



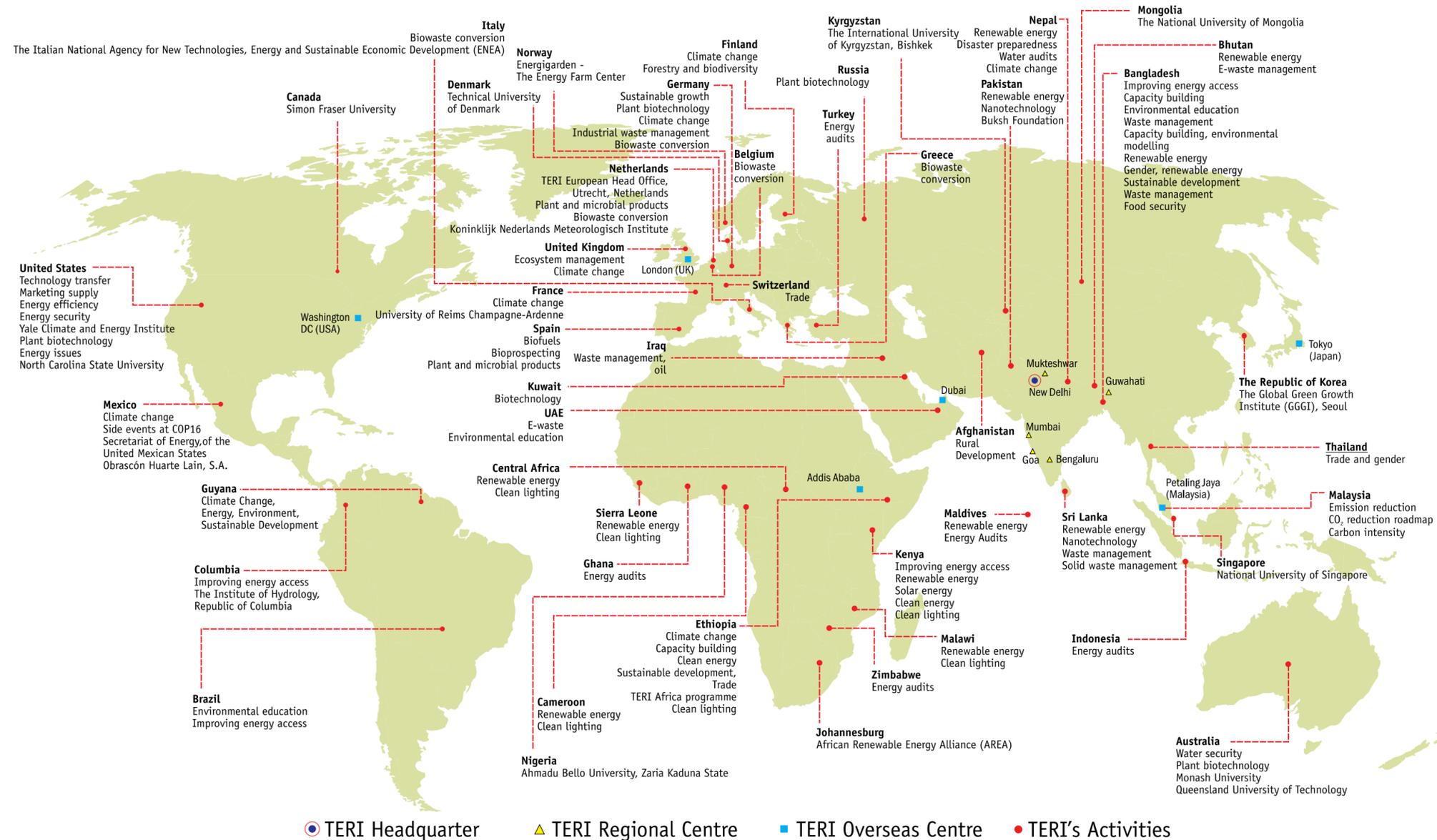
**ANNUAL REPORT** **2017 / 18**



**teri**

# Our growing commitment to a sustainable future

Research and outreach activities in over 50 countries



## About TERI

We are an independent, multi-dimensional organization, with capabilities in research, policy, consultancy and implementation. We are innovators and agents of change in the energy, environment, climate change and sustainability space, having pioneered conversations and action in these areas for over four decades.

We believe that resource efficiency and waste management are the keys to smart, sustainable and inclusive development. Our work across sectors is focused on

- Promoting efficient use of resources
- Increasing access and uptake of sustainable inputs and practices
- Reducing the impact on environment and climate

Established in 1974, TERI is headquartered in New Delhi. We have regional centres and campuses in Gurugram, Bengaluru, Guwahati, Mumbai, Panaji, and Nainital. Our 1000-plus team of scientists, sociologists, economists and engineers delivers insightful, high quality action-oriented research and transformative solutions supported by state-of-the-art infrastructure.

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# DIRECTOR-GENERAL'S MESSAGE



In its endeavour to develop and promote clean energy solutions, we established a theme-based platform under the aegis of the Energy Transitions Commission (ETC) to build and disseminate knowledge and guide the path for energy transition of the country. ”



The year 2017/18 marked the metamorphosis of TERI from Division-based areas of work to a more amalgamated Programme-based work space. The erstwhile divisions and areas of the organization were integrated into umbrella research programmes—energy, integrated policy analysis, natural resources and climate, sustainable habitat, social transformation, environmental and industrial biotechnology, and sustainable agriculture—and continued their effort towards achieving sustainable development. In its research endeavours, TERI was ably assisted by the support services—communication outreach and advocacy unit, project management unit, knowledge management, and growth diversification and commercialization unit. The support units—administrative services, human resources, and information technology also efficiently supported TERI's research efforts.

In its endeavour to develop and promote clean energy solutions, we established a theme-based platform under the aegis of the Energy Transitions Commission (ETC) to build and disseminate knowledge and guide the path for energy transition of the country. TERI hosts the secretariat of the ETC India and the Electricity and Fuels Division, in coordination with other divisions of TERI, is leading a diverse group of stakeholders to enable a smooth transition towards low-carbon pathways in the energy sector through a collaborative approach. The ETC India project aims to develop a narrative for the policymakers to adopt low-carbon pathways so as to enable a smooth transition towards a carbon neutral or zero carbon energy sector in India. Under Solar City Initiative, TERI conducted a consumer aggregation campaign for Rooftop Solar PV at Dwarka (Delhi) with support from GIZ India and BSES Rajdhani Power Ltd (BRPL). A portal was developed to solicit interest from group housing societies in Dwarka. Till date, nearly 100 societies have registered on the portal with more than 2 MWp already installed. In keeping with our mandate of promoting energy efficiency and facilitating deployment of energy efficient technologies in the micro, small, and medium enterprises (MSME) sector, we successfully organized the second MSME Energy Efficiency Summit in New Delhi, which was inaugurated by the Minister for MSME, Government of India.

As a result of the growing interest in coal bed methane (CBM), both for production of energy and reduction of greenhouse gases, we have recently started with CBM generation through methane-producing bacteria. CBM has been used as an alternative fossil resource, and methane generation from coal reservoirs is contributing in meeting clean energy demand. The year also witnessed successful completion of the 'Sustainable Environmental Economic Development (SEED) Project', an industrial scale, acquired from Kuwait Oil Company (KOC) through a global competitive bid in the year 2012. The project saw clean-up of more than 217,000 m<sup>3</sup> soil contaminated with petroleum hydrocarbon pollutants successfully remediated through three different processes; Indirect Thermal Desorption Unit (ITDU), Direct Thermal Desorption Unit (TDU), and Bioremediation process through the use of 'KT-Oilzapper' (developed from indigenous microbes of Kuwait). The calendar year 2018 also witnessed completion of 25 years of the existence of the North Eastern Regional Centre of TERI, established in August 1993, and its contribution in sustainable development through innovative research in the fields of agriculture and biotechnology and implementing projects related to rural extension and research activities.

In our role as the focal point for studies and projects on resource efficiency, sustainable consumption, and resource governance, including issues related to trade in natural resources, the year under review saw us successfully

complete a study on resource efficiency in India with support from GIZ. The study provided inputs for the end-of-life vehicle scrapping policy and metal recycling policy prepared by the Central Pollution Control Board; these are currently under consideration by the Government of India. We also organized in 2017/18, a number of international, national, and local training programmes, including two ITEC (Indian Technical and Economic Cooperation) programmes for the Government of India. As in previous years, we undertook an assessment of the

Union Budget for its impact on energy, environment, and natural resources.

In 2017/18, we also completed a project supported by the European Commission with the objective to explore strategic options before India in pursuing the Nationally Determined Contributions (NDCs) while responding to immediate imperatives of development. We also significantly contributed to the Global Environment Outlook (GEO) 6, a publication by the United Nations Environment Programme (UNEP), which informs environmental decision-making by providing an integrated assessment on state, trends, and outlook of the environment and facilitates interaction between science and policy.

In addition to concentrating our focus on species or habitat loss, we also worked on policies and social and economic issues that undergird biodiversity declines—arguably one of the most vexing problems facing the world today. Over the years, we have influenced strategic planning in biodiversity by developing a detailed biodiversity strategy and action plans for several Indian states (including Uttar Pradesh, Uttarakhand, and Punjab) and mainstreaming biodiversity through its incorporation in climate action plans. We have been working on a range of projects of national and international significance, including the GEF Satoyama project, wherein TERI is mainstreaming community-conserved areas (CCAs) for biodiversity conservation in Nagaland by linking the CCAs across the landscape for forest protection. With possibilities of accessing carbon-based financing from forestry activities, we organized a capacity building and training programme of the Chhattisgarh Forest Department for assessment of the carbon stocks of forests and also developed a manual on the carbon stock assessment of forests. A similar training programme is scheduled in Uttarakhand and also in other states in the near future. We have also been engaged in estimating the minimum support price for selected Minor Forest Produce with the Tribal Cooperative Marketing Development Federation of India Ltd and in this context have completed the estimation of minimum support price (MSP) for 54 minor forest produce (MFP). It is pertinent to note here that based on TERI's research, the government is revising the rates for these MFPs.

TERI also contributed on the important emerging issue of water–energy–food- and climate change nexus and analysed the intricate nexus at various spatial scales with a focus on urban areas and power generating plants. We have been actively involved in carrying out various research activities in the high altitude regions, including studies on glaciers and glacier-fed catchments and their impact on the downstream community.

In our capacity of studying the environmental dimensions of various economic activities and resource-use patterns and exploring strategies to mitigate the adverse effects, we assisted the Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India, in the preparation of the draft National Environment Policy. We have also been recognized by the MoEFCC as one of the National Host Institutes for facilitating development of State of Environment Reports at the state level. We have also been providing state-level policy recommendations through several source apportionment studies which guide state-level regulatory authorities to develop local action plans for control of air pollution and its adverse impacts. The year 2017/18 saw our participation in negotiations as part of the Montreal Protocol Amendment, as a knowledge partner to the Indian Government, where India made ambitious pledges towards efficient refrigerant transitions. We are also exploring linkages between Sustainable Development Goals and Nationally Determined Contributions to develop an understanding on the role of co-benefits in meeting climate action targets.

Carrying forward our vision of researching on policies, regulation, governance, and management of solid and liquid waste streams, we recently completed the Municipal Solid Waste Initiative Implementation project, in collaboration with the Climate and Clean Air Coalition (CCAC). TERI worked with selected eight cities in India to improve their solid waste management practices to reduce short lived climate pollutants (SLCPs), such as black carbon and methane. In the project, Strengthening Water and Sanitation in Urban Settings, supported by USAID, we worked in the urban slum 31 clusters in Chennai and Kolkata for an extensive baseline survey on various socio-economic aspects, health, sanitation, and solid waste management and help rehabilitate community toilet complexes in the slums in the two cities.

During the year, we continued our pioneering work to help achieve universal access to sustainable, affordable, reliable, and modern energy to attain the goal of SDG 7, thereby catalysing socioeconomic development of communities in a gender and socially-inclusive manner. In 2017/18, our interventions in this domain went beyond basic energy access and weaving 'energy' as a contributor towards other associated aspects of development, such as health, education, livelihoods, empowerment, and mitigating climate change. Our Lighting a Billion Lives (LaBL) programme in the



The calendar year 2018 also witnessed completion of 25 years of the existence of the North Eastern Regional Centre of TERI, established in August 1993, and its contribution in sustainable development through innovative research in the fields of agriculture and biotechnology and implementing projects related to rural extension and research activities. ”



In our capacity of studying the environmental dimensions of various economic activities and resource-use patterns and exploring strategies to mitigate the adverse effects, we assisted the Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India, in the preparation of the draft *National Environment Policy*.

last decade has positively impacted 5.3 million lives across 23 states in India and 12 countries in Africa and South Asia. We also engaged with the Karnataka Watershed Development Department for MELD of World Bank-assisted KWDP-II (Sujala-3). The scope of MELD is to carry out intensive monitoring, evaluation, learning, and documentation in nine sub watersheds (nine districts) covering an area of 46,640.8 ha.

In consonance with achieving sustainable agriculture and resolving the challenges and pressing problems encountered in the field of agriculture, environment, and bioenergy, we expanded our scope of work with inauguration of the state-of-the-art TERI-Deakin Nano Biotechnology Centre (TDNBC), established at Gwal Pahari, Gurugram, in April 2017 by the Prime Ministers of India and Australia. The Centre aims to support and nurture innovative ideas for existing problems of Indian agriculture, amongst other sectors and has also been rated as a 5-star GRIHA building; as an example of resource efficiency and smart future.

