient partnerships, effective collaborations, and long-term associations with the communities as well as across the multidisciplinary programmes within the organization.



Sustainable Development and Outreach

Sustainable Development and Outreach (SDO), through its constructivist and stakeholder engagement approach advances the cause of integrating and mainstreaming sustainable development across various sectors of the society. We drive leadership through pioneering conversations. Through our annual convening, research and engagement, we seek to advance narratives that drive global ambition and actions at all levels. We provide a platform for exchange of knowledge, ideas, and best practices to advance leadership. We contribute towards achieving Sustainable Development Goals (SDGs) and the key aspects of the Paris Agreement. By bringing together leaders and stakeholders, we encourage informed, integrated and collectively driven discussions and actions. We promote mainstreaming of sustainable development through promotion of policy approaches such as green budgeting, green public procurement, SDGs' blueprint, and climate action.

Themes and Commitments

Thematic focus

We create societal impact through outreach. Through conceptualization and supporting of policy design, stakeholder engagement and knowledge outputs, we amplify actionable messages to key stakeholders including policymakers, media, and the public. Being driven by this intent, the SDO comprises two functional domains:

- Centre for Sustainable Development Research and Leadership (CSDRL); and
- Communications and Stakeholder Engagement (CSE).

Mobilizing collective leadership is key to mainstreaming sustainable development. World Sustainable Development Summit (WSDS), the annual flagship event curated by TERI, is the only independently convened international summit on sustainable development



Statistics @WSDS 2023



and climate action based in the Global South. The Summit series aims to extend its reach through closer engagement with stakeholders to collectively act through a major initiative on policy research and dialogue — #Act4Earth. Effective communications and outreach are crucial for a research organization to make societal impact. Cutting-edge research at TERI strives to bring about change—small and big—through stakeholder engagement and uptake. Through its multiple channels, the SDO Programme works to communicate TERI's research to stakeholders including policymakers, civil society, research and academia, business and industry, and the media and public at large.

Larger goals and the context

SDO's research and engagement endeavours to cover SDGs: SDG 2, SDG 7, SDG 12, SDG 13, SDG 14, SDG 15, and SDG 17. Concerted engagement and innovation in the domains of policy research, sensitization and curation have paved the way for driving leadership at all levels.

Sustainable solutions promoted

Annual convening platform

- WSDS serves as a socialization space that facilitates the construction of discourse aimed at fostering commitments and promoting equity.
- Serves as a platform for world leaders across the board to reflect upon their experiences and further build on their own representations and incorporate

new information into their pre-existing knowledge.

- Reinforces and strengthens commitments at all levels to enhance ambition and action to create a more sustainable and equitable world for present and future generations.

SDG-linked green budgeting

- Design policy processes for integration is sustainable development in budgeting.
- Technical support for the preparation of green budget statements and tagging of SDGs, climate goals, themes, and activities.
- Stakeholder engagement and capacity building to enable design of effective processes to facilitate green budgeting in Bihar and Puducherry.

Community outreach through Kumaon Vani

- Create content that benefits the farming communities in Uttarakhand on agriculture, education, women's health, and nutrition issues.
- Local community-driven community radio station with radio jockeying, as well as editorial and technical production.
- Grassroots engagement with the community by promoting community-driven knowledge and engagement.

Our accomplishments

The projects with SDO are multidimensional which range from policy research, and mass communications-related activities wherein a variety of stakeholders



56 Heads of State and government	126 Ministers	13 Nobel Laureates	1932 Business Leaders	3023 Speakers	39,483 Delegates
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WSDS Summit Series (2001–2023)



are engaged with. The reach of the World Sustainable Development Summit Series (2001–2023) has been depicted here.

Approach and innovation

The theory of change for SDO is based on constructivism and stakeholder engagement for advancing the cause of integrating and mainstreaming sustainable development across various actors and segments of the society. From community engagement, to engaging with global leaders, SDO prides itself in being unique in its approach towards outreach.

Inspirational evidences

WSDS: The 22nd edition of the annual flagship event of TERI—the World Sustainable Development Summit (WSDS)—was held from February 22–24, 2023 at India Habitat Centre in New Delhi. The Summit deliberations focused on the umbrella theme: Mainstreaming Sustainable Development and Climate Resilience for Collective Action. Considering the global milestones of G20 in India and the Global Stocktake at COP28, the deliberations at the 2023 edition of the Summit focussed on topics such as green growth, lifestyles, energy security, climate action, SDG ambition, nature-based solutions, and G20 leadership.

After two virtual editions due to the pandemic, this was the first Summit largely held in an in-person mode with a few speakers contributing virtually and digitally. The Summit saw 1,200+ in-person delegates. 25 organizations partnered for the Summit. The Summit also saw engagement with Lifestyle for Environment (LiFE) as a special initiative. The media coverage for the Summit was 2,000+, social media reach was 1 million+ and the Summit page views were more than 85,000.



WSDS 2023 Inaugural Session, February 22, 2023



WSDS 2023 Valedictory Session, February 24, 2023



When we started WSDS, 22 years ago, a lot of our focus was on informing people about Sustainable Development, Climate Change, and Land Degradation. Today, our focus is on actions we need to take in order to address sustainable development issues.

Mr Nitin Desai, Chairman, Governing Council, TERI



Kumaon Vani: Riding the airwaves at 90.4 MHz (FM), the station covers the radius of 20 km reaching out to almost 350,000 people in and around Nainital, which is pre-dominantly an agricultural community. Among the various community-related programmes initiated and broadcast by the radio station in 2022–23, there was an 18-episode series titled ‘Swasthya Sankalp.’ This series aimed to raise awareness about COVID-19 vaccination for all eligible age groups and also covered topics related to nutrition. In addition, the community radio also produced ‘Birds of Kumaon’ which is based on the ubiquity and ecological importance of birds that are excellent indicators of the state of our natural world.

Kumaon Vani also broadcasted information on environment, education, disaster and social welfare schemes. Link: <http://bit.ly/KumaonVaniYouTube>



Kumaon Vani community radio station activities



COP27 Compass: The COP27 Compass initiative, led by TERI researchers and Act4Earth partners, has generated two significant knowledge documents. The initial document tackled crucial COP27 climate negotiations, encompassing adaptation, loss and damage, climate finance, and global stocktaking. The second document highlighted the importance of Global Commons and Climate Action, advocating for a shift in the approach to the climate-oceans interface. This shift aims to foster greater synergies, not only with the Rio Conventions but also with the United Nations Convention on the Law of the Sea (UNCLOS), in order to enhance international cooperation and environmental protection. The outreach of TERI's work was organizing events in blue zone and green zone at Sharm el-Sheikh, Egypt during COP27. Link: <https://wsds.teriin.org/2023/cop-compass.php>

SDG Charter: Under the SDG Charter, the two key domains were covered. The first centres around Sustainable Consumption and SDG 12. The objective was to contribute to the formulation of sustainable lifestyles and consumption patterns, while also exploring how this aligns with the internationalization of LiFE (Lifestyles and Future Earth). This entails an examination of diverse instruments such as policy, market, and social tools to promote sustainable lifestyles. The second domain revolved around Inclusive Energy Transitions. This involves using case studies from G20 nations' agriculture, MSMEs, and transport sectors to shed light on fostering energy transitions that are inclusive. Through these efforts, the aim was to promote cleaner and more accessible energy sources while addressing the unique needs of these sectors. Link: <https://wsds.teriin.org/2023/sdg-charter.php>

Green budgeting: TERI supported Bihar (with Asian Development Research Institute) and UT of Puducherry (with Puducherry Climate Change Cell) to design and implement the policy innovation of green budgeting. TERI played a pivotal role by offering technical support to stakeholders, building upon prior green budgeting endeavours at the state/ UT level. TERI also organized a consultative workshop in Puducherry in December 2022 along with organization of a national webinar on green budgeting where the green budgeting portal was launched as a one-stop resource on green budgeting.



Consultative Workshop to Design the Process of Green Budgeting in Puducherry, Dec. 2022



Green budgeting portal
- <https://greenbudgeting.teriin.org/index.php>

Link: <https://www.teriin.org/project/green-budgeting-puducherry>

Act4Earth: TERI launched a major initiative titled, 'Act4Earth' in the valedictory session of the 21st Edition of World Sustainable Development Summit (WSDS). Building on the discussions from the Summit, this initiative will seek to continuously engage with stakeholders across the board on issues related to sustainable development and climate action.

Link: <https://wsds.teriin.org/2023/about-act4earth.php>

Social media performance of TERI FY 2022-23

Platform	01-Apr-22	31-Mar-23	Increase
LinkedIn	57,396	73,153	15,757
Twitter	21,587	24,070	2,483
Instagram	2,350	3,291	941
Facebook	35,938	37,297	1,359
YouTube	74,689	80,482	5,793



Impact We Created

- The myriad of Summit sessions, which included 17 plenary sessions, 25 thematic tracks, 3 special events, and 18 exhibition booths and were driven by 109 plenary speakers and 184 thematic track speakers, witnessed in-depth deliberations on issues ranging from G20 leadership, climate action, sustainable lifestyles, energy security, green growth, and climate finance.
- The Summit has a mix of stakeholders with enhanced voices of women and youth. Among its peer group in India, TERI is the topmost organization in terms of social media outreach. TERI uses LinkedIn, Twitter, Instagram, Facebook, and YouTube to share impactful messages and activities. Outreach that excludes social media translates to losing out on crucial platforms that connect with a larger network of stakeholders.

Media analytics FY 2022-23

Activity	Total
Interviews	682
News Stories	2163
Op-eds	117
Press Releases	447

Events statistics FY 2022-23

Type of Events	Total
Webinar Events	46
Physical Events	92
Hybrid	38
VIP Visits	28

Films/ videos and Podcasts

Several film and videos were produced in FY 2022-23. Several webinars and events were also live-streamed on the YouTube channel - <https://www.youtube.com/teri>

Films & Videos

Film / Video	YouTube link
Promoting Science & Health Communication through Outreach and Capacity Building	https://youtu.be/MlyM4m_eA8l

Green Shoots: A teaser	https://youtu.be/GGTqzdgwAZY
Solar Flow In Mandakini: A film on battery powered boat	https://youtu.be/bj2N50_S5jA
Weaving in The Sunshine: A film on hybrid solar charging unit for power loom	https://youtu.be/2oQEHmjIMdU
Green Shoots: One change to heal the planet	https://youtu.be/YSDtK9aX1Xc
Industry Charter for Near Zero Emission Ambition by 2050	https://youtu.be/-AOtvmHe8E4
TAKE 3: Air Quality Index	https://youtu.be/ahZI7yuvYFw
TAKE 3: Extreme Weather Events	https://youtu.be/qiAQkanP89A
Green Skill Development Programme by TERI ENVIS Resource Partner	https://youtu.be/v8Kr3nNmRSg
Jhum: The shifting Landscape	https://youtu.be/8poQEz7njKY
TAKE 3: National Green Hydrogen Mission	https://youtu.be/mR1jryNVuik
TERI: The best way to predict the future is to create it	https://youtu.be/aLqznmZKFME

Podcasts - The Earth Pod

TERI engages with multiple facets of sustainable development from science and technology to policy. The Earth Pod steers conversations with experts on issues related to climate change, energy transitions, and environment-friendly growth.

Podcasts	
Podcast	Spotify link
Episode-1 — What to expect from COP27?	https://open.spotify.com/episode/1c0G796KreXnlQJ71VQumr
Episode-2 — India's G20 Presidency: What's in Store?	https://open.spotify.com/episode/4HE32CTaTaQjSq365b7OqV



Podcasts	
Episode-3 — TADOX: The Wastewater Treatment Technology	https://open.spotify.com/episode/400aMCuhxR3wTOgXHFC2MJ
Episode-4 — Shaping a Truly Multilateral World	https://open.spotify.com/episode/5gOtzKDhhQEzrZ2x1aiUUA



To deliberate on issues of climate change and sustainability, TERI through WSDS has brought together prominent leaders from the government, international organizations with academia and civil society to mainstream climate resilience for climate change. This edition of the summit becomes more important as India is holding G20 Presidency.

- Dr Vibha Dhawan, Director General, TERI



Knowledge building and dissemination

Launch of COP27 Compass and SDG Charter outputs:

As a part of the WSDS activities, outputs of the COP27 Compass and SDG Charter were launched in Sharm el-Sheikh at an official side event of the United Nations Framework Convention on Climate Change in the Blue Zone and at the COP27 Presidency event in the Green Zone. A policy brief on G20 and Lifestyle for Environment was also launched at the India Pavilion.

Act4Earth Outreach at UNFCCC side event Act4Earth Outreach at India Pavilion event

- **Inclusive Energy Transitions and Messages for the G20 Forum:** https://wsds.teriin.org/2023/assets/pdf/WSDS_SDG_7_Policy_Brief_2022_Inclusive_energy_transitions.pdf

- **Road to Sharm el-Sheikh:** Towards Equity and Climate Justice: https://wsds.teriin.org/2023/assets/pdf/Act4Earth_Policy%20Brief_Road_Sharm_el-Sheikh.pdf
- **Internationalizing Lifestyles for Environment-Messages for G20:** https://wsds.teriin.org/2023/assets/pdf/Act4Earth_PolicyBrief_Sustainable_consumption_Lifestyles.pdf
- **Oceans-Climate Interface:** Implications for Global Commons based Climate Action: https://wsds.teriin.org/2023/assets/pdf/Act4Earth_PolicyBrief_Ocean_Climate_Interface.pdf

WSDS knowledge creation and dissemination:

The Summit has a strong knowledge creation and dissemination component linked with it through outputs such as Summit Overview Document, Act4Earth Manifesto, and Daily Summit Bulletins.