Our flagship GRIHA Summit in December 2017 saw the launch of a new rating variant 'GRIHA for Affordable Housing'; the rating was developed through consultative process with all stakeholders and is in line with the guidelines of the Pradhan Mantri Awas Yojna (PMAY). The Ministry of Housing and Urban Affairs (MoHUA) has recognized TERI as a centre of excellence (CoE) in urban development and management. Also, TERI has established a CoE on Energy Efficient Buildings, in collaboration with United Technologies Corporation. Recently, TERI partnered with Mahindra Lifespaces to create a CoE for sustainable habitat. We also conducted detailed studies on analysing the future prospects of electric mobility in India and, along with IIT-Delhi, established an Electro-Mobility Platform for knowledge sharing. In partnership with the World Bank and the International Transport Forum, TERI has developed a city-level model which evaluates the decarbonization potential of different transport investment strategies.

In its seventeen year (2001–2018) journey, the World Sustainable Development Summit (WSDS), the annual flagship event of TERI, has become a focal point for global leaders and practitioners to congregate at a single platform to discuss and deliberate over climatic issues of universal importance. The Summit series has emerged as the premier international event on sustainability which focusses on the global future, but with an eye on the actions in the developing world which could bend our common future. The 2018 edition of the WSDS had the honour of being inaugurated by the Hon'ble Prime Minister of India, Shri Narendra Modi, who echoed India's commitment to a sustainable planet, for us and for future generations.

Looking back, 2017/18 was a gratifying year for us at TERI; being a source of satisfaction and yet, at the same time, urging us to constantly move ahead in our efforts to achieve a sustainable society for all.

**Ajay Mathur**  
Director General, TERI



# TERI'S GOVERNING COUNCIL



Shri Ashok Chawla  
Chairman



Shri Deepak S Parekh



Dr Shailesh Nayak



Shri Hemendra M Kothari



Dr Henrik O Madsen  
(Up to 13.02.2018)



Dr Ajay Mathur



Dr Naushad D Forbes



Prof. (Ms) Basabi Bhaumik



Prof. (Ms) Laurence Tubiana

# THE MANAGEMENT TEAM



**Dr Ajay Mathur**  
Director General, TERI

Mr I H Rehman  
DGO



Mr Prabir Sengupta  
Knowledge Management



Ms Minni Sastry  
Sustainable Habitat



Ms Akshima Tejas Ghatge  
Sustainable Habitat



Mr Girish Sethi  
Industrial Energy Efficiency



Dr Ritu Mathur  
Integrated Assessments  
and Modelling



Dr Prodipto Ghosh  
Earth Science & Climate Change



Ms Rishu Nigam  
Sustainable Development  
Outreach & Youth Education



Mr Pronab Dasgupta  
TERI-SRC



Mr Amit Kumar  
Social Transformation



Dr Banwari Lal  
Environmental & Industrial  
Biotechnology



Dr Alok Adholeya  
Sustainable Agriculture



Dr Annapurna Vancheswaran  
Sustainable Development Outreach  
& Youth Education



Ms Suruchi Bhadwal  
Earth Science & Climate Change



Ms Livleen K Kahlon  
Sustainable Development  
Outreach & Youth Education



Mr Pradeep Kumar  
Sustainable Habitat



Mr Sanjay Sethi  
Sustainable Habitat



Dr Anjali Parasnis  
Nutritional Security



Dr Suneel Pandey  
Environment & Waste Management



Ms Divya Datt  
Integrated Policy Analysis



Mr Debajit Palit  
Social Transformation



Dr Syamal Kumar Sarkar  
Water Resources



Mr Anshuman  
Water Resources



Dr G R Narasimha Rao  
Industrial Energy Efficiency



Col (Retd.) Sanjai Joshi  
Administrative Services



Mr Shirish Garud  
Energy Environment  
Technology Development



Mr Puneet Chandra  
Growth, Diversification &  
Commercialization Unit



Dr Dipankar Saharia  
Environmental & Industrial  
Biotechnology



Mr A K Saxena  
Electricity & Fuels



Dr Vibha Dhawan  
DGO

# TERI'S DISTINGUISHED FELLOWS



**Mr S Sundar**  
Distinguished Fellow & Professor,  
TERI University; Former Secretary,  
Ministry of Surface Transport,  
Government of India



**Dr Prodipto Ghosh**  
Distinguished Fellow, TERI;  
Former Secretary,  
Ministry of Environment and Forests,  
Government of India



**Mr Prabir Sengupta**  
Distinguished Fellow, TERI;  
Former Secretary, Ministries of  
Commerce, Petroleum and  
Natural Gas, Defence Production,  
Government of India



**Air Commodore (Retd)  
M M Joshi**  
Distinguished Fellow and  
Former Director, TERI



**Mr Shri Prakash**  
Distinguished Fellow, TERI;  
Former Member (Traffic) Railway  
Board, Ministry of Railways,  
Government of India



**Mr K Ramanathan**  
Distinguished Fellow, TERI;  
Former Member,  
Central Electricity Authority



**Mr Ajay Shankar**  
Distinguished Fellow, TERI;  
Former Secretary, Department of  
Industrial Policy and Promotion,  
Government of India



**Mr S Vijay Kumar**  
Distinguished Fellow, TERI;  
Former Secretary,  
Ministry of Mines,  
Government of India



**Dr Syamal Kumar Sarkar**  
Distinguished Fellow, TERI;  
Former Secretary, Ministry of  
Water Resources and DoPT



**Amb. Ajai Malhotra**  
Distinguished Fellow, TERI;  
Former Ambassador of India  
to the Russian Federation



**Mr Pronab Dasgupta**  
Distinguished Fellow and Director,  
Industrial Energy,  
Southern Regional Centre, TERI;  
Former Member, TDSAT



**Dr Vibha Dhawan**  
Distinguished Fellow &  
Senior Director, TERI



**Mr Arvind Kaushal**  
Distinguished Fellow, TERI;  
Former Secretary, ICAR  
(Up to 10.01.2018)



**Mr Dipak Dasgupta**  
Distinguished Fellow, TERI; Former  
Principal Economic Adviser, Ministry of  
Finance, Government of India

# RESEARCH PROGRAMMES





ENERGY



**E**nergy is a vital input for production and growth; it drives socio-economic development. As India continues on a path of rapid expansion and growth in every sector of its economy—industry, agriculture, transport, housing, etc.—the challenge before the country is to meet the increasing requirements for energy while simultaneously minimizing the adverse environmental impacts that result from increased resources extraction, power generation, and energy usage. The Energy Programme at TERI focusses on supporting the transformation of the nation's energy sector on both supply and demand sides: by fostering development and deployment of adequate, dependable and affordable supply of clean and renewable energy as well as by promoting energy-efficient technological solutions and practices for end-users in diverse sectors of the economy.

The Energy Programme organizes its work under three broad Divisions, which work in the domains enumerated herein:

- The Electricity and Fuels Division (EFD) carries out policy and regulatory analysis related to the energy sector (electricity, coal, oil and gas). EFD primarily focusses on developing low carbon pathways through detailed demand assessments and emerging supply mix, integrated demand-supply analysis in the medium- and long-term, integration of renewable energy and smart grid solutions, demand side management (DSM), and many other related aspects in the electricity sector. The Division has considerable experience of working with regulatory bodies, public and private utilities, and ministries and government departments.
- The Renewable Energy Technologies (RET) Division provides cost-effective and sustainable RE-based technological solutions for diverse user-groups in the industrial, commercial, and rural sectors. It has developed and disseminated technologies for conversion of biomass into useful end products, such as gaseous energy, electrical energy, crude bio-oil, etc. The Division also focusses on research-oriented activities and consultancy projects aimed at developing and promoting solar (including solar rooftop) and wind energy.
- The Industrial Energy Efficiency (IEE) Division works closely with the corporate sector and provides energy audit services to industrial clients in sectors, such as cement, chemicals, pulp and paper, iron and steel, thermal power plants, food processing, glass & ceramics, etc. In addition, it works with many energy-intensive MSME (micro, small and medium enterprises) clusters and provides long-term hand-holding support in terms of adopting energy-efficient technologies and best operating practices. The Division has also been working closely with ministries and government departments, multilateral/ bilateral institutions, foundations and other stakeholders in the field of energy efficiency.

Building on its four decades of experience in developing and promoting clean energy solutions, the Energy Programme shall continue to forge strong and synergetic partnerships/ collaborations with multiple stakeholders at every level—policy, institutional, academia, industry, and community—in order to maximize the effectiveness of its initiatives and ensure their sustainability. Apart from its focus on India, the Energy Programme also works on promoting clean energy solutions in other parts of the world with a focus on developing countries in Africa, South Asia, and the Caribbean.

## Electricity and Fuels Division

Electricity is a critical input for economic growth and development. Over the years, the electricity sector has witnessed substantial growth; the growth in the last few years is laced with changes in the demand profile as well as supply mix. The trend is likely to continue in the coming years more significantly. The Electricity and Fuels Division of TERI works on cross-cutting themes of the electricity with allied focus on fuels, such as coal and natural gas, used in the sector for power generation. Most of the research, consultancy, and capacity building activities of the Division pertain to demand and supply of the electricity sector. During 2017/18, a theme-based platform under the aegis of the Energy Transitions Commission (ETC) was established with the objective to build and disseminate knowledge and guide the path for energy transition for the country. It is important to note here that TERI is involved in a multi-stakeholder project for the ETC, headquartered in the United Kingdom. TERI hosts the secretariat of the ETC India and the Electricity and Fuels Division, in coordination with other divisions of TERI, is leading a diverse group of stakeholders to enable a smooth transition towards low-carbon pathways in the energy sector, through a collaborative approach. The activity is majorly funded by Hewlett Foundation, Bloomberg Philanthropies, Oak Foundation, and Shakti Foundation with partial support from NTPC.

The ETC India project aims to develop a narrative for the policymakers to adopt low-carbon pathways so as to enable a smooth transition towards a carbon-neutral or zero carbon energy sector in India. This requires study of various options of supply of clean power to match the estimated demand for the country till 2030 and accordingly the project has been divided into five work-streams that will look after demand, supply, grid-balancing, investments and policy-making for the energy sector. The first year of the overall work programme focussed on fostering adoption of low-carbon pathways in the power sector and ensuring that the findings assist the government in decision making. All of the Division's activities have been tailored accordingly to fall under the central theme of transitioning towards low-carbon pathways and are structured so as to support and facilitate this transition.

In the domain of power distribution, the Division has been performing distribution system studies with support of MacArthur Foundation for assessing the technical impacts of large-scale integration of renewable energy (RE)-based generation on the distribution system and suggesting possible mitigation measures to the distribution utilities in the states of Delhi (BRPL), West Bengal (WBSEDCL), and Andhra Pradesh (APSPDCL). TERI worked with Central Electricity Authority (CEA) to draft charging standards for electric vehicles (EVs) in India and prescribe appropriate charging standards which India can adopt in future (TERI is an Associate

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Member of CharIn, Berlin in India). EFD is also working with utilities (BYPL) for supporting and managing electric vehicle (EV) integration by performing system impact studies including EV charging harmonic measurements for assessing power quality issues. Accordingly, the Division's research activities involve detailed modelling of distribution feeders and distributed RE-based generators, simulation studies, such as load flow, short-circuit and harmonics and protection-coordination impact studies to recommend possible system upgrades to accommodate increasing RE and EV penetration. The Division also works on sizing battery energy storage systems (BESS) for various grid-scale applications at the distribution network level, modelling of EVs as mobile, distributed energy storage, and simulation of the various services and benefits that they can provide to the distribution grid and for planning, designing, and facilitation of pilot-scale BESS implementation on distribution feeders. Development of an open-source tool to forecast load profiles for one of the distribution licensee of Karnataka, that is, BESCOM to help them



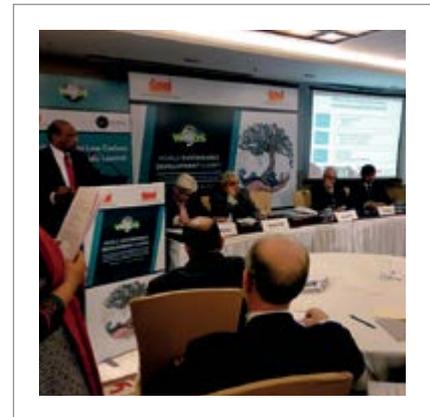


manage their day-to-day operations is amongst the recent activities that has been initiated by the Division.

In September 2017, the Division got engaged in a prestigious competitively bid Indo-US project on battery energy storage jointly funded by the US Department of Energy (DOE) and the Department of Science and Technology, Government of India. The US-India Collaborative for Smart Distribution System with Storage (UI-ASSIST) is a multi-partner research project that focusses on research, development, demonstration, and pilot-scale implementation of BESSs at the distribution grid level for various applications under the smart grid paradigm. The project partners, include institutes, industrial organizations, and utilities, both from India and the US. Institutions, such as WSU (US lead), MIT,

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Texas A&M University, Idaho National Lab, LBNL, and organizations, such as ETAP, GE, ABB along with some start-ups are involved on the US side. TERI is one of the partner institutes on the Indian side along with 5 IITs, namely IIT Kanpur (India lead), IIT Delhi, IIT Roorkee, IIT Bhubaneswar, IIT Madras and NTPC NETRA; industrial partners, such as Customized Energy Solutions, GE Global, Mindteck Consulting, Panasonic India, Synergy System Solutions, and utility partners, such as, POWERGRID, UPPLCL, and BSES Rajdhani Power Limited (BRPL). TERI has partnered with BRPL for installation of grid-scale BESS on distribution feeders catering to three categories of consumers, that is, institutional premises, gated residential colonies, and apartments. The sizing, siting (at LT feeder-level or DT-level), and design parameters will be determined as part of the pilot implementation activities, in a phased manner over the project horizon of 5 years. The project also has a research and development (R&D) component wherein TERI will work on the design, development, and testing of Battery Management System (BMS) control logic for coordinating various grid-scale applications, such as peak shaving, power backup, voltage support, etc.