- **Summit Overview Document:** https://wsds.teriin.org/2023/assets/pdf/WSDS_2023_Summit_Overview.pdf
- **WSDS Daily Bulletins:** <https://wsds.teriin.org/2023/news-pressrelease.php>
- **WSDS Special Issue of TerraGreen:** https://wsds.teriin.org/2023/terragreen_special_edition.php
- **Act4Earth Manifesto:** <https://wsds.teriin.org/2023/act4earth-manifesto.php>

Partnerships and networks

SDO Programme could successfully mobilize support from the ministries as well as multiple bilateral and multilateral agencies for WSDS, the flagship event of TERI. WSDS 2023 was supported by the Ministry of Environment, Forest and Climate Change [Nodal Ministry] in partnership with the Royal Norwegian Embassy [Country Partner], Bloomberg Philanthropies and Bill and Melinda Gates Foundation [Star Partners]; Rockefeller Foundation [Premier Partner]; German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, IKI, European Union and World Bank [Senior Partners]. Summit outreach partners: Kaizzen, Press Club of India, The Foreign Correspondents Club, Climate Trends, Outlook Group, IFAT India, POP Movement, The World Sustainable Development Forum, The Climate Group, and NRDC.

Details on Knowledge Building; Partnerships and Networks can be viewed via the following URLs:

- ¹ https://www.teriin.org/files/TERI_Annual_Report_Knowledge_Contributions.pdf
- ² https://www.teriin.org/files/TERI_Annual_Report_Partnerships_and_Networks.pdf



Environment Education and Awareness

It is conceivable that students who are educated to be active learners since childhood can evolve into an active citizenry, participating in activities aimed at achieving sustainable development. SDG 4 (Quality Education) aims at achieving inclusive and quality education for all and reaffirms the belief that education is one of the most powerful and proven vehicles for sustainable development. Environment Education and Awareness (EEA) Division conducts regular training programmes for students, teachers and youth to promote environmental sustainability and support them in value-based learning for creating environmentally responsible citizenry and self-reliance in communities through action research and locale-specific interventions.

Impact We Created



Global Rank holder, GREEN Olympiad 2021 addressing stakeholders during GREEN Olympiad Stakeholders' Meeting 2022

- GREEN Olympiad reached out to 50,000 students from across the country, also covering 78 of the total 112 aspirational districts in India. GREEN Olympiad received endorsement from the Ministry of Environment, Forest and Climate Change, Government of India; Kendriya Vidyalaya Sangathan; and SCERT, Goa. GO4Youth targeting undergraduate and postgraduate students received endorsement from All India Council for Technical Education (AICTE) and UN-SDSN South Asia and UN-SDSN Youth.

- The Green School Initiative (in association with Tata Steel Foundation), Phase V reached out to 11,169 students, 371 teachers, and 5,217 community members across 45 targeted schools in Odisha and Jharkhand. Project activities raised awareness and facilitated behavioural changes in vulnerable communities. Green libraries were established with over 60 illustrative books, promoting environmental conservation.



Leading the change: Green Skippers steer the future at World Sustainable Development Summit 2022

- Project Ocean Matters is a citizen science project where schools are engaged in sampling, testing, data collection, documentation, and researching on the health of waterbodies in



Teachers from schools of Marmugao, Goa learning about Microplastics Monitoring Protocol Trial (MMPT)



their vicinity. Teachers are trained to use the internationally accredited Global Learning and Observation to Benefit the Environment (GLOBE) protocol as well as testing the presence of microplastics using a protocol developed by an international team of scientists from Deakin University, Labter Crea and Globe Italia. Ocean Matters has trained over 200 teachers and 1,000 students along the India's west coast.

- CCPME Project (in association with GIZ): Developed Standard Operating Procedure for Cleanup Drives to be launched by the Ministry.



Turning steps into impact: Students plogging for a Cleaner Kanpur in CCPME's Campaign at Parmat Ghat

- Local Air Quality Management Programme (in association with EDF): Initiated a perception study covering socio-demographics, to assess knowledge, attitude and behavioural responses towards air quality. Schools and the general public were approached across Dewas, Indore, and Patna localities to gather opinions and insights.



Unveiling Monuments' tales through air quality perception at Gol Ghar, Patna

- Youth Climate Conclave (YCC) was held in February 2023, with support from EU. More than 100 youth were trained on the science of climate change and the Youth Pledge was presented at the World Sustainable Development Summit 2023.



Youth Climate Conclave 4th Edition

Few Flagship Events

- Special interaction with youth was organized to guide them on a path of learning about climate change, resulting in a paradigm shift in their behaviour. An in-person session, on 'Youth for a Greener Future' was organized in honour of a visit of HE Ursula Von der Leyen, President of the European Commission, in April 2022.



Visit of HE Ursula Von der Leyen, President of the European Commission in April 2022

- Youth Climate Conclave was selected as one of the 70 projects which were showcased in the fifth edition of the Paris Peace Forum in Paris, 2022.
- Two official photo exhibitions were organized as part of Youth Climate Conclave at the Italian Cultural Centre, Delhi in February 2023 followed by Museo Camera, Gurgaon in March 2023 showcasing the winning photos of the competition organized as part of the project.





Youth Climate Conclave Exhibition held at Italian Embassy, Delhi

- Signed a Memorandum of Understanding (MoU) with Tata Power Delhi Distribution Limited (Tata Power-DDL), a pioneering power utility supplying electricity to a populace of over 7 million in North Delhi to promote the core strengths of both entities for effective utilization of energy and green energy efficiency.



Signed a Memorandum of Understanding (MoU) with Tata Power-DDL

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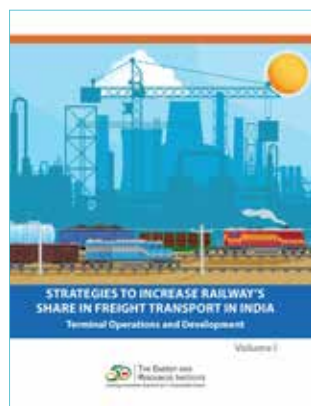
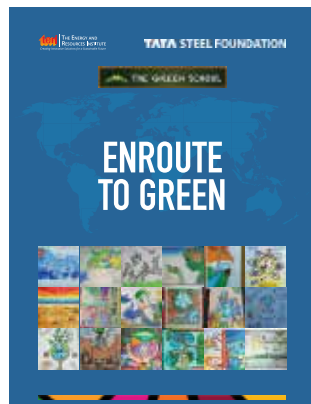
² https://www.teriin.org/files/TERI_Annual_Report_Partnerships_and_Networks.pdf



TERI Publications

TERI Publications division, the publishing arm of TERI, is one of India's prominent publishers in the areas of environment, energy, and sustainable development. The Publications division publishes books, journals, and magazines on these topics at all levels.

TERI Publications, in its endeavour to bring greater ecological awareness, has an extensive range of print publications; widely accessible e-books; and sophisticated, interactive e-learning products that cater to every type of reader and knowledge requirement on diverse areas of the environment.



We work with academics across the globe to produce quality content and materials and contribute significantly towards enhancing learning outcomes of the students.

Our Accomplishments

Number and nature of projects

With close to 400 published titles over the years, TERI Press has been a valuable source for filling the learning gap on environment and sustainability.

We also provide support and assistance to all programmes for their various publication needs on a wide range of projects.

TERI Publications division also conceptualizes customized knowledge resources, based on the needs and assessments of the target group. This includes undertaking environment-related projects to encourage an active social connect with the environment.

With every carefully chosen and published title, quality has been the single major idea that drives TERI publications.

TERI Publications books and learning resources create a lasting impression and aim to make a positive difference. During 2022/23, while the world continued its path of Covid-19 recovery, TERI Publications division continued disseminating relevant content to its readers via both analogue and digital platforms.

TerraGreen

TERI's flagship digital magazine that deals with issues related to sustainable development, environment, and energy.

Energy Future

It aims to educate and inform you about the wide world of energy: its history, its future, how the energy industry works, how it has affected the world and how it continues to affect you and me.



World Digital Libraries (WDL)

WDL is an international peer-reviewed biannual journal, that seeks quality research papers that present original theoretical approaches.

Electronic Newsletter on Renewable Energy and Environment (eNREE)

Beneficial for policymakers, researchers, consultants, academicians, and students engaged in the area of renewable energy and environment.

Journal of Resources, Energy, and Development (JREaD)

It provides a forum for comprehensive investigation, analysis, and review of subjects in the fields of energy, environment, and natural resource management that confront decision-makers, planners, consultants, politicians, and researchers.

TERI Energy & Environment Data Diary and Yearbook (TEDDY)

It is the only comprehensive energy and environment yearbook in India that provides updated information on the energy supply sectors (coal and lignite, petroleum and natural gas, power, and renewable energy sources), energy demand sectors (agriculture, industry, transport, household, buildings), and environment (local and global).



TERI COUNCIL FOR BUSINESS SUSTAINABILITY



The Council for Business Sustainability at TERI undertakes policy advocacy through thought leadership reports and industry dialogues; and builds capacity through trainings, learning visits, webinars, conferences, etc.



TERI Council for Business Sustainability (CBS)

TERI Council for Business Sustainability (CBS) serves as the interface for TERI's research work to be connected to the corporate world. The Council is a network of Indian business leaders working on a shared commitment to mainstream sustainability in business strategies and practices. Set up in 2001, the Council recognizes and promotes sustainability leadership practices. Member companies of the Council include public and private sector, including MNCs – representing various industry sectors, sizes, and geographies. Activities of the Council are governed by an Executive Committee from amongst member companies.

Themes and Commitments

Thematic focus

TERI CBS engages with the core issue of what businesses must do to shape and lead in sustainability. The Council co-creates business solutions with member companies to address national sustainability challenges; curates common interest forums of member companies with the participation of board members and Chief Sustainability Officers; undertakes policy advocacy through Thought Leadership reports and industry dialogues; and builds capacity through trainings, learning visits, webinars, conferences, etc. With individual member companies, the Council provides a range of tailor-made advisory services. These comprise sustainability strategy development, performance assessment and improvements, capacity building and facilitates showcasing best practices in national and international forums.

The year 2022–23 witnessed that both governments and businesses have increased their ambition to meet the goals of the Paris Agreement, as well as wider net zero and Sustainable Development Goals. Of the NDCs (Nationally Determined Contributions) covering 193



► JNPA Sustainability Report Release in May 2022

parties to the Paris Agreement, 24 have communicated new or updated NDCs since COP26. Businesses are increasingly ambitious too with more than 4,000 companies committed to science-based targets, and more than 2,000 of those have approved targets. We indeed are thankful to the support from all our partners and the companies in the Council's network, who helped build a system that provides policymakers with reliable, relevant and real-world evidence from businesses to support the translation of NDCs and sustainability goals into effective policies and regulations.

During the year 2022–23, we witnessed enthused participation of our national and global partners as well as diverse government stakeholders at the state and central levels, alongside global partners. The regular engagements with the businesses and member





companies of our Council ranged from diverse webinar sessions, sustainability assessments and in-person workshops and high-level convenings at major global events.

Larger goals and the context

The industrialization of the Indian economy has been responsible for a significant proportion of economic growth since 1947, with strong industrial policy being cited as a key driver for alleviating poverty. The heavy industries, namely iron & steel, cement (and concrete), petrochemicals, aluminium, fertilizers, and bricks shall be providing the materials to support a modern economy. If India is to remain globally competitive and achieve sustainable growth, within the constraints of the environment, future industrial strategy should prioritize greater resource efficiency in the heavy industry sectors. Beyond energy efficiency, these sectors should also consider the adoption of new technologies to further reduce emissions in order to keep temperatures within the limits agreed under the Paris Agreement. Based on research at a global level, it seems technically possible to reduce emissions from these sectors to near zero levels, although many of the technologies require further development to reach commercial scale. There are several promising technology solutions which could support deeper decarbonization of the HTA sectors, beyond that of improving energy efficiency or reducing demand.

TERI as the Indian partner of the Leadership Group for Industry Transitions (LeadIT) was well recognized.

A unique public-private partnership led by India and Sweden—LeadIT convened the need for sectoral roadmapping in the India steel and cement sector. Through the global partnership with LeadIT, TERI convened a high-level dialogue on the sidelines of Stockholm +50 conference. Industrial site visit for Indian government representatives from the Ministry of Environment, Forest and Climate Change, the Ministry of Steel and the Department for Promotion of Industry and Internal Trade, the Ministry of Commerce and Industry were undertaken to state-of-the-art industrial sites in Europe.

The voluntary actions undertaken by the signatory companies of the Industry Charter for Near-Zero Emissions Ambition by 2050, instituted by TERI were recognized across varied international fora. This Charter emerged as an important step from Indian industry to voluntarily commit themselves to decarbonization measures and to work together in key thematic areas that can make a 'zero carbon' future, a reality for India. The existing Charter Signatories unanimously expressed their intent to make their companies exemplars of low or zero carbon technology solutions within their sectors, and gradually bring more heavy industry sectors into the fold of the Charter. During the year, the Division garnered support from 52 Indian CEOs for the Industry Charter for Near Zero Emissions by 2050 along with engagements with businesses and policymakers on raising climate ambition.

The potential for significant and sophisticated policy advocacy is strong, and TERI's partnership with the We



Mean Business Coalition offered the resources needed to super-charge these efforts. The foundational goal of this partnership was to accelerate the ambition loop in India and contribute to India strengthening its NDCs, putting forward an ambitious long-term strategy, and strengthening domestic policies in key sectors to accelerate emissions reductions. During 2022–23, ‘policy hotspots’ were identified, where existing policies are already helping companies decarbonize faster and what new policies or policy changes are needed. Through continuous engagements with businesses and policymakers, it is established that businesses are crucial partners in implementing NDCs and lending predictability to India’s long-term strategy and policymaking. During the year, through continuous interventions with leadership team of businesses and policymakers, TERI has showcased that strong leadership of businesses is crucial to strengthen the ambition loop. These interventions motivated Indian businesses to come forward and commit to climate action. At the United Nations annual climate conference COP27 at Sharm el-Sheikh, Indian business leaders echoed these recommendations which further aided in building a positive impact to accelerate voluntary actions on emission reduction targets.