In the emerging domain of smart grids, the Division also works on laboratory hardware including emulators and real-time control hardware/embedded systems for development of effective control systems for battery systems and solar photovoltaic (PV) inverter integration with distribution networks. The Division also helped install a novel smart grid pilot project, with the support of NEDO, in the licensee area of UHBVN, Haryana, India. The plant was inaugurated by the Chief Minister of Haryana during the year. Capacity building is also one of the activities that the Division undertakes so as to facilitate the provision of skilled/well-trained manpower to the industry. Series of training sessions for circle level officers in 6 DISCOMs (TANGEDCO, APSPDCL, KSEBL, BESCOM, CESC, GESCO) falling in the states of Tamil Nadu, Andhra Pradesh, Kerala, and Karnataka on demand side management under a project commissioned by the BEE were successfully completed during the year. We believe in a collaborative and inclusive approach and listening to the concerns of the relevant stakeholders to solve the pressing issues in the electricity sector. During the year, a Distribution Utilities Forum was constituted to facilitate dialogue amongst the electricity distribution companies in the country

and to provide them a platform to discuss their issues, share learning, and come up with collective solutions.

## Renewable Energy Technology Division

India is a vast country lying in sub tropics with about 900 GW of estimated potential of renewable energy. Currently, India is implementing one of the largest programmes globally for the expansion of RE power by targeting 175 GW capacity by 2022. India's Intended Nationally Determined Contributions (INDC's) reaffirm its continued growth through its intention to increase the share of non-fossil fuels generation in the total installed capacity to 40% by 2030.

Achieving these poses several challenges in terms of policy, technology, viable business models, and availability of skilled manpower. The Renewable Energy Technology (RET) Division primarily supports this national endeavour through research and development, implementation of projects, commercialization of technologies, policy research and project management consultancy services, especially in the area of biomass technologies and rooftop solar. The RET Division works in partnerships with national and international institutions, bilateral and multilateral agencies, and most importantly, investors and industry. With a strong team of more than 30 research professionals, the Division comprises a diverse group of experts in bio, solar, wind, and hydro energy. Laboratory infrastructure and technology platform in bio energy, solar PV lighting, and product testing-NABL accredited test lab for PV products testing & certification, smart

grid and inverter testing, provided unique advantage of laboratory to market connectivity to the RET Division.

During the year, the Division has undertaken a number of initiatives, including implementation of field projects within the country as well as abroad. Some of the Division's major projects and success stories include the following:

- Development of a web based portal for monitoring of Renewable energy Purchase Obligations (RPOs) by various stakeholders under support from the MNRE.
- Carrying out a study on biomass potential and benchmarking costs for biomass-based power industries in Gujarat.
- Implementation of research projects on Solar microgrid and solar PV waste management in technical collaboration with the University of Agder, Norway under Framework Agreement between the Norwegian Ministry of Foreign Affairs and TERI.
- Development of Standards and Guidelines for large-scale biogas plants with GIZ support for MNRE.
- Providing technical support to International Solar Alliance (ISA) as knowledge partner for developing roadmaps for the member countries and developing a programme for mid-career executives in the area of solar energy jointly with National Institute of Solar Energy and TERI School of Advances Studies. A new initiative with German Association named German Watch on De-risking German Investments in Indian RE sector has been taken up.
- Providing hand-holding support to Surat Municipal Corporation on faster adoption of solar rooftop in a targeted manner. TERI's support resulted in installation of 4,500 systems with a capacity of 14 MWp in a short span of time within the Surat Smart City area.
- Undertaking feasibility study on potential assessment of solar rooftop for over 2,400 central government campuses across India for SECI using satellite data; also, a market potential study for rooftop solar PV in Turkey was implemented under World Bank programme using GIS-based assessment of solar rooftop potential.
- Under Solar City Initiative, the Division has conducted a consumer aggregation campaign for Rooftop Solar PV at Dwarka (Delhi) with support from GIZ India and BRPL. A portal was developed to solicit interest from Group Housing Societies in Dwarka. Till date, nearly 100 societies have registered on the portal with more than 2 MWp already installed.
- Implementation of TERI's rice husk based gasifier for electricity generation in Cambodia with the United Nation's Industrial Development Organization's (UNIDO) support. Also, an advanced gasification system, based on two-stage technology, has been licensed to Verde Institute, Japan for its commercialization in Japan, the Philippines, and markets in Indonesia.
- Commissioning of thermal biomass gasifier for jaggery cluster in Belgavi, Karnataka with financial support from WISION. In addition, three waste-to-energy projects (i.e., TERI's TEAM process) were commissioned during the year in various units of NTPC at Tanda UP and Ramagundam, Andhra Pradesh.
- A simulation based performance evaluation study on different Solar Photovoltaic (SPV) technologies in five different climatic zones was conducted for the Defence Research and Development Organization (DRDO), Government of India.
- A project on market development study for advanced solar modules



developed by M/s Power Roll, United Kingdom (previously known as BIG Solar Ltd, UK) is under implementation under Innovate UK programme.

- Two bilateral projects supported by DST have been implemented by the Division viz.
  - » “Plastic to Fuel (P2F): Gasification and Pyrolysis of Waste Plastic for Fuel Generation through Nano Catalytic Conversion” with Beni Suef University, Egypt under Indo-Egypt technical cooperation.
  - » Research study on Aerosol Impact on Solar radiation in collaboration with FMI, Finland under Indo-Finland technical cooperation.
- The Division has also successfully organized a three week International Training Programme on “Renewable Energy and Energy Efficiency” under ITEC Programme of Government of India. Thirty-two delegates, representing 29 countries, participated in the programme.

## Industrial Energy Efficiency (IEE) Division

The industry sector is a crucial component of the Indian economy in terms of its contribution to economic growth, trade, and as a provider of employment. The sector is also the largest consumer of commercial energy, accounting for nearly half of the total energy consumed in the country. Industry sector is a mixture of large as well as micro, small and medium enterprises (MSMEs). India's growth story and the government's ambitious 'Make in India' campaign is dependent upon the prosperity of this sector. The challenge, however, is to grow in a manner that is resource-efficient and addresses sustainability considerations from all perspectives—social, economic, and environmental. In this context, the Industrial Energy Efficiency (IEE) Division works closely with the corporate sector and provides services to both large and small industries to improve their energy performance. In order to maximize the reach of its specialist teams and synergize their capabilities and activities, both within and outside India, IEE functions from two hubs: Industrial Energy Efficiency and Sustainable Technologies (IEEST) Area, located at TERI,



New Delhi and Industrial Energy Group (IEG), located at TERI's Southern Regional Centre, Bangalore (TERI-SRC).

The pool of engineers in the Division, many of who are accredited and certified energy auditors with the Bureau of Energy Efficiency (BEE), Government of India, regularly conduct energy audits in industries to identify options for energy conservation at the plant level. With expertise and deep knowledge of applicable technologies, TERI is able to offer corporate sector high-quality technical advice on ways to reduce their carbon footprint. TERI is a leading name in promoting energy efficiency and facilitating deployment of energy efficient technologies in the MSME sector, courtesy the IEE Division's continuous engagement with the sector for the past over two decades.

During the year, the Division undertook energy audits in different kinds of industries in India in sectors, such as oil & gas, textiles, cement, chemicals, steel, pulp & paper, plywood, auto components, and fast-moving consumer goods (FMCG) as well as in thermal power plants. Few prominent groups where IEE rendered services were Ambuja Cements, Amway, Emami, Indian Oil, Cairn, Indorama, Mondelez Foods, MRF, Saint Gobain, Jindal, and Swaraj. The Division also undertook energy audits of water pumping installations in a few towns in Karnataka and Jharkhand as a part of the Municipal Energy Efficiency program of Energy Efficiency Services Limited. TERI continued to provide support under the Perform Achieve and Trade (PAT) scheme of BEE for large industrial consumers. With support from Shakti Sustainable Energy Foundation (SSEF), TERI helped BEE in including the naphtha and gas cracker units under the fourth cycle of PAT. In addition, TERI also undertook energy conservation studies in plants located in other countries, including the well-known global ceramic plant, RAK Ceramics located in UAE. The activities of IEE Division in the MSME sector were primarily supported

by Swiss Agency for Development and Cooperation (SDC), United Nations Industrial Development Organization (UNIDO), United Nations Development Programme (UNDP), and SSEF. The highlights during the year were:

- Expanding the knowledge collation and dissemination activities under the SAMEEESHKA (Small and Medium Enterprises Energy Efficiency Knowledge Sharing) platform
- Conducting field level surveys and developing cluster-level profiles for nearly 30 energy intensive MSME clusters
- Providing support for implementation of energy-efficient technologies and best operating practices in foundries in Rajkot, Ahmedabad, and Howrah
- Organizing the second MSME Energy Efficiency Summit in New Delhi, which was inaugurated by the Minister for MSME, Government of India
- Developing five training modules on energy efficient practices for shop floor-level technicians working in SME engineering cluster in Faridabad
- Undertaking comprehensive energy audit studies in select Electric Arc Furnaces (EAF) and developing a technology compendium and a ready reckoner that can act as a guide for the EAF units in the country

The IEE Division continued working closely with Japanese expert institutes in the field of energy and environment, such as the Institute for Global Environmental Strategies (IGES), Energy Conservation Center Japan (ECCJ), and New Energy and Industrial Technology Development Organization (NEDO). JITMAP (Japan India Technology Matchmaking Platform), a joint initiative of TERI and IGES was launched by the Vice-Minister, Ministry of Environment Japan (MoEJ) in a special session during the World Sustainable Development Summit (WSDS) in February 2018.



# ENVIRONMENTAL AND INDUSTRIAL BIOTECHNOLOGY



**T**he Environmental and Industrial Biotechnology Programme (EIB) has been committed towards protection of the environment and development of sustainable innovative technologies and renewable energy options in fast growing economy for comprehensive commercial application. EIBD focusses on basic and applied research for exploring microbial-based solutions towards the development of bioenergy and biofuel-based programme.

With state-of-the-art pilot scale bioreactor facility, the Programme has successfully developed best-selling technologies—'Oilzapper' and 'MEOR'—at a large scale. Oilzapper is globally acknowledged for its broad-scale implication in cleaning of oil spills and treatment of oily sludge generated by refineries, whereas MEOR (a Microbial Enhanced Oil Recovery) technology developed by EIBD with the aid of IRS/ONGC has achieved substantial recognition across public sector oil companies in India for enhanced oil recovery from oil reservoirs by tackling the worldwide problem of oil well stripping. The Oilzapper technology not only helped several petroleum industries (ONGC, IOCL, HPCL, BPCL, Oil India Ltd, Tata Power, BG Exploration Ltd, and Reliance Petroleum) across India in providing a sustainable solution for bioremediation of oil spills and oily sludge-contaminated sites in a cost-effective manner but also spread its roots in the international arena which helped grab a major project of Kuwait Oil Company (KOC) through a global competitive bid, for the bioremediation of 400,000 tonnes (cu. m) of oil-contaminated soil. After the successful completion of bioremediation work in the above project, the Oilzapper technology has bid for another second phase mega tender (KERP Bio remediation at South East Oilfield at Kuwait) for remediation of total petroleum hydrocarbon (TPH) contaminated soil in KOC oil field and for clean-up of oil-contaminated sites.

In the northeastern region of India, the Programme also focusses on production of quality planting material and providing rural extension services. Carrying forward its activities, the Programme is now focussing its efforts on commercializing its low-cost, highly effective bio-based technologies for tackling viscosity reduction of heavy oil in flow line, enhanced methane production from coal bed, and biological hydrogen production process which has prime importance in generating hydrogen in a sustainable manner from waste without relying on conventional fossil-based resources.

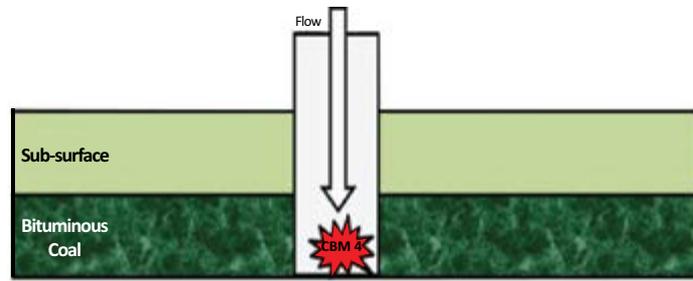
Currently, in partnership with various industries, the Programme is keen on finding a sustainable solution to climate change-related problems by identifying bacteria for the production of cost-to-cost, cleaner energy forms, for carbon capture and storage that would displace the methane on coal seams with carbon dioxide, bio-butanol production from lignocellulosic biomass, extraction of essential oil, food testing services, and promotion of organic cultivation, specifically in the tea sector.