► COP27 Showcasing Business Ambition, Action & Accountability

By means of various policy products such as ‘Think Pieces’, ‘Policy Briefs’ and ‘Discussion Papers’, TERI provides high quality multidisciplinary insights on SDGs towards strengthening its engagement with stakeholders in the government and business sectors to promote integrated thinking on sectoral and multi-sectoral national policies in the context of the SDGs. Through its ongoing partnership with the National Foundation for Corporate Governance (NFCG), Ministry of Corporate Affairs, Government of India, TERI aims to augment and accelerate business action on SDGs in

India. During the year, the CBS Division completed the research study on “Enhancing the role of businesses towards achieving the SDGs in India” as part of grant by the NFCG. The report underscores the need and relevance of SDGs to enhance and accelerate business action on sustainability in today’s time. The report highlighted the need to apply the SDG lens while evaluating business strategy and actions; illustrated how the SDGs can be used by businesses to design focused sustainability actions; and demonstrated the results that may be achieved when companies embrace and fully integrate the SDGs into their business strategy and actions.

Our convenings with CEOs and CFOs at TERI’s annual World Sustainable Development Summit 2023 revealed the urgency of actions on sustainable development. The discussions pointed out that it is time now that we exhibit our intentions through putting together the business plans, investment plans and design lighthouse projects that articulates a narrative on how the future India would be.

Our accomplishments

- The engagements with industry representatives from steel and cement sectors have increased on building a narrative on importance of technological innovation and low carbon industry transition with steel sector representing 45% of market share and cement sector representing more than 42% of market share. Through a series of consultations held with representatives of Indian heavy industries, a set of recommendations on financing the industry transitions was published.
- Industry charter on commitment to Near Zero Emissions Ambition by 2050 was launched during New York Climate Week of 2020 with 6 signatory CEOs which increased to 52 CEOs on-board as of March 2023.
- The inaugural edition of the India Sustainability Lounge at the 2023 annual meeting of the World Economic Forum in Davos featured two high-level side events. These side events, jointly organized with Invest India and Ministry of Commerce & Industry, showcased TERI’s work on energy transitions, industrial decarbonization initiatives and sustainable lifestyles. Initiatives of Council member companies and global partners were showcased at the global platform.
- Voluntary actions on climate change by the signatory companies of the Industry Charter were showcased at a High Level Convening at the annual meeting of the Clean Energy Ministerial in Pittsburgh, USA.





► CEM Side Event_Pittsburgh

- The Hon'ble Minister for Ports, Shipping and Waterways, Shri Sarbananda Sonowal along with Chairman & Managing Director and Deputy Chairman of Jawaharlal Nehru Port Authority launched the Sustainability Report. This Report developed by TERI marks the first Sustainability Report by India's major ports.



► World Economic Forum Fireside Chat in January 2023

Inspirational evidences

- To act as a catalyst to accelerate RE deployment within the Commercial and Industrial (C&I) sector, which would facilitate India Inc.'s transition to RE in alignment with the national climate commitments a set of indices were developed. PRAMAAN (Portal for Renewable Energy Action Assessment Metrics) rating lays emphasis on clean energy transition for organizations to reduce their power procurement

costs, adhere to legislation, and increase sustainability.

- PRAMAAN provides a set of indicators for an organization to assess its progress in moving towards a low-carbon future and can be used as a framework to prioritize electricity options, assess risks, identify opportunities, set targets, and develop a sustainable energy roadmap. All commercial and industrial entities including medium, small and micro enterprises (MSMEs), large corporates interested in knowing their RE transition progress and readiness can participate in the PRAMAAN rating. Organizations will be evaluated on two broad parameters: 1) RE progress headway; and 2) RE transition readiness, and six sub-parameters.
- Pilot-testing of the PRAMAAN methodology was conducted with 22 Indian C&I sector organizations. The methodology is expected to be finalized by incorporating the results of these tests, along with feedback from Indian industries.

Knowledge building and dissemination

- Ten high-level interventions strengthening engagement between leading businesses and policymakers on corporate action on climate change.
- Two policy briefing documents published on the role of corporates in enhancing NDC ambition.
- Strong India business presence at global platforms, i.e., Stockholm +50 in Sweden, COP27 in Sharm



el-Sheik, Clean Energy Ministerial meeting in Pittsburgh, USA and World Economic Forum in Davos, Switzerland.

- Seven relevant central/state-level departments engaged for advocacy on corporate RE procurement framework.
- Two policy briefing documents citing growing business momentum and illustrating the business case for Industry Transitions in India published.



► Capgemini MoU Signing & Paper Release during WSDS 2023



SUPPORT UNITS AND INFRASTRUCTURE FACILITIES



Support Units aid TERI to continue its work on climate resilience, renewable energy technologies, participatory forest management, and knowledge generation. They ensure smooth and timely management of work throughout TERI and help it emerge as a premier think tank. TERI's infrastructure facilities are instrumental in facilitating its research work. Equipped with the best and latest advancements, these facilities help the programmes in making their various initiatives a success.



Information Technology and Services

TERI Information Technology and Services Division is in charge of giving other divisions cutting-edge IT infrastructure, communication platforms, and smart applications for their efficient operations. The Division is also responsible for creating specialized applications and platforms for researchers. The IT Division has introduced unified communication tools and strengthened communication networks. This has made it possible for TERI's offices and centres to collaborate via instant messaging, web conferencing, and videoconferencing. It has also made it possible for mobile researchers to stay connected and operate remotely. The main goal is to give everyone secure access to IT applications and services from any location, at any time, and on any device. Additionally, it aims to make IT services adaptable enough to alter in accordance with business requirements and needs.

The IT infrastructure team is transitioning towards cloud-based architecture in order to stay current with IT standards. To guarantee the highest possible uptime for our websites and other services, the majority of our websites/applications are hosted in a cloud environment.

With more than 70 network switches, seven firewalls, and 40+ Wi-Fi access points, TERI's centres are connected to one another without interruption and the network security is ensured by Sophos XG series Firewall.

Our accomplishments

The following is the list of important projects that the IT Division undertook during 2022-23:

- **WSDS 2023**
Link: <https://wsds.teriin.org/2023/>
 - **GEF Small Grants Programme (SGP)**
Link: <https://sgp-india.org/>
 - **Just Transition website**
Link: <https://justtransition.in/>
 - **Youth Climate Conclave 2023 (YCC)**
Link: https://wsds.teriin.org/2023/ycc_v4/youth-climate-conclave-4.php
 - **Green Olympiad Online Examination**
Link: <https://www.teriin.org/olympiad/>
- **Green budgeting' or 'Environmental budgeting**
Link: <https://greenbudgeting.teriin.org/>
 - **IKI India**
Link: <http://www.iki-india.com/>



Knowledge Resource Centre

Knowledge Resource Centre (KRC) has been at the forefront of knowledge creation and dissemination. We are engaged in establishing knowledge management system, developing value-added services, imparting skill development programmes on sustainability issues across India.

Thematic focus

Library and Knowledge Management

KRC caters to the knowledge needs of TERI researchers and other stakeholders from government, corporate, bi/multilaterals and academic organizations by disseminating innovative knowledge-based products and services using ICT tools. Knowledge services are provided using physical and e-resources. Besides providing research assistance, the KRC professionals are also engaged in multi-stakeholder research projects, data analysis, developing international and national-level networking, conducting capacity-building programmes for researchers, web content and database development, bringing out peer-reviewed publications and knowledge products. KRC also maintains a state-of-the-art knowledge management system as a research support tool, which captures and disseminates TERI's vast knowledge and research data.

Specialized Information Centres

KRC has set up several specialized information centres for knowledge dissemination on sustainability areas on transport, renewable energy and climate change, and sustainable development. These centres create knowledge products, maintain websites and repositories, and provide online knowledge services to stakeholders.

Knowledge Sharing and Collaboration

During 2022–23, KRC executed several knowledge-based activities that include development of Digital Repository of S&T publications <[\[nstmis-dst.org\]\(http://nstmis-dst.org\)> and Digital Library on Green Mobility \(DLGM\) <<https://greenmobility-library.org>> under the India component of NDC Transport Initiative for Asia project, supported by GIZ India. Under DLGM, a webinar on 'Sustainability Assessment of Electric Vehicles: Opportunities and Challenges' was held on September 2, 2022.](http://digitalrepository-</p></div><div data-bbox=)

KRC hosts the EIACP (Environmental Information, Awareness, Capacity Building and Livelihood) Resource Partner on Renewable Energy and Climate Change <<http://terienvs.nic.in>> supported by the Ministry of Environment, Forest and Climate Change, Government of India, which works relentlessly towards knowledge creation and dissemination for education, awareness and inputs to policymaking.

Preservation and Protection of Traditional Knowledge—Documentation initiative in the North-East Region, India

It is a collaborative project implemented by Bio-Resources Development Centre, and TERI sponsored by the North-Eastern Council, Ministry of Development of North-Eastern Region, Government of India. The project aims to identify, document, preserve, safeguard and promote forms of Traditional Knowledge (TK) that existed and are still practised at the community level. The Meghalaya Traditional Knowledge Portal <<http://netkp.org/>> is a repository of the knowledge resources that were obtained and captured out of the current study.

With support from the Ministry of Development of North Eastern Region, Government of India, KRC in collaboration with TERI North-East Centre carried out Study of Studies to assess impact of research projects on different sectors in North-East region.

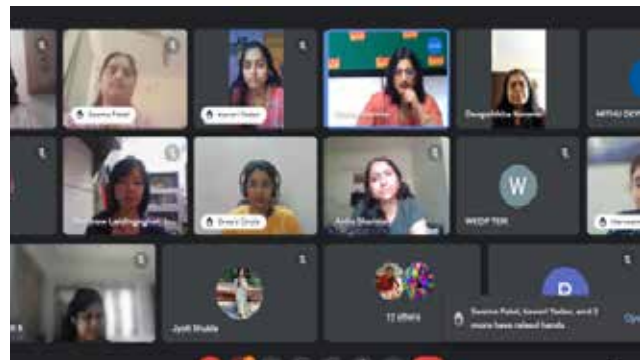
Training and Skill Development

TERI, with support from NABARD and I-STEM, conducted specialized skill development training programme on



Skill Development Training for Unemployed Youth of Lucknow Region, Uttar Pradesh on solar energy and its technologies with reference to agriculture for rural youth of Lucknow, Uttar Pradesh. TERI provided classroom-based training programmes (comprising of 40% theory and 60% practical) at the designated site for 32 trainees. The training programme included site visits and handholding to provide practical understanding of the functioning and maintenance of solar power plants, solar pump, solar dryers, solar cold storage, solar lighting-cooking, and other solar systems.

Women Entrepreneurship Development Programme (WEDP) was organized under the aegis of NSTEDB, Department of Science & Technology, Government of India. WEDPs aim at training the S&T graduates and diploma holders in the essentials of conceiving, planning, initiating, and launching an economic activity or an enterprise successfully.



Knowledge building and dissemination

We have been at the forefront of knowledge creation through acquisition, organization, dissemination of knowledge resources and providing value-added services on energy and environmental topics.

Partnerships and networks

- Most of the funding and support have been received from the government sector comprising the Ministry of Environment, Forest and Climate Change; the Department of Science and Technology; and the Ministry of Development of North Eastern Region, Government of India.
- Partnership with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH has resulted in the development of Digital Library on Green Mobility.
- Partnership developed with multiple academic institutions and NGOs resulted in successful conduction of skill development programmes in different Indian states.

Impact We Created

- Online knowledge platforms and contents developed by us have been used by over 9500 diverse stakeholders for carrying out research, decision making, and developing collaborations with others.
- Thirty-five women students were trained online to develop entrepreneurship aptitude. Out of these, two have already started own start-ups
- Over 32 students have been trained under Skill Development Training for Unemployed Youth and 100% of them are engaged in industries in various capacities or initiated their own business.



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Project Management Unit

The Project Management Unit (PMU) is the institute's central hub for all project activities. At any given time, more than 300 projects, ranging from research to implementation, would be underway. The objective of PMU is to efficiently manage the projects—from their inception through to their conclusion. The PMU's key responsibilities include:

- Identifying funding opportunities and areas of dissemination and coordination
- Facilitation for the preparation and submission of bids
- Team and relationship management, including the ongoing communication of duties and responsibilities within the project teams
- Ensuring a timely delivery of all contractual obligations—interim, mid-term, and project completion reporting
- Contract administration and budget control
- Quality control
- Facilitating effective utilization of resources
- Generation of MIS reports
- Maintenance of knowledge repository

TERI's PMU uses sound project management techniques and customized software tools to facilitate deliverables on time and within strict quality guidelines, thereby ensuring that the desired outcomes of the projects are met. It also ensures that all the projects are well documented and catalogued in TERI's knowledge repository.



Human Resources Division

The Human Resources (HR) Division aims to engage the workforce to ensure a growth enabling, progressive working environment, which facilitates the realization of the vision and mission of TERI. The Human Resources Division has been instrumental in facilitating learning and development initiatives for staff to keep them in sync with the changing business environment and plays a crucial role in promoting and maintaining a positive and productive work environment at TERI.

The Division's primary objectives are as follows:

- 1. Fostering engagement:** The Division focuses on actively engaging the colleagues, ensuring colleagues are motivated, satisfied, and committed to the TERI's goals and values with the aim to implement various programmes and initiatives to enhance morale and well-being.
- 2. Growth enablement:** The HR Division works towards creating an environment that fosters growth and development. This involves talent management, performance evaluations, career planning, and opportunities for skill enhancement.
- 3. Progressive working environment:** The HR Division strives to maintain a forward-thinking and innovative workplace. With the aim to implement policies and practices that encourage creativity, collaboration, and adaptability, HR department is able to establish progressive culture.
- 4. Realization of vision and mission:** The Division aligns HR practices with TERI's vision and mission, ensuring that employees are working towards the TERI's overarching goals and objectives.
- 5. Learning and development:** The HR Division is responsible for designing and implementing learning and development initiatives. These programmes help employees acquire new skills and stay updated with industry trends and best practices. HR Department aims to establish 'Total People Development Plan'.

Our Human Resources department plays a pivotal role in providing internship opportunities to top graduates from leading institutes in the country. These interns work closely with researchers on various projects, ensuring that TERI has access to the best talent available.