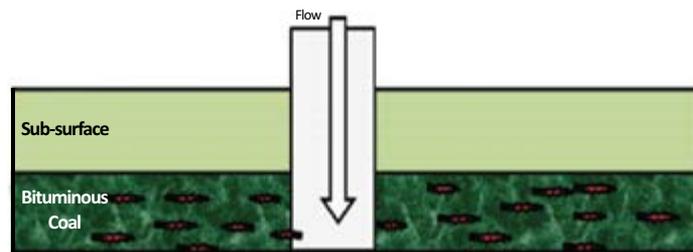
# Microbial Biotechnology Area

## Development of microbial process for in situ generation/enhancement of methane from underground coal seams

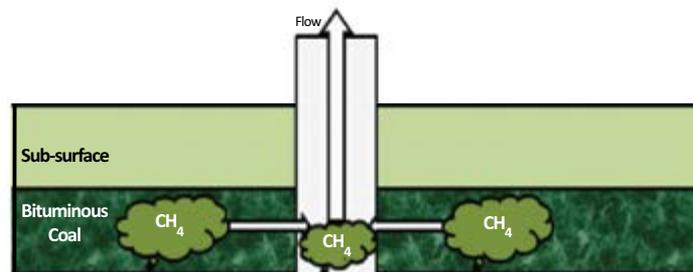
Recently, we have started with coal bed methane (CBM) generation through methane-producing bacteria. There has been a growing interest in CBM both for production of energy and reduction of greenhouse gases. CBM has been used as an alternative fossil resource and methane generation from coal reservoirs is contributing in meeting clean energy demand. India has the potential to generate CBM but lacks in technology for in situ biogenic methane generation from its coal reservoirs. Therefore, to explore the possibility of enhancing bacterial methane production in coal reservoirs, in this project, high temperature methane generating indigenous bacteria were isolated from samples collected from CBM wells of ONGC situated in Jharkhand, India, that has temperature of 60 °C. Microbes were enriched with 1% (w/v) bituminous coal obtained from the same coal mines. These bacteria when enriched through nutrient supplements in our lab showed promising results in methane generation from coal under the reservoir's simulated conditions. Subsequently, the effect of coal loading, temperature, pH, and salinity were optimized for enhanced CBM generation for the selected consortium. Also, the nutrient medium components were optimized as the cost of injected nutrients is also a major concern. Optimization results increased the production rate of metabolites, in lesser time enhancing the coal bed



Microbial consortium CBM 4 along with nutrient injection in coal reservoir



Microbial consortium CBM 4 interaction with Bituminous coal reservoir



Process of enhanced methanation

### Process of enhanced methanation

methane process. Also, the optimization study led to an overall reduction of cost by optimizing concentrations of expensive components, making it more cost-effective. On the basis of lab results, field application in CBM wells were also performed. In the field implementation, we have injected nutrient into the CBM well to enhance the indigenous bacterial coal to methane conversion inside the coal bed methane well. The microbial and stable gas isotope analysis data support the stimulation of microbial communities and in-situ biological gas production.

As per field demonstration it was observed that manifold increase in methane production and enhanced activity of methanogen leads to

additional methane generation in CBM wells. Therefore, microbially-stimulated CBM can increase the longevity and productivity of the CBM fields. This implication of microbes is a hot cake in today's scenario giving answers to the problems of petroleum industry.

### Harnessing microbes for hydrogen production from woody waste biomass

Energy plays a key role in socio-economic development of a nation and thus energy strategy of a nation targets energy security as well as energy efficiency. Current global energy demand is relying mostly on fossil

Owing to the rising population, limited crude oil reserves due to fast depletion of conventional fossil fuel sources along with rising greenhouse gas (GHG) emissions, there has been a global concern for energy security and environmental protection.



Field execution at Jharia site



**Fermentative biohydrogen production by C5 sugar utilizing *Enterobacter cloacae* DT-1 strain (isolated by TERI) from lignocellulosic biomass sugar (second generation feedstock) in 150 litre pilot scale bioreactor (100 litre working volume), through dark fermentation route**

fuels. Owing to the rising population, limited crude oil reserves due to fast depletion of conventional fossil fuel sources along with rising greenhouse gas (GHG) emissions, there has been a global concern for energy security and environmental protection. Considering these concerns, clean energy production, especially from sustainable sources, has become the prime focus for national as well as for international policies. In these perspectives, hydrogen gained substantial global attention as the most promising fuel and the cleanest form of energy owing to its highest gravimetric energy density, ease of transportation, high efficiency of conversion to usable power, high conversion efficiency to power, and how it generates clean water on combustion. Current hydrogen production processes are highly energy intensive and rely on fossil-based sources. Hydrogen production through biological route by microbes offers promising alternative as these processes do not rely on fossil sources and can be operated in mild condition and are less energy intensive. Amongst biological processes, hydrogen production through the dark fermentation process has significant advantages as this process has higher production rate and has potential for valorization of waste water, organic wastes, including residual biomass. To achieve the goal of sustainability, TERI researchers explored intensively on fermentative hydrogen production with the financial assistance provided by the Department of Biotechnology, Hindustan Petroleum Corporation Ltd (HPCL), Center for High Technology (CHT), the Ministry of Petroleum and Natural Gas (MoP&NG), and the Ministry of New and Renewable Energy (MNRE), Government of India. In-depth research explorations by TERI

researchers along with the existing state-of-the-art large-scale fermentation facilities at TERI, eventually paved the way for successful development of a pilot 1,000 L scale fermentation process for hydrogen production from sugarcane blackstrap molasses. Considering food security issues, subsequent research explorations in this domain were focussed on hydrogen production from lignocellulosic/woody biomass. Lignocellulosic biomass is present in agricultural residues, grasses, hardwood, softwood, and is most abundant in nature and provide wide avenues for use as non-feed competitive feedstock for clean fuel production. However, these biomass samples mainly composed of polymers of cellulose and hemicellulose (polymers of glucose [C6 sugar], xylose [C5 sugar]). Most of the microbes utilize glucose effectively. However, the crux lies in utilization of xylose (C5 sugar). Only those microbes having potential for C5 and C6 sugar utilization can use lignocellulosic biomass as feedstock for biofuel production. Keeping this in mind, TERI researchers explored on isolation of desired microbe that can utilize both C5 and C6 sugar for hydrogen production. A unique C5 & C6 sugar fermenting microbe was isolated at TERI. This microbe utilized broad spectrum C5 sugar rich biomass samples, such as woody biomass (rice straw, wheat straw, sugarcane bagasse, sorghum stover, sugarcane trash), aquatic plant, algal biofilm, and produced hydrogen with significant yield efficiency. Further process parameters were optimized to produce hydrogen through dark fermentation by this microbe from woody biomass. This process was successfully scaled up in 150 liter scale fermenter at TERI's state-of-the-art Fermentation Technology

Research Center, TERI GRAM. Further research explorations are in progress in this domain to fill the transition gaps to move this technology to demonstration/pre-commercialization scale. Presently, cost is one of the great concerns and thus research explorations are in progress to reduce the overall cost of the process by utilizing the spent effluent of this process for production of value-added products, in a bio-refinery concept. Maturation of this technology will eventually contribute for substantial cost reduction of this process.

### **Biotechnological intervention for production of 2,3-butanediol by indigenous bacterial strains isolated from hydrocarbon contaminated sites**

2,3-Butanediol (2,3-BD), a platform chemical is estimated to have a worldwide market of 32 million tonnes/annum valued at approximately USD 43 billion in sales. 2,3-BD has its applications in manufacturing of synthetic rubber, printing ink, antifreeze, flavouring agents, pharmaceuticals, and cosmetics.

The present work was undertaken to harness the potential of microorganisms to produce 2,3-BD as major metabolite. Further, attempts were undertaken to maximize the production of 2,3-BD through process optimization using glucose and wastes as substrate. Fed-batch fermentation was also done by adopting methods for an economical scale up. Subsequently, downstream processing of 2,3-BD from the fermentation broth was investigated. A holistic approach with step-wise customized parameters were implemented for the selected strain to provide a cost-effective method of 2,3-BD production and downstream processing.

Out of the total 21 strains screened from hydrocarbon-contaminated sites, 13 strains showed potential to produce 2,3-BD. Glucose was found to be the cheapest and showed maximum 2,3-BD production with a yield of 0.49 g/g in shake-flask condition. Amongst the different wastes, *E. cloacae* TERI BD 18 showed the utilization of all the substrates for growth (rice straw hydrolysate, waste glycerol, dairy waste, molasses, distillery waste, and syngas). However, significant 2,3-BD yield was from rice straw hydrolysate (0.40 g/g) and waste glycerol (0.41 g/g). By using the residual fed-batch with secondary pH and agitation change strategy, the final 2,3-BD productivity was achieved up to

1.73 g/l/h with a yield of 0.48 g/g of 2,3-BD per gram of glucose in 150 L bioreactor, which was 8% higher than the best result controlled by single pH and agitation speed and accounts to 96% of the theoretical value of 0.500 g 2,3-BD/g glucose.

Amongst the different downstream methodology (membrane separation, sugaring out, salting out) adopted for 2,3-BD separation from the fermentation broth, the salting out effect was found to be efficient in the present study. Maximum recovery of 99% was observed using salting out method. NMR study confirmed the purity of the product. The reuse of materials multiple times for fermentation, or repeated downstream separation provides a solution to reduce the waste generation and make the overall process more sustainable and efficient.

## Bioremediation Technology Area

The Bioremediation Area has been implementing technologies such as 'Oilzapper' (for bioremediation of oil spill and oily sludge). This technology was eventually commercialized and implemented at a large scale in India and abroad with the joint venture 'ONGC TERI Biotech Ltd (OTBL)'. Production facility at Fermentation Technology Research Center has done production of 180 tonnes of Oilzapper during the financial year 2017/18 and supplied to joint venture company OTBL. TERI has successfully completed an industrial scale 'Sustainable Environmental Economic Development (SEED) Project' acquired from Kuwait Oil Company (KOC) through a global competitive bid in the year 2012. In SEED project clean-up of more than 217,000 m<sup>3</sup> soil contaminated with petroleum hydrocarbon pollutants successfully remediated through three different processes; Indirect Thermal Desorption Unit (ITDU), Direct

TERI has successfully completed an industrial scale "Sustainable Environmental Economic Development (SEED) Project" acquired from Kuwait Oil Company (KOC) through a global competitive bid in the year 2012. ]



*Ahmedabad Kalol Farmer Land, May 2018, Before Bioremediation*

Thermal Desorption Unit (TDU), and Bioremediation process through the use of 'KT-Oilzapper' (developed from indigenous microbes of Kuwait). With bioremediation process using Oilzapper alone 123,000 m<sup>3</sup> oil contaminated soil is remediated and acquired recognition by Kuwait Oil Company (KOC). Based on the success of bioremediation process, a new tender "KERP (Kuwait Environmental Remediation Programme) Remediation South East Kuwait 1" was released in the month of May 2017 as a part of world's largest remediation project referred to as KERP. TERI, through a joint venture company OTBL, has participated in KERP Remediation SEK1 project tender and anticipating SEK1 project from Kuwait Oil Company (KOC). Further, the success of the bioremediation process paved the way forward for upcoming bioremediation of hydrocarbon contaminated soil of more than 4,000,000 m<sup>3</sup> volumes in North Kuwait area referred as Remediation NK project.

### Microbial production of xanthan gum for implication in drilling mud formulation

Drilling the wellbore is one of the most expensive steps in the oil & gas industry that requires the use of drill in fluids/muds. These fluids, being a major component of the well drilling operations, owe economic value in drilling of oil reservoirs. Most of the drilling fluids used are chemical based and TERI with the goal of developing sustainable solutions has initiated work to develop bio-based XC polymer at Fermentation Technology Research Center (FTRC), TERI Gram, Haryana, with expertise in oil industries. Microbial production of xanthan gum has been explored since the past two years and is currently engaged with formulation of an indigenous drilling mud chemical that will significantly benefit the oil



*Ahmedabad Kalol Farmer Land, May 2018, After Bioremediation*

industries for their exploration and production tasks. Bio-based XC polymer was produced in lab and formulated with selective chemical additives to meet out the requirement of drilling fluid. Bio-based XC polymer product was sent to Chemical laboratory, Oil India Ltd, Duliajan, for testing quality desired parameters. Major quality parameters were achieved as per the analysis result received from chemical laboratories and Oil India, Ltd, Duliajan.

### Remediation and reclamation of Hexachlorocyclohexane (HCH) dumpsite by using microbial bioremediation technology

A Department of Biotechnology (DBT) funded project on 'Remediation and Reclamation of Hexachlorocyclohexane (HCH) dumpsite by using Microbial Bioremediation Technology' was awarded in March 2018 in collaboration with Delhi University, CSIR-National Botanical Research Institute, and Indian Institute of Toxicological Research, Lucknow,



*Scale up of the process for Xanthan gum in laboratory scale bioreactor*

India. In this project, TERI focussed on bioremediation of HCH dump-site through bio-stimulation of the indigenous microbial population and bio-augmentation with HCH degrading bacterial strain B90A isolated by Prof. Rup Lal from University of Delhi. This 20-year-old HCH waste dumpsite was located in a forest land at Umari village at Barabanki district of Uttar Pradesh. TERI will bio-remediate 4,000 tonnes of HCH waste material present in the dumpsite. TERI is scaling up the production of HCH degrading bacterial strain B90A provided by Delhi University using various capacity bioreactors. After scale up, mass scale production of HCH degrading B90A bacteria will be carried out by TERI using industrial scale bioreactor facility located at Fermentation Technology Research

Center (FTRC), TERI Gram, Haryana, and supplied at HCH waste dump site. Within two years, the dumpsite shall be restored and native plant species introduced to rejuvenate the pesticide contaminated site completely.

## TERI North Eastern Regional Centre

The North Eastern Regional Centre of TERI, established in August 1993, is completing 25 years of its existence in the region, during the year under review, where it has contributed in sustainable development through innovative

research in the fields of agriculture and biotechnology and is also implementing projects related to rural extension and research activities. Over the years, the centre has formed collaborative partnerships with different government agencies and non-governmental institutions, thus transforming TERINE as a premier institute of the northeastern region for issues related to sustainable development. The centre as a whole works on a wide range of thematic areas, such as natural resource management, livelihood enhancement, sanitation, biodiversity conservation, algal biofuel, mycological research, etc. The centre is also extending its services in capacity-building of different stakeholders in the prioritized areas.



*HCH bioremediation field trial is under progress at Umari village of Barabanki, Uttar Pradesh*



*First application of bacterial formulation and nutrient mixture in HCH-contaminated soil by all project partners on September 6, 2018*



# INTEGRATED POLICY ANALYSIS

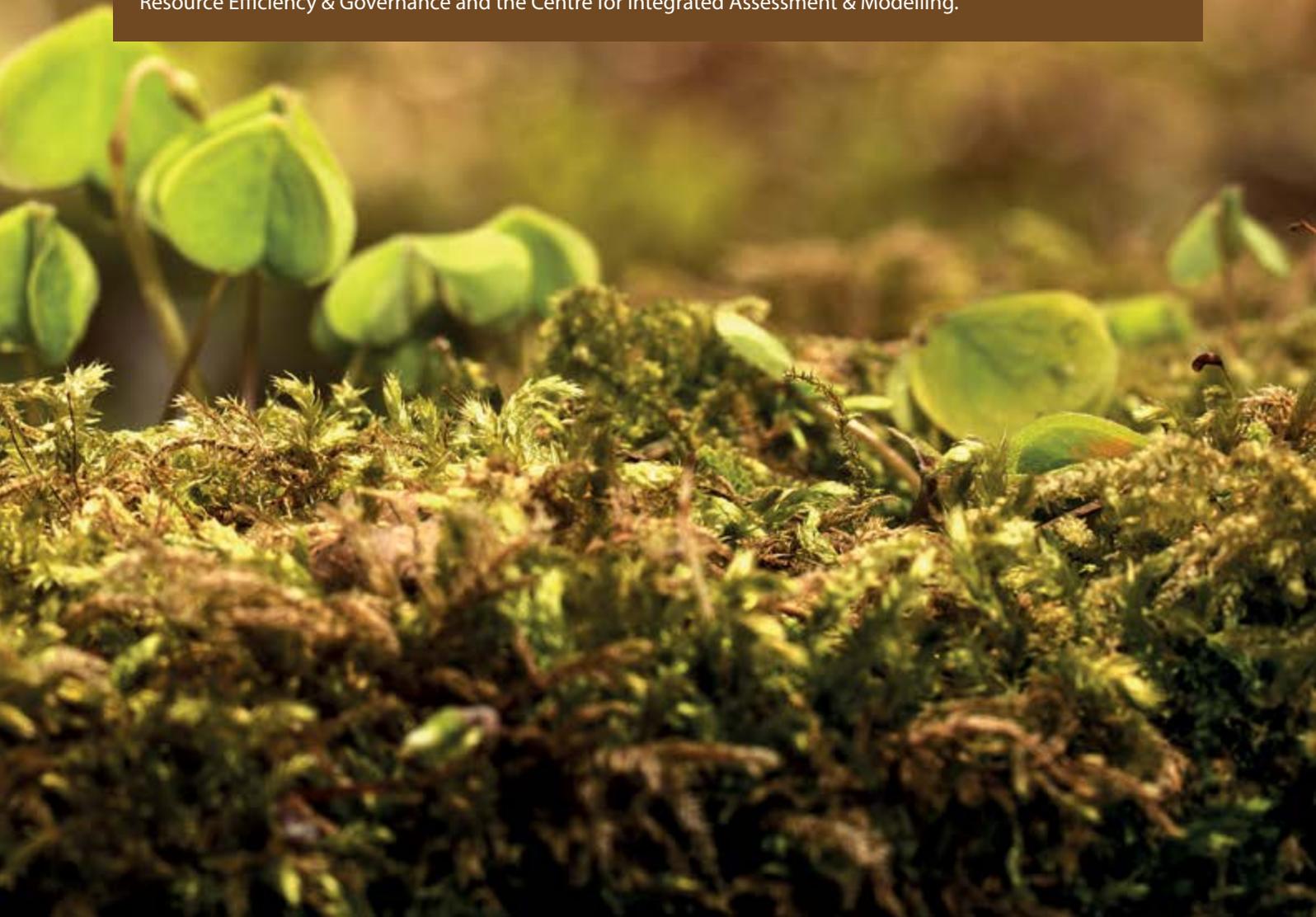


**T**he Integrated Policy Analysis (IPA) Programme aims to inform policy on the critical sustainability issues of our time through in-depth and inter-disciplinary research. Our research seeks to answer the central question, 'How can policy be designed to scale up solutions that successfully decouple economic development from natural resource use and environmental degradation while enhancing livelihood opportunities and the quality of life?'

The Programme aims to provide an integrated perspective for policy design, with a focus on analysing the following issues:

- Demand and availability of resources from multiple perspectives and scenarios, including carrying capacity assessments;
- Sustainable production including resource efficiency, waste management, and circular economy, and linkages with larger socio-economic issues;
- Sustainable consumption, with a focus on lifestyles, consumption patterns, and waste generation;
- Resource and environmental governance and its political economy at local, national, and global levels;
- Modelling of economy–energy–environment linkages and alternative development pathways;
- Bio-physical interactions across land, water, air, and biodiversity

Research on these issues is complemented by a range of publications and active participation of the programme members in training programmes, conferences, other events, and government working groups to enhance the outreach and impact of work. This work is carried out through two centres of the Programme—the Centre for Resource Efficiency & Governance and the Centre for Integrated Assessment & Modelling.



## Centre for Resource Efficiency & Governance

The Centre for Resource Efficiency & Governance (CREG) within the IPA programme serves as the focal point for TERI's work on studies and projects on resource efficiency, sustainable consumption, and resource governance, including issues related to trade in natural resources.

The division successfully completed a study on resource efficiency in India with support from GIZ. The study provided inputs for the end-of-life vehicle scrapping policy and metal recycling policy prepared by the Central Pollution Control Board, which are currently under consideration by the Government of India. In continuation of this work, TERI, with support from the European Union, launched another initiative on resource efficiency to cover new sectors, such as renewable energy and electric mobility.

The division completed a systematic study on resource revenue management and an evidence summary study on disaster management practices. A study on 'Technology Foresight for Natural Resources and Environment Security', in collaboration with Technology Information, Forecasting and Assessment Council (TIFAC), is in its final leg, and the National Security Council has already taken note of it. The division is also preparing the *State Environment Report* for Nagaland.

The division also undertakes capacity building and advocacy on regulatory issues applicable to energy, minerals, and the environment. Accordingly, in 2017/18,



**Towards Resource Efficient Management of Plastic Wastes at the WSDS 2018**

the division organized a number of international, national, and local training programmes, including two ITEC (Indian Technical and Economic Cooperation) programmes for the Government of India. Divisional members have served as faculty for training programmes organized by other agencies, such as the Comptroller and Auditor General of India. Conferences organized by the division included themes, such as resource efficiency, water resource security, and marine resources. During the year under review, the researchers of the division have brought out several publications in the form of books, book chapters, and articles in journals, newspapers, and magazines. A collection of papers, titled *India's Resource Security: Trade, Geopolitics and Efficiency Dimensions*, highlighting major aspects encompassed by resource security, such as sustainable resource development and extraction, production and use, trade and investments, geopolitical considerations,

and intergovernmental and multilateral cooperation, was published in January 2018. As in the previous years, the Division undertook an assessment of the Union Budget for its impact on energy, environment, and natural resources. The assessment was shared with the media and made available on TERI's website. The researchers of the Division also made presentations at various national and international conferences.

## Centre for Integrated Assessment & Modelling

The Centre for Integrated Assessment & Modelling (CIAM) is continuously engaged in the development and use of various tools and modelling frameworks



**Book Launch of Policy & Business in Action Towards Closing the Loop at the WSDS 2018**

for energy and economic forecasting, techno-economic analysis and scenarios of energy and environmental simulation and optimization. Through these models and tools, the Centre provides energy, economy, and environment-related inputs to researchers, industry, and policy makers at the global, national, and sub-national levels.

In 2017/18, the division successfully completed a project supported by the European Commission with the objective to explore strategic options before India in pursuing the Nationally Determined Contributions (NDCs) while responding to immediate imperatives of development. The study analysed the Indian economy over the last few years, with reference to the power sector, to understand the various possibilities in the near- to mid-term future for transforming the sector. Another project, supported by GIZ, focussed on estimating the energy efficiency potential of India. The objective was to identify key focal points in the Indian energy system where transition to energy-efficient processes and technologies would have the maximum impact.

The division is currently undertaking two power sector related projects supported by the Norwegian Ministry of Foreign Affairs (NFA). The objective of the first is to provide forecasts of electricity demand across regions and different consumer categories. The second aims to develop an integrated energy demand-supply model (using the TIMES platform) towards a resource efficient and sustainable energy sector.

Another ongoing study on Linking Climate and Development Policies, supported by the European Commission, aims at improving the scientific understanding of the linkages between climate change and multiple



**Electric Vehicles in India: The Resource Efficient Way at WSDS 2018**

sustainable development objectives, through joint research and sharing of experiences, methods, and data between leading research institutions and key stakeholders from G20 countries. As part of the project, and in association with the International Institute of Applied Systems Analysis (IIASA), the division hosted a set of events around energy and resources modelling from March 19–23, 2018. The events brought together a consortium of 19 leading international research organizations (from Brazil, China, India, Japan, Russia, Republic of Korea, USA, and Europe) to explore national and global transformation strategies for climate change and their linkages to a range of sustainable development goals (SDGs).

The *TERI Energy and Environment Data Diary and Yearbook (TEDDY)*, a comprehensive energy and environment publication, is brought out annually by TERI. The coordination work for publication of this yearbook is executed by the division. The annual

publication seeks to support policy research and decision-making by providing state-of-the-art information and analysis on energy supply, energy demand, and the environment. Each edition of TEDDY contains India's commercial energy balances that provide comprehensive information on energy flows within different sectors in the economy.

The division has significantly contributed to *Global Environment Outlook (GEO) 6*, a publication by the United Nations Environment Programme (UNEP), which informs environmental decision-making by providing an integrated assessment on state, trends, and outlook of the environment and facilitates interaction between science and policy. Besides focussing on issues related to air, water, climate change, chemicals and waste, biota, etc., this year the analysis looked into the cross-cutting interactions between energy and each of these environmental domains.



# NATURAL RESOURCES AND CLIMATE



The Natural Resources and Climate (NRC) Programme spearheads research in providing innovative and resource-efficient solutions for management of water resources, waste resources, and bioresources (including application of bioresources); aims to become a global leader in providing scientific knowledge and solutions through evidence of air pollution, climate change, and their impacts, by involving ecological processes, technology, institutions and policy initiatives; and seeks to spearhead on field programmes to eradicate malnutrition from the rural and urban areas of India.

The NRC Programme seeks to facilitate maximization of socially-acceptable resource recovery and recycling and address health impacts, release of climate pollutants from waste disposal; provide safe water and improvement in water use efficiency in industrial, domestic, and irrigation sectors and enhance water availability through water conservation interventions; link sustainable forest management and biodiversity conservation with poverty alleviation; facilitate actions at the centre and state levels to improve air quality in Indian cities by at least 50%; facilitate governments to go beyond commitment in NDC (Nationally Determined Contribution) and create sustainable models demonstrating efficient resource use in rural and tribal areas.

The NRC Programme consists of five divisions—Earth Science and Climate Change; Forestry & Biodiversity; Environment & Waste Management; Water Resources; and Nutritional Security.

A multidisciplinary team of research professionals in the Programme conducts action research on issues ranging from regional impacts of the changing climate, international climate negotiations to grassroots innovation on climate action. Over the last two decades, the Programme has developed state-of-the-art capabilities for assessment of air pollution and its contributing sources which are essential for development of air quality management plans. The NRC is also working for sustainable forest management and has been providing solutions to generate finance through carbon trading from forests, fixing minimum support price of minor forest produce, developing quality planting material, establishing the methodology for carbon assessment and community-based ecotourism. The NRC focusses on areas covering policy and regulatory issues, waste management planning and financing, research and development (R&D) and technology deployment for waste processing, recovery and recycling, and material flows and linkages to circular economy. The NRC has comprehensive infrastructure & expertise for undertaking projects in the field of water use efficiency & water conservation, watershed management, urban water demand management, glacier research, hydrological assessments, rural water supply and sanitation, water quality & pollution studies, and policy analysis. On the issue of nutrition, the NRC is committed to develop sustainable solutions to tackle malnutrition across all sections of the society through approaches, such as research, policy interventions, and implementation of innovative approaches and technologies.

The primary focus of the Programme is to promote landfill-free cities by facilitating resource recovery and recycling; establish sectoral benchmarks for water use to assist policy for enhancing water use efficiency and create a cadre of water auditors through training & capacity building; facilitate increase in water conservation through rainwater harvesting, groundwater recharge, etc., at the household and watershed levels; quantify sustainable harvest of minor forest produce and enhance income of Forest Dwelling Communities (FDCs) through value addition and market mechanism; develop Interactive Climate Tool (ICT) for decision making and prediction of climate extremes at regional scales; develop standardized tool for tracking achievement of implementation of NDCs and sustainable development goals (SDGs); and develop healthy communities through policy interventions and awareness.

# Forestry & Biodiversity Division

## Centre for Biodiversity and Ecosystem Services

The Centre for Biodiversity and Ecosystem Services, besides focussing on species or habitat loss, also lays stress on policies and social and economic issues that undergird biodiversity declines—arguably one of the most vexing problems facing the world today. Over the years, we have influenced strategic planning in biodiversity by developing a detailed biodiversity strategy and action plans for several Indian states (including Uttar Pradesh, Uttarakhand, and Punjab) and mainstreaming biodiversity through its incorporation in climate action plans. The centre is working on a range of projects of national and international significance, including the GEF Satoyama project, in which TERI is mainstreaming community-conserved areas (CCAs) for biodiversity conservation in Nagaland by linking the CCAs across the landscape for forest protection. Other activities include developing nature-based ecotourism and developing a state-level policy for community conservation. Linking conservation with traditional practices and beliefs is another focus area, including exploring the potential of sacred natural sites in enabling forest protection, for instance, in Uttarakhand. Additional elements of work relate to protected area management, addressing human–wildlife interactions, assessing the socio-economic linkages and dependencies of local communities on forest and protected areas, community institutional strengthening, biodiversity surveys, and management planning for protected areas.



GEF Satoyama Workshop in Mauritius

## Centre for Forest Management and Governance

### *Training and Capacity Building of the Forest Department*

With possibilities of accessing carbon-based financing from forestry activities, the group has organized a capacity building and training programme of the Chhattisgarh Forest Department for assessment of the carbon stocks of forests and also developed a manual on the carbon stock assessment of forests. A similar training programme is scheduled in Uttarakhand and also in other states.

### *Monitoring and Evaluation*

Assessment of impacts in the area of forestry and natural resource management is a continuing area of interest in the group. The group has carried out a major long-term study on Monitoring, Evaluation, Learning and Documentation (MEL&D) of projects under Integrated Watershed Management Programme (IWMP) for batch II, III, and IV projects in Uttarakhand and has completed all the tasks, including baseline reports, thematic reports, work phase reports, preparatory phase reports, indicator-wise monthly process monitoring reports, case-studies, etc.

“The centre is working on a range of projects of national and international significance, including the GEF Satoyama project, in which TERI is mainstreaming CCAs for biodiversity conservation in Nagaland.”

The assignment has been implemented by a multidisciplinary team, comprising of professionals specializing in forestry, agriculture, hydrology, watershed management, GIS, biodiversity, livestock, economics, and sociology.

### *Estimation of Minimum Support Price*

The group has been involved in estimating the minimum support price for selected Minor Forest Produce with the Tribal Cooperative Marketing Development Federation of India Ltd. The group has completed the estimation of minimum support price (MSP) for 54 minor forest produce (MFP). It is pertinent to note here that based on TERI's research, the government is revising the rates for these MFPs.



Training of forest personnel of assessment of carbon stock



## Nutritional Security Division

The Nutritional Security Division (a newly formed division in TERI's organizational structure) has been actively working in the field of nutrition security since the past 6 years, as part of TERI's Western Regional Centre (WRC). The primary vision of the division is promotion of sustainable methods and practices to address the issue of malnourishment, including micro-nutrient deficiencies, in rural and urban areas. The main focus of the division is to promote localized solutions to address malnutrition through short-term and long-term strategies, while using innovative approaches to tackle bottlenecks. The team, comprising experts from diverse fields, works on a diverse range of projects including urban farming, compiling analytical status reports, and so on with stakeholders, such as corporates, government agencies, industries, citizens, and academia. The division is continually working on carrying out research and developing prototypes that could be successfully demonstrated while at the same time exploring the replication of successful projects to maximize the impact.

## Water Resources Division

Water resources in India are under severe pressure due to escalating demand, over-exploitation, inefficient use and pollution, amongst others. With an aim to develop and implement integrated solutions for sustainable water management, the Water Resources Division provides services in core areas, such as applied research, training, and

implementation. The division has core competencies in quantitative and qualitative assessment of water resources, water audit and water foot-printing, watershed management, urban water demand management, glacier research, hydrological assessments, rural water supply and sanitation sector, water quality and pollution studies, and policy analysis. The division has also assisted the state government in developing sustainable lake water management plan and has been instrumental in assisting corporates in implementing safe water and sanitation interventions and in pond water rejuvenation.

The group also works on the important emerging issue of water-energy-food and climate change nexus and has analysed the intricate nexus at various spatial scales with a focus on urban areas and power generating plants. The division has been actively involved in carrying out various research activities in the high altitude regions, including studies on glaciers and glacier fed catchments and their impact on the downstream community. The division is also a Resource Centre on Water Use Efficiency, jointly hosted by TERI and Jain Irrigation

Systems Ltd. It has been endorsed as the Regional Knowledge Hub for Water and Climate Change Adaptation by the Asia Pacific Water Forum. It has also been recognized as the National Key Resource Centre for rural drinking water and sanitation by the Ministry of Rural Development, Government of India.

With a multi-disciplinary team of experts, the division has been instrumental in providing research-based innovative solutions for sustainable water management as well as policy inputs to assist the goals of the government.

## Earth Science and Climate Change Division

### Centre for Environmental Studies

The Centre for Environmental Studies (CES) works with a broad aim to study the environmental dimensions of various economic activities and resource-use patterns and explore strategies to mitigate the adverse effects. The group conducts applied and policy research to address environmental problems and assesses the relationships between energy and environment in urban, industrial, and rural settings. The CES group has undertaken various projects to examine environmental impacts associated with urbanization, industrialization, and other anthropogenic activities. Our research has focussed on several aspects of air pollution, including regional-scale assessment of air quality, impacts of air pollution on health and agriculture, indoor air quality assessment in rural and urban buildings, management of emissions from transport and industrial sectors, linking air quality to climate





**EU-India Air Quality Initiative**

change, training and capacity building in air quality, etc. CES has also been active in providing assistance to government bodies for the formulation of *State of Environment Reports* and environmental policies. The group assisted the Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India, in the preparation of the draft National Environment Policy and has also been recognized by the MoEFCC as one of the National Host Institutes for facilitating development of *State of Environment Reports* at the state level. The CES group has also been focussed on providing state-level policy recommendations through several source apportionment studies which guided state level regulatory authorities to develop local action plans for control of air pollution and its impacts. The group has made several policy submissions to the highest levels in the government in the field of air quality management. Latest in the series is a report on *Breathing Clean Air - Ten Scalable Solutions for Indian Cities* which identifies solutions for clearing up the air in India. The group also released its assessment report on the odd-even assessment and also submitted an emergency response plan to both state and central government for tackling high air pollution episodes. The group continues to strengthen and build capacity and spread awareness on different environmental issues, including air pollution. Training programmes are regularly conducted for different stakeholders to build their capacity in air quality modelling, exposure assessment, indoor air pollution, environmental pollution and health, and other environmental issues.

### **Centre for Global Environment Research**

The Centre for Global Environment Research is involved in research on

global, national, and sub-national climate policy which is strongly supplemented by climate and hydrological modelling to arrive at evidence-driven climate mitigation and adaptation strategies and pathways for a resilient planet. The Centre builds on a strong interdisciplinary team comprising of economists, physical scientists, engineers, and social scientists to aide in holistic climate change planning and decision making. The Centre, in the year 2017/18, was involved in negotiations as part of the Montreal Protocol Amendment, as a knowledge partner to the Indian Government, where India made ambitious pledges towards efficient refrigerant transitions. The team is also exploring linkages between Sustainable Development Goals and Nationally Determined Contributions to develop an understanding on the role of co-benefits in meeting climate action targets. The Centre through its research on the various articles of the Paris Agreement has developed options for operationalizing the agreement. Domestically, the Centre worked on a novel climate risk profiling, delivering asset risk profiles, and necessary actions for India's public sector oil & gas companies. Through its strong expertise on hydrological, climate, and geospatial modelling, the division delivered an evidence base for disaster mitigation and climate change adaptation strategies, working on flood-mapping (for the city of Bengaluru) and urban-heat island study (for the city of Jharsuguda and New Delhi) at a sub-national level. Under its recent collaboration with central ministries and international research institutes of repute, the centre has initiated policy relevant scientific research focussing on monsoons, extreme climate, and impact studies.

The team is also currently assisting various bilateral, multilateral, and governmental donor agencies in

implementing projects related to greenhouse gas inventories and Monitoring, Reporting and Verification of mitigation actions; climate change vulnerability and adaptation in the Hindu Kush Himalayan region; assessing the impact of key climate finance models and schemes on achieving climate goals and to understand and provide inputs for developing carbon markets; and developing stakeholder-driven climate information portal for various extreme and slow onset climate impacts. For the ensuing years, the centre is prioritizing research on managing hydrological disasters, sub-national actions through State Action Plans on Climate Change in India, market-based mechanisms for climate change mitigation, and efficient refrigerant transitions.

## **Environment & Waste Management Division**

The mandate of the Environment & Waste Management Division includes researching on policies, regulation, governance, health and technological solution development for pollution control, and management of solid and liquid waste streams.

Under the division's recently completed Municipal Solid Waste Initiative Implementation project, in collaboration with the Climate and Clean Air Coalition (CCAC), the division worked with selected eight cities in India to improve their solid waste management practices to reduce short lived climate pollutants (SLCPs), such as black carbon and methane. In the project, Strengthening Water and Sanitation in Urban Settings, supported by USAID, the division worked in the urban

slum clusters in Chennai and Kolkata for an extensive baseline survey on various socio-economic aspects, health, sanitation and solid waste management and help rehabilitate community toilet complexes in the slums in two cities.

Implementation of Resource Efficient Cleaner Production (RECP) measures continued for the metal sector in Bangladesh, Nepal, and Sri Lanka as part of the METABUILD project supported by the European Commission under the SWITCH Asia programme. In the second year of the project, close to 250 companies were involved; more than 200 measures were implemented and 87 showcases were identified. The division was also involved in RECP implementation in industrial clusters in Delhi and Vapi. Around 100 companies were assessed and implementation support is being provided to 30 companies. During the year under review, the division successfully completed two studies on 'The Assessment & Mapping of Cement Plants & Municipal Solid Waste Processing Facilities', in partnership with GIZ, and 'Feasibility Study for RDF Availability for Cement Kilns in India', supported by Suez, to estimate the availability of RDF within 100, 200, and 300 km radius of cement kilns for promoting usage of municipal solid waste or MSW-based RDF for co-processing in cement plants in India and developing innovative business models to help facilitate this mechanism.

The work on the water/wastewater treatment focussed on membrane bioreactors, forward osmosis process, and resource recovery. Under this, a forward osmosis is being studied for melanoidins concentration and water recovery in distillery wastewater. The division is also involved in developing various applications, such as high performance nano-composites using recycled comingled plastics for fire retardant applications; electromagnetic Interference (EMI) shielding by divisional members at Bengaluru; and different superabsorbent bio nano-composite by microwave-assisted method for removal of toxic dyes and heavy metals from water bodies.

On the health side, a study is being undertaken to generate exposure–response function or relative risk information based on ambient air pollution and health outcomes. Under this study, we are collating daily disease specific, hospital admission data for selected respiratory and cardiovascular conditions from Delhi-based hospitals and using ambient air pollution data for fine particulate matter (PM<sub>2.5</sub>) and

ozone concentration from stationary air quality monitors of Delhi Pollution Control Committee (DPCC) and Central Pollution Control Board (CPCB) to quantify this association. As per a larger initiative, Understanding Climate Health Associations in India (UCHAI), partially supported by the NIEHS and NOAA, we are also developing a tool/ app to predict reported cases of disease—specifically malaria as a proof-of-concept using meteorology parameters. Besides this, the division undertook many capacity building and dissemination activities during 2017/18.

## Centre for Waste Management Area

The Centre for Waste Management (CWM) recently completed a project in collaboration with the Climate and Clean Air Coalition (CCAC) Waste Initiative. In the project, the team worked with selected eight cities in India to improve their solid waste management practices to reduce short lived climate pollutants (SLCPs), such as black carbon and methane. The team also modelled SLCPs for East Delhi and Coimbatore and formulated work plans for waste management and identifying priorities for waste management in respective cities. An Indian CCAC city network has been formed and capacities of city officials were built in various spheres of waste management via series of 10 webinars, 3 workshops, and 2 site visits.

Under the USAID-funded project on 'Strengthening Water and Sanitation in Urban Settings', the project involved working with urban slum clusters in Chennai and Kolkata for an extensive baseline survey on various socio-economic aspects as also health, sanitation, and solid waste management parameters and also conducted drinking water testing to establish a correlation between health and sanitation. Thereafter, through pairwise ranking method, sanitation interventions in the two cities were identified and implemented, along with a local self-help group. The interventions have been sustained beyond the project period and help in reducing burden of water-borne diseases in the selected urban slum clusters. The broader objective of the study was also to develop a course curriculum on WaSH which has been implemented in the TERI School of Advanced Studies and is spreading to other universities.