Furthermore, we are strong proponents of a work-education culture. Through our employee-friendly policies, we create a conducive environment for researchers to pursue PhD programmes at renowned global universities, thus helping them realize their full potential.

Diversity and cultural sensitivity are highly valued within TERI's ecosystem, as they are essential for establishing and maintaining a respectful and engaging workplace environment. We take pride in specializing in providing cross-divisional work and career opportunities, enabling professionals to contribute their expertise in areas beyond their primary research, thereby enhancing our interdisciplinary capabilities and contributions to a sustainable world.

TERI places a strong emphasis on its employees' well-being. We provide wellness programs that include training and guidance to motivate and enable our employees to lead healthy lifestyles, ultimately enhancing their work productivity. Our commitment to transparency and employee engagement is reflected in the work culture fostered by TERI's Administrative Services.

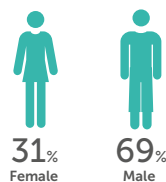
Human Capital and Infrastructure Facilities

The Administrative Services Division also looks after The RETREAT (Resource Efficient TERI RETREAT for Environmental Awareness and Training). The RETREAT Centre is a training and conference facility at TERI Gram. It provides organizations an opportunity to use its

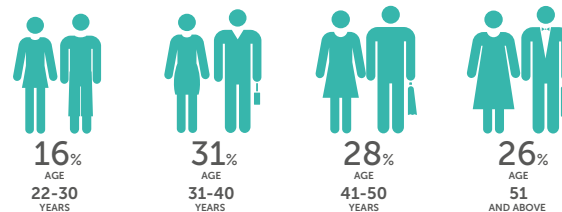


facilities for holding training programmes, workshops, and conferences with an objective of linking the process of corporate growth and training with the expression of corporate responsibility towards protecting the environment. The facility provides a unique experience of doing things in an unconventional yet viable way. TERI's growing reach and visibility make it an integral part of the itineraries of many international dignitaries and delegates, including heads of governments. The professional coordination and conduct of all such visits continues to receive appreciation from the heads of missions in New Delhi.

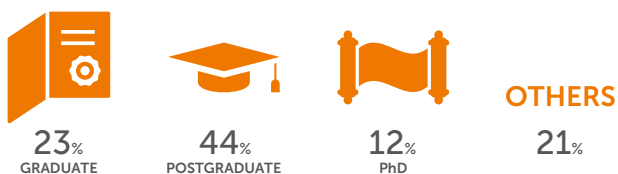
GENDER



AGE DISTRIBUTION



QUALIFICATION



SPECIALIZATION



Administrative Services

TERI's Administrative Services primarily focus on streamlining activities related to the extensive research conducted by TERI. In essence, our core mission is to reinforce research endeavours. We achieve this by offering administrative and maintenance support services across multiple locations, including TERI Headquarters at India Habitat Centre, regional centres in Bengaluru, Goa, Guwahati, and Mumbai, as well as the campuses at TERI Gram in Gurugram and TERI Himalayan Centre in Mukteshwar, Uttarakhand.

Our responsibilities also extend to managing, maintaining, and operating amenities and utilities in alignment with international standards and norms. Notable examples include our Quality Management System (QMS) certified to ISO 9001:2015 standards,

Health and Safety Management System in compliance with ISO 45001:2018, and Environmental Management System adhering to ISO 14001:2015.

One of our core responsibilities is the management of the RETREAT (Resources Efficient TERI RETREAT for Environmental Awareness and Training) located at TERI Gram. This unique facility offers a sustainable and unconventional approach to training and conferences, reflecting TERI's commitment to environmental awareness and practical sustainability.

As TERI's reach and visibility continue to expand, we have become an integral part of the itineraries of many international dignitaries and delegates, including Heads of Governments. This underscores our growing influence and impact on the global stage.



Infrastructural Facilities

TERI requires state-of-the-art, modern, and vital infrastructure facilities, which are instrumental in facilitating research and development on a large scale. TERI has developed a host of infrastructure facilities, across the length and breadth of the country, which continued to propel the Institute through a tough time during the Covid-19 pandemic and steered us towards greater success in the year 2021/22.

CMCC Germplasm Bank

The Centre for Mycorrhizal Culture Collection is stepping into its second-generation level with an objective of supplying well-characterized mycorrhizal cultures to researchers and industry. The Bank has three temperature-controlled greenhouses at Gual Pahari which house 2,800 isolates of Arbuscular Mycorrhizal Fungi (AMF) and 285 cultures of Ectomycorrhizal Fungi (EMF) collected from different soil types from India and around the globe. Our molecular biology and biochemical labs are equipped with avant-garde equipment which aid in characterizing each isolate and help in generating an information database which is available on the CMCC website (<http://mycorrhizae.org.in/CMCC>).

Solar Smart mini-grid facility

TERI has established solar hybrid smart mini-grid at its Gual Pahari campus. The mini-grid has inhouse developed controller for load scheduling and load & grid management including prioritizing of solar PV utilisation.

Mass production technology

In vitro mass production technology produces viable, healthy, genetically pure, and high-quality mycorrhizal propagules without any pathogenic contamination in a sterile environment.

DNA Fingerprinting and Molecular Breeding Lab

The DNA fingerprinting facility is a state-of-the art laboratory for varietal identification, mapping of genetic diversity, and marker assisted breeding. The facility harbours a LICOR 4300 DNA analyser and other molecular biology-related equipment. The facility is being used for providing DNA fingerprinting services to state horticulture departments and genotyping services to plant breeders for their breeding programmes.

Plant Genetic Transformation and Functional Genomics Laboratory

This laboratory has all the basic equipment such as Real Time-PCR, gel electrophoresis systems, and plant culture room. It works on developing genetically modified plants for better quality and productivity under changing environments.

Micropropagation Technology Park

Complete with infrastructural facilities ranging from modern laboratories and greenhouses to nurseries that are required for mass production of tissue-cultured plants, the facility has an annual production capacity of over two million plants.

Herbal Garden at Supi

The herbal garden is home to more than 60 different varieties of fresh and dry exotic vegetables, fruits, and herbs such as Broccoli, Pockchoy, Kiwi, Plum, Parsley, Rosemary, Thyme, Oregano, and Peppermint.



TERI-Deakin Nanobiotechnology Research Centre

The Centre bridges the gap between industry and academia through research and collaboration of leading international experts to generate effective solutions for a sustainable future. This Centre is working towards a greener and more advanced use of nanotechnology for resolving challenges in agriculture, biofuel production, and biomedical issues through nanoparticles, nanobiosensors, nanocarrier-formulations, nanodelivery of agrochemicals, and seed coating formulations (details available at: <http://tdnbc.teriin.org>).

Fermentation Technology and Research Centre

The Centre is a state-of-the-art fermentation with a pilot-scale platform to carry out studies. It has a series of fermenters of working volume ranging from 3.5 litres to 13,000 litres. Apart from mass-scale production of indigenously developed oil degrading bacterial cultures, the facility has capacity to carry out research on anaerobic fermentation processes in pilot and large industrial scale.