The CWM Area successfully completed two studies on Cement Plants—'The Assessment & Mapping of Cement Plants & Municipal Solid Waste Processing

Facilities' in partnership with GIZ and 'Feasibility Study for RDF Availability for Cement Kilns in India', supported by Suez. The GIZ study was to estimate the availability of RDF within 100, 200, and 300 km radius of cement kilns for promoting usage of MSW-based RDF for co-processing in cement plants in India and developing innovative business models to help facilitate this mechanism. The Suez study was to study the technical and financial feasibility of co-processing RDF in cement plants. The study explored opportunities and barriers presented by the mechanism in India. The study also covers detailed discussions with waste management experts and key cement kilns operators with experience of working with RDF as an AFR.

On the health side, study is being undertaken to generate exposure–response function or relative risk information based on ambient air pollution and health outcomes. Under this study, we are collating daily disease specific, hospital admission data for selected respiratory and cardiovascular conditions from Delhi-based hospitals and using ambient air pollution data for fine particulate matter (PM<sub>2.5</sub>) and ozone concentrations from stationary air quality monitors of DPCC and CPCB to quantify this association. Another area of focus is creation of a health and wellbeing index to assist and monitor its achievement brought forth by the Health and Family Welfare department. This study uses systematically collated data in six domains—child health, women's health, climate-sensitive illnesses, chronic morbidities, communicable diseases, and mental health to rank small administrative areas (districts). This methodology helps to proactively identify areas for innovation, interventions and policymaking for better population level health outcomes. As per a larger initiative, Understanding Climate Health Associations in India (UCHAI), partially supported by NIEHS and NOAA we are also developing a tool/ app to predict reported cases of disease, specifically malaria as a proof-of-concept using meteorology parameters.

Many capacity building and dissemination activities were organized during 2017/18— Global Natural Resources Conclave (GNRC) on 5 and 6 April, 2017, at Taj Palace, New Delhi; operationalization and handing over of community toilets organized in Kolkata on 29 August, 2017, and in Chennai on 27 October; Workshop on capacity building in environmental exposure assessment and health research, UCHAI workshop on High Resolution Climate Projections and Analysis for India;

Workshop on enhancing city readiness on Solid waste management, Bengaluru on 19 December, 2017, and Delhi on 21 December, 2017, and under the CCAC project a series of ten webinars and 3 site visits were also organized.

### Resource Efficient Technologies

The activities in water/wastewater treatment focussed on membrane bioreactors, forward osmosis process, and resource recovery. Forward osmosis is being studied for melanoidins concentration and water recovery in distillery wastewater. A membrane bioreactor with ash-based ceramic membranes has been installed in a school in Guwahati for treating sewage from the toilets. Anaerobic membrane bioreactor is being tested on-site at Barapullah drain as part of an Indo-Dutch project. Biomass from phytoremediation is being used as a source for activated carbon which is being tested for removal of volatile organic compounds.

Environment-friendly plastics, such as biodegradable polymers for packaging, biomedical, fire resistant applications, and eco-friendly additives for electromagnetic interference (EMI) shielding are being developed at TERI Bengaluru. High performance nano-composites using recycled comingled plastics for fire retardant applications were developed. We have also

developed different superabsorbent bio-nano-composite by microwave-assisted method for removal of toxic dyes and heavy metals from water bodies. The group also has well-furbished laboratory for polymer materials which is fully equipped with all the necessary instruments and equipment needed for processing and to carry out various tests.

Implementation of resource efficient cleaner production (RECP) measures continued for the metal sector in Bangladesh, Nepal, and Sri Lanka as part of the METABUILD project supported by the European Commission under the SWITCH Asia programme. In the second year of the project, close to 250 companies were involved; more than 200 measures were implemented and 87 showcases were identified. TERI was also involved in RECP implementation in industrial clusters in Delhi and Vapi. Around 100 companies were assessed and implementation support is being provided to 30 companies. The savings from these implementation measures are being quantified.

### Resource efficient supply chain for metal products in buildings sector in South Asia (METABUILD)

This project targets enhancement in the use of sustainable production technologies and practices in 400 small

The division is also a Resource Centre on Water Use Efficiency, jointly hosted by TERI and Jain Irrigation Systems Ltd. It has been endorsed as the Regional Knowledge Hub for Water and Climate Change Adaptation by the Asia Pacific Water Forum. It has also been recognized as the National Key Resource Centre for rural drinking water and sanitation by the Ministry of Rural Development, Government of India.

and medium enterprises (SMEs) in the metal products supply chain for the building and construction sector in Bangladesh, Nepal, and Sri Lanka. The other target groups include technology suppliers, financial institutions, customers, and public officials and local consultants.

The project is currently working with close to 250 companies in Bangladesh, Nepal, and Sri Lanka and more than

This section details the projects undertaken by the Division during 2017/18 along with a short description of their purpose and areas of work.

200 RECP implementations have been completed. Several RECP measures have been implemented across industries (<https://www.metabuild-southasia.org/resource-centre/showcases>) in all three target countries, thereby validating the METABUILD approach.

### Local Treatment of Urban Sewage Streams for Healthy Reuse (LOTUS<sub>HR</sub>)

LOTUS<sup>HR</sup> will demonstrate a novel holistic (waste-) water management approach for the recovery of water, energy, and nutrients from urban wastewater. The required treatment and reclamation steps will be determined by the water quality needed for safe and healthy reuse in households, industry, and urban agriculture. Innovative but proven robust technologies will be incorporated in a



Anaerobic membrane bioreactor being explained to visitors from The Netherlands

modular pilot treatment plant along the Barapullah drain.

The project has established the site for analytical laboratory and demonstration plants for anaerobic treatment, algal treatment, and wetlands have been set up. TERI has set up anaerobic membrane

bioreactor with ash-based ceramic membranes and is also involved in socio-economic studies related to treated water reuse.

## Strengthening Water and Sanitation in Urban Settings

The USAID-funded project on Strengthening Water and Sanitation in Urban Settings, includes other partner institutions, such as Coca Cola, TERI School of Advanced Studies, and TERI. The project involved working with urban slum clusters in Chennai and Kolkata for an extensive baseline sanitation survey on various aspects of socio-economic conditions, health, sanitation, solid waste management, and also conducted drinking water testing to establish a correlation between health and sanitation. Thereafter, through pairwise ranking method participatory sanitation interventions in the two cities were identified and implemented,

▣ The work on the water/wastewater treatment focussed on membrane bioreactors, forward osmosis process, and resource recovery. Under this, a forward osmosis is being studied for melanoidins concentration and water recovery in distillery wastewater. ▣



*Meeting at Kolkata with community-based institutions*

along with a local self-help group. The intervention which is sustained beyond the project period, helps in reducing burden of water-borne diseases in the selected urban slum clusters. The broader objective of the study was also to develop a course curriculum on WaSH which has been implemented in the TERI School of Advanced Studies and is spreading to other universities.

### The Climate and Clean Air Coalition Initiative: Municipal Solid Waste Implementation

With a mandate to reduce Short-Lived Climate Pollutants (SLCPs), TERI along

with Climate and Clean Air Coalition (CCAC) worked on first, improving waste management practices in two Indian cities, that is, East Delhi and Coimbatore, and second, establishing an Indian city network under the CCAC- Municipal Solid Waste initiative for building capacities and helping in reduction of SLCPs from the municipal solid waste (MSW) sector vis-a-vis improving waste management practices. The current waste management systems of East Delhi and Coimbatore were reviewed, SLCP emissions were estimated (from waste handling, transportation, treatment, disposal, and combustion), and priorities in waste management were identified for cities, helping them manage



*Renovated toilet at Chennai*



*Team working at Ghazipur landfill site at East Delhi to support in landfill fire and slope stability*

MSW and reduce SLCP emissions. The priorities for the city were identified considering various sustainable, technical, economic, environmental, and social aspects. The cities' financial mechanisms were reviewed and officials were trained to help them find possible options for financing waste processing projects. Indicators were developed for measurement, reporting, and verification, insofar as what can be measured, can be managed. East Delhi was also assisted in conducting a feasibility study to address slope stability of existing landfill and managing fires at the landfill site. The city network created in India as part of the project, helped in developing inter-city partnerships, extending technical assistance opportunities to all the eight cities part of this city network. This assistance was provided through identification of gaps and priorities of the network cities in various aspects of waste

**■** The current waste management systems of East Delhi and Coimbatore were reviewed, SLCP emissions were estimated (from waste handling, transportation, treatment, disposal, and combustion), and priorities in waste management were identified for cities, helping them manage MSW and reduce SLCP emissions. **■**

management. A series of eight webinars were conducted along with on-site visits to discuss solutions to common issues faced by the municipal corporations.

### **Global Natural Resources Conclave (GNRC)**

TERI was involved as a knowledge partner in a project with Network 18 in organizing the Global Natural Resources Conclave (GNRC) on 5 and 6 April, 2017, at Taj Palace, New Delhi. The Conclave served as a platform that aimed to create awareness and also explained the ground realities in terms of issues and opportunities and drawing the natural resources dividend. The Conclave saw proactive collaboration from industry

leaders in the natural resources space, spanning all sub-sectors, including oil & natural gas, mining & minerals, power, metals, such as aluminium, copper, zinc, etc. This Conclave aimed to position India as a formidable global player in the natural resources landscape, enabling an opportunity for global business to partake of the untapped opportunity in India and bringing together relevant experts, including policymakers and industry leaders. The two-day event was attended by about 1,000 delegates, including participants from over 30 countries and had 20 foreign speakers. The event witnessed several industry stalwarts, ministers, global thinkers, industry bodies, and think tanks deliberate upon the present and the



*Facilitating site visit to Pune to build capacities of the CCAC Indian network cities*

Understanding Climate Health Associations in India (UCHAI) initiative has been housed at TERI. It brings together professionals, experts, organizations, and knowledge systems to address climate change and health issues in India. UCHAI assists with building capacity for climate proofing of the human health sector in India.

future challenges being faced by the sector in India. With a broadcast and digital footprint that reached millions, GNRC emerged as the biggest event of its kind organized by a media house. The editorial might of Network18 lend itself to amplify the initiative with coverage across CNBC-TV18, CNN-News18, CNBC Awaaz, News18 India (international feed), Firstpost.com, and Moneycontrol.com. The social media campaign with the hashtag #GNRC2017 reached more than 16 million users and generated close to about 1,000 unique tweets by the end of the Conclave.

**Global Natural Resources Conclave (GNRC) on 5 and 6 April, 2017**

*Understanding Climate Health Associations in India (UCHAI)*

- Majority of the population in India currently suffers from high burden of vector-borne diseases, heat stress-related diseases, and malnutrition. These health problems are all sensitive to seasonal variations in temperature and precipitation patterns. These short-term variations in temperature and precipitation as well as extreme storms have been observed to be increasing in intensity due to global climate change. Consequently, it is important to build climate resilience within the health systems to deal with these problems more effectively in the present and into the future as climate change progresses. With this background, Understanding Climate Health Associations in India (UCHAI) initiative has been housed at TERI. It brings together professionals, experts, organizations, and knowledge systems to address climate change and health issues in India. UCHAI assists with building capacity for climate proofing of the human health sector in India. It aims to bring together academicians, researchers, practitioners, and students from multidisciplinary fields, including climate science, environment, public health, public policy, social development, and urban planning through a resource network and community of practice.
- For information on the network, please log on to the UCHAI website at <http://uchai.net/>

- UCHAI workshop on “High Resolution Climate Projections and Analysis for India”

**Assessment and mapping of Cement Plants and Municipal Solid Waste Processing Facilities**

GIZ partnered with TERI in a study to map and assess cement plants and MSW processing facilities in India. The objective of the study was to estimate the availability of RDF within 100, 200, and 300 km radius of cement kilns for promoting usage of MSW-based RDF for co-processing in cement plants in India. Further, TERI was also involved in developing innovative business models to help facilitate this mechanism.

**Feasibility study for RDF availability for cement kilns in India**

Suez Environment partnered with TERI to study the technical and financial feasibility of co-processing RDF in cement plants. The study explored opportunities and barriers presented by the mechanism in India. The study also covers detailed discussions with waste management experts and key cement kilns operators with experience of working with RDF as an AFR.



Renovated toilet complex at Kolkata



# SOCIAL TRANSFORMATION





The Rural Energy and Livelihoods Division of TERI's Social Transformation (ST) Programme continues its pioneering work to help achieve universal access to sustainable, affordable, reliable, and modern energy to attain the goal of SDG 7, thereby catalysing socio-economic development of communities in a gender- and socially-inclusive manner. Innovations in technological solutions as well as business models, partnerships, and knowledge generation are the cornerstones of its action-research based approach. Towards this, it leverages multi-disciplinarity on one hand and its breadth spanning decades of hands-on implementation experiences to appropriate technologies to markets to policies to capacity building, on the other. Over the years, the group has developed a deep understanding of field-level challenges, including consumer behaviour; establishing value chain and financing at different levels. The strength of the Social Transformation Programme lies in establishing partnerships with grassroots institutions—such as Rural Livelihood Missions—and its ability of working bottom-up through extensive stakeholder engagement, especially women. Its multi-dimensional approach brings together evidence-based research; technology, socio-cultural, and economic aspects of the universal energy access. The fact that it covers the whole gamut, from research to piloting to capacity building to knowledge generation, adds to its uniqueness.

Besides provisioning of basic energy, that is, energy for lighting and cooking; now there is an increased thrust on clean energy interventions for livelihood creation and enhancement under its flagship programme 'Lighting a Billion Lives' (LaBL). Working with loom owners, weavers and boatmen in and around Varanasi is a part of that endeavour. Witnessing the problems faced by many power looms in villages near Varanasi that remain immobile for hours daily due to erratic electricity supply resulting in loss of income for both, the loom owners and the weavers; TERI came up with solar-grid hybrid looms to address this widespread problem. Solar and state-of-the-art Lithium-ion batteries now ensure uninterrupted operation. As a result, not only weavers now earn about 40%–50% more, they also enjoy better social life as well. Likewise, analysing problem of diesel boats belching thick black smoke along with constant jarring noise in close consultation with the local boatmen; TERI worked out a solution consisting of advanced electric outboard motor with solar charged Lithium-ion batteries. But instead of voluminous solar panels being mounted on the boat, new business model of central solar charging station with battery swapping facility was tried. While these boats are easy to navigate and move with comparable speed even in strong currents, Li-Ion batteries weighing only about one-sixth of conventional batteries, makes battery swapping easier. These 'Uttam Urja' boats create zero pollution of any kind, not even a buzz. In yet another initiative, micro solar pump with sprinkler irrigation system is being used to enhance farmer's income in a small village in Assam.

LaBL has been working to promote energy entrepreneurship for over a decade, from Village Level Entrepreneurs (VLEs) to cluster-level energy entrepreneurs for providing clean energy services as well as in sales, service, and awareness generation for lighting and cooking energy in the rural areas.

The Social Transformation Programme aims to enlarge its global footprint in provisioning of sustainable energy for inclusive development of rural communities and enterprises; besides being a knowledge repository in this field.

# Centers for Impact Evaluation and Energy Access

Centers for Impact Evaluation and Energy Access (CIEEA) at Delhi and Bengaluru work closely with rural communities on overarching themes of energy, gender, social inclusion and livelihoods through research and analysis, impact evaluation, need assessment; market studies, socio-economic surveys, watershed development and efficient utilization of natural resources like fuels. In the past year, CIEEA, Delhi, has worked on a variety of research areas spanning issues of energy access, electricity pricing, clean cooking, gender inclusion, replacement of fossil fuel subsidies and health impacts of indoor air pollution. The key clients include DFID, The World Bank, WHO, IISD, GIZ, and ENERGIA.

The Centre for Impact, Evaluation and Energy Access, Bengaluru (CIEEAB)

With the support of the Department of Science and Technology, the area is aiming to improve sustainable energy access amongst SC/ST households in Chamarajanagar district in Karnataka. During the year 300 improved cookstoves, 125 Integrated Domestic Energy System (IDES) have been disseminated, along with user training and capacity building of local technicians.



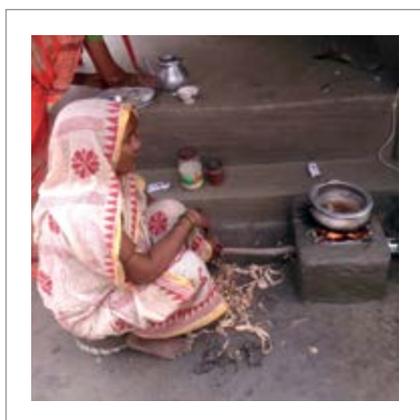
works with rural communities, on aspects such as renewable energy, watershed development, women empowerment, social inclusion, livelihoods, and efficient utilization of natural resources, particularly fuel sources.

During this fiscal, the CIEEAB actively engaged with the Karnataka Watershed Development Department for MELD of World Bank assisted KWDP-II (Sujala-3). The scope of MELD is to carry out intensive monitoring, evaluation, learning and documentation in nine sub watersheds (nine districts) covering an area of 46,640.8 ha.

The CIEEAB has conducted another interesting evaluation of the Udyogini scheme which aims to empower women by providing loans through banks and other financial institutions and a subsidy from Karnataka State Women's Development Corporation to undertake business activities/micro enterprises. The study was sponsored by the Karnataka Evaluation Authority. TERI studied over 1091 beneficiaries and stakeholders across 11 districts. TERI's recommendations were accepted by the Government to bring in policy/guideline changes for improving the effective delivery of the scheme.

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disseminated, along with user training and capacity building of local technicians.

Under the CSR partnership with IREDA, CIEEAB carried out a need assessment for installation of solar powered borewells for drinking purpose, solar streetlights and off grid lighting solutions for villages in the states of Uttar Pradesh, Uttarakhand and Bihar. It also carried out a need assessment for installation of solar-powered borewells for drinking purpose, solar streetlights and off-grid lighting solutions for villages in Uttar Pradesh, Uttarakhand, and Bihar with support from Indian Renewable Energy Development Agency.

## Centre for Rural Action

With 'energy access' as a pivotal theme for Centre for Rural Action (CfRA), efforts have been to address two key aspects for effective and sustainable energy provisioning, through LaBL. The first is to ensure that affordable and reliable clean energy solutions for lighting and cooking reach rural households. The second key aspect of CfRA's work in 2017/18 pertains to interventions going beyond basic energy access and weaving 'energy' as a contributor towards other associated

aspects of development, such as health, education, livelihoods, empowerment, and mitigating climate change. LaBL in the last decade has positively impacted 5.3 million lives across 23 states in India and 12 countries in Africa and South Asia. In the case of clean cooking solutions, CfRA has worked towards customizing forced-draft cooking technology to improve quality, addressing consumer preferences and prevailing cooking conditions. Having developed more than 11 variants of forced-draft cooking solutions, around 1 lakh clean cookstoves have been disseminated so far.





# SUSTAINABLE AGRICULTURE





**T**he concern for food security is increasing rapidly. With recent projections of global population revised to 10 billion by 2050, the pertinent questions that arise are: How do we feed these numbers without degrading the environment further? Sustainable agriculture and efficient land utilization holds the key. Through advanced research, education, societal engagement, small farmer entrepreneurship, transfer of finished products and technologies to industries and stakeholders for wider reach, the Sustainable Agriculture Programme of TERI has a vision to identify and develop new ways to farm profitably while conserving natural resources. The Programme's initiatives include achieving sustainability in agricultural practices, mitigating environment-related problems, such as toxic chemicals and wastes, innovating solutions for cleaner and greener energy, safe natural products to ensure human health, policy research and cross-cutting research that bridges all areas (water, energy, soil, solid waste, environment, and alternative farming systems).

## Sustainable Agriculture

The Programme comprises three areas, each one specializing in different but related fields with the mission to create innovative and green solutions for the challenges and pressing problems being faced in the fields of agriculture, environment, and bioenergy. In view of the stark reality of increasing demand for food production, food security, and nutrient deficiency, Mycorrhiza will in the future play a key role owing to its contribution to the plant apropos to all major and micronutrition in agriculture. Mycorrhiza, with its mutualistic, symbiotic association, is of great relevance and significance to problems, such as nutrient deficiency, particularly in marginal lands. The Centre for Mycorrhizal Research (CMR) has successfully translated the nutrient tapping potential of mycorrhizae and developed a technology that eventually produces mycorrhizae-based biofertilizer. The activities of the CMR focus on increasing the productivity and productive capacity of all types of land (including degraded lands) using cost-effective, eco-friendly mycorrhizal fungi. The Nanobiotechnology Centre (NBC) is using pioneering technologies and solutions to achieve sustainability in agriculture through nanotechnology and next-generation genomics interventions. The Centre has been making significant strides in developing nanofertilizers, nanopesticides, and precision delivery carriers and formulations. Keeping in mind deteriorating soil health, growing demand of food and water safety are the biggest challenges. The Centre

is uniquely poised to develop path-breaking technologies using biologicals interwoven with nanotechnologies and biocompatible materials. The Centre has been expanded with the inauguration of the state-of-the-art facility in April 2017 by the Prime Ministers of India and Australia. The Community Farming and Livelihood Area is dedicated to providing innovative yet simple technological solutions to marginal farming communities in many parts of our country. The area works on production of quality planting material through micropropagation at the Micropropagation Technology Park situated at the TERI GRAM campus. Also, the area is centrally engaged for enhancement of livelihood of hill farmers in the state of Uttarakhand through sustainable agricultural practices and technologies. Prime Minister Shri Narendra Modi along with Australian Prime Minister Mr Malcolm Turnbull, inaugurated the world's most advanced nanobiotechnology research centre, a joint venture between TERI and Deakin University, Australia. To celebrate this occasion the Minister of Education and Training, Government of Australia and Secretary, Department of Science and Technology, Government of India, graced the Centre with their august presence on April 11, 2017.

"The cooperation in the field of education and research is the most important field of engagement between India and Australia. TERI-Deakin Nanobiotechnology Research Centre is a classic example of the kind of cutting-edge research being done by the two countries. The \$100 million Australia-India Strategic Research Fund is for collaborative research in areas,

“The Community Farming and Livelihood Area is dedicated to providing innovative yet simple technological solutions to marginal farming communities in many parts of our country. The area works on production of quality planting material through micropropagation at the Micropropagation Technology Park situated at the TERI GRAM campus.”

such as nanotechnology, agriculture, food security, smart cities, etc. Our joint research has entered the phase of field trials and this outstanding science cooperation is firmly rooted in tangible outcomes, that is, to improve the lives of millions”, said Hon'ble Prime Minister Shri Narendra Modi while digitally inaugurating the TERI Deakin Nanobiotechnology Centre. Speaking on the occasion, the Australian Prime Minister, Mr Malcolm Turnbull said, “The TERI Deakin Nanobiotechnology Research Centre, which we just inaugurated, is brilliant and I want to say thank you to the Chancellor and Vice-Chancellor of Deakin University. So well done! This research centre will bring up to 100 researchers together to solve some of the world's biggest problems in developing biofuels to early detection



**Shri Narendra Modi, Hon'ble Prime Minister of India and The Hon'ble Malcolm Turnbull MP, Prime Minister of Australia, jointly inaugurated the TERI-Deakin Nanobiotechnology Centre in April 2017**



Unveiling of the Researchers Residence by Senator, the Hon'ble Simon Birmingham, Minister for Education & Training, Government of Australia in the presence of Dr Ashutosh Sharma, Secretary, DST

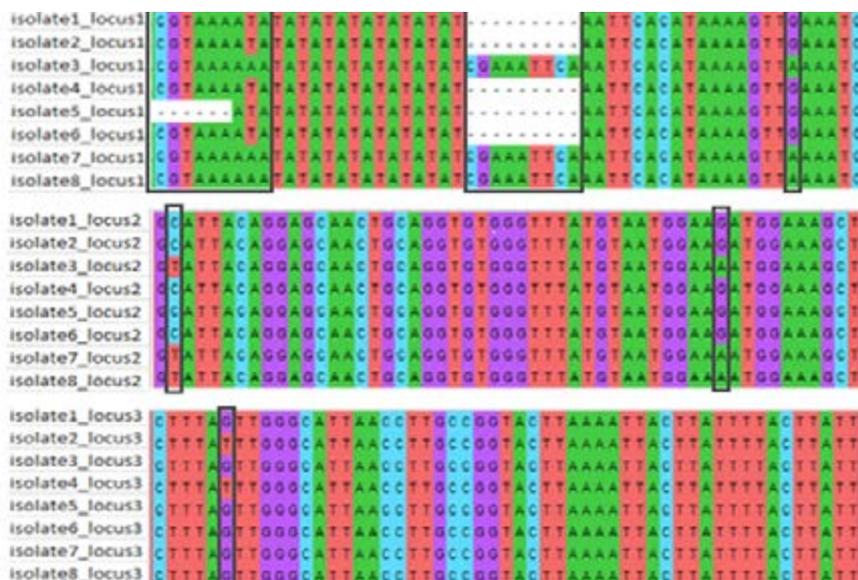
of crop diseases to improve productivity. And these are practical solutions with commercial prospects for both of our countries," added Mr Turnbull.

The TERI-Deakin Nano Biotechnology Centre (TDNBC), established at Gwal Pahari, Gurugram, aims to support and nurture innovative ideas for the existing problems of Indian agriculture, amongst other sectors. This Centre has also been rated as a 5-star GRIHA building; it is an example of resource efficiency and smart future. The Class 10000 and 1000 controlled environment Centre is spread over 5 acres of land and houses high-end scientific equipment, such as Nano particle analyser (XETA sizer), Lazer scanning microscope (Confocal), Scanning electron microscope (SEM), and Transmission Electron microscope (TEM) and many more.

The key working areas of the Sustainable Agriculture Programme are detailed in the following section:

### Agriculture

Agriculture holds the key to the overall development of a country's economy. Keeping in mind that improving soil health, food, water safety, and crop productivity are the biggest challenges in sustainable agriculture, the Programme is uniquely poised to develop pioneering technologies and solutions using microbial systems, bio-fertilizers, bio-pesticides, genetic improvement, crop diversification, bioinformatics, nanotechnologies, and biocompatible materials. It offers cross-sectoral, technology-based solutions that are to be implemented in an integrated manner for achieving equitable yet sustainable goals.



Molecular barcode developed for detection of AMF species and isolates

### Development of molecular tools for detecting arbuscular mycorrhizal fungi

Arbuscular mycorrhizal fungi (AMF) develop mutualistic interactions between plant roots and rhizosphere microbiome, which leads to a significant improvement in crop yield and health. During 2017/18, TERI worked towards development of 'diagnostic markers' for the identification and detection of AMF species and isolates that benefit agricultural crops. The TERI team has aligned molecular approaches, such as those based on next generation and high through-put sequencing of AMF genomes, followed by construction of molecular markers