Microbial Biotechnology Laboratory

The Laboratory is an experimentation facility for the exploration of microbial diversity to provide biotechnological solutions in the field of environmental protection and sustainability, especially in the sector of oil and gas. The facility has state-of-the-art set ups for petrochemicals, petroleum microbiology, petroleum hydrocarbons, and molecular biology. with automated facility and real-time PCR systems. Infrastructure for both aerobic and anaerobic microbiology facility is also available. The laboratory is supported by analytical facility that is equipped with Gas Chromatography, High Performance Liquid Chromatography, Gas Chromatography-Mass Spectrometry, GC-headspace systems with other requisite instrumentations.

Supercomputer to enhance climate modelling capabilities

TERI has a well-equipped climate modelling infrastructure, which consists of a supercomputer with a peak performance of 12TeraFLOPs - to carry out the climate simulations at various spatial and temporal scales with varying global and regional horizontal resolutions. High-end servers are also present for running impact models at ultra-high resolutions. TERI's research in climate science and associated modelling

spans a whole range of activities beginning with the understanding of the climate system through the use of state-of-art modelling tools like Global Climate Models viz. CCSM, CESM and NorESM; Regional Climate Models viz. PRECIS, WRF and COAWST and impact models viz. ADCIRC (for storm surges and coastal inundation), MIKE-11 (for inland flooding), SWAT (for water resources), DSSAT (for agriculture), and DIVA (for coastal zones).

TERI Water Laboratory

Recognized and certified under the Environment (Protection) Act of 1986 by the Ministry of Environment and Forest (now, Ministry of Environment, Forest and Climate Change), Government of India, the laboratory is equipped with field sampling, monitoring equipment, and analytical instruments. The laboratory provides multi-disciplinary water quality and quantity monitoring, testing, and related services.

TRISHA

TERI's Himalayan Centre at Latey Bunga exemplifies 'ideal' green environment. It is a symbol of optimum use of natural resources such as solar and other forms of renewable energy.



► Himalayan Centre at Latey Bunga

TERI's research facility in Bengaluru

The TERI Southern Regional Centre building is a judicious blend of technology and tradition that promotes energy efficiency and sustainable development. The centre has a state-of-the-art environmental laboratory at Bengaluru office, which includes:

- Sophisticated instrumentation, such as atomic force microscopy and FTIR spectroscopy;



- Polymer-processing equipment such as Dynisco table top twin-screw extruder, Microwave reactor, Brabender plastic order, and compression moulding;
- Testing instruments such as Extensometer, EMI shielding analyzer, Delta mode systems, and Specific gravity tester.

Knowledge Resource Centre

TERI library houses a wide array of resources on energy, environment, and sustainable development—from books, journals, and papers to the world’s leading academic databases. A book digitization scanner — Bookeye 4 — is installed in the Library and Information Centre.

TERI Gram

TERI Gram is located on the outskirts of Delhi. It is a sustainable habitat consisting of residential as well as conference facilities, powered by a specially designed renewable energy system to meet its energy requirements.

Test Bed Facility, Gual Pahari

TERI and Somfy India Private Limited had partnered to set up a Test Bed Facility at Gual Pahari in the year 2015/16. The main objective of setting up this facility is to derive the benefits of Somfy Roller Blinds in test building.

TADOX® Wastewater Treatment Plant

TERI Advanced Oxidation Technology (TADOX) for the treatment of industrial and municipal wastewater is currently being demonstrated at TRL-7 with a wastewater treatment plant of 10 KLD (10,000 L per day) capacity. The USP of this technology is that it can treat in few hours and bypass any kind of biological treatment and directly utilizes Advanced Oxidation Nanotechnology for the treatment of sewage and mixed effluents from the campus.

Mahindra Centre for Excellence

A joint research initiative of Mahindra Lifespace Developers Limited (MLDL) and TERI, the vision of the Mahindra-TERI Centre of Excellence (MTCoE) for Sustainable Habitats is to foster sustainability by developing innovative and resource-efficient solutions tailored to the Indian building sector and climate.

The CoE, inaugurated as a SVAGRIHA 5-star rated facility, has received accreditation from National Accreditation Board for Testing and Calibration



► MTCoE Lab

Laboratories (NABL) for testing the thermal properties of building materials. It is equipped with a one-of-its-kind ‘Guarded Hot Box’, that was fabricated under the close guidance of TERI researchers. The facility has a ‘Sky Scanner’ installed to monitor the sky conditions of Gurugram city. The findings of the study would throw light on the impacts of climate change and provide a fresh perspective on the way we design buildings today. The water sustainability city-level assessment, building-level water audits, and a web-based tool are likely to generate awareness among relevant stakeholders, mitigate potential risks, and ensure efficient water management at micro and macro levels. A web-based EcoNiwas Samhita Design aider tool has been developed to ease the implementation of the residential building code at the design level. To know more about the CoE, please visit the website Mahindra-TERI Centre of Excellence (mahindratericoe.com).

TERI Food Testing Laboratory at NERC

The Food Testing Laboratory partially funded by the Ministry of Food Processing Industries (MoFPI) has been developed for testing of packaged water, food, and beverages for determining chemical, microbial and elemental parameters. The Laboratory has been accredited as NABL testing lab for testing of Packaged Drinking Water (As per IS: 14543) for some chemical parameters from 1st June 2022. Apart from the scopes for ensuring food safety, in due course of time nutritional profiling and GMO testing will also be included in the scope of services of this lab.

Nano Production Technology

The National Centre of Excellence for Advanced Research in Agricultural Nanotechnology is the first-of-its-kind research platform in India, which endeavours





- ▶ *Field evaluation of TERI Nano Urea formulation following drone-based supplemental spray on the paddy crop at Davangere, Karnataka, during Kharif 2022. This resulted in enhanced yield of up to 17.1%.*

to carry out end-to-end research to innovate green nanoproducts including nano-fertilizer, nano-pesticide and nanocarrier products and technologies. Safe and efficacious nanoproducts will be developed by the Centre in order to meet the global food demand along with protecting environment and human health.

Centre of Excellence in Agriculture and Environment

We make significant contributions to the development of the research and scholarly capabilities of the future generation in partnership with TERI SAS in India and Deakin University in Australia.



Foliar spray with TERI Nano Urea

Farmer's Practice, 100% Urea

- ▶ *Evaluation of TERI Nano urea product under drone application in Chilli*



FINANCIAL SUMMARY 2022/23

INFLOWS (₹ in Lakh)



97.38%
₹17942.95
INCOME FROM
PROJECTS



1.53%
₹281.19
INCOME FROM
INVESTMENTS



0.53%
₹96.86
SALE OF
PUBLICATIONS



0.56%
₹104.58
INCOME FROM
OTHERS

TOTAL **100%** (₹ 18425.58)

OUTFLOWS (₹ in Lakh)



42.99%
₹5953.33
SALARIES



1.06%
₹147.36
EQUIPMENT



47.81%
₹6621.27
RESEARCH
MATERIAL, TRAVEL



5.42%
₹749.14
RENTAL, UTILITIES,
INFRASTRUCTURE
AND MAINTENANCE



2.72%
₹376.91
ADMINISTRATIVE
EXPENSES

TOTAL **100%** (₹ 13848.01)





**THE ENERGY AND
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Creating Innovative Solutions for a Sustainable Future

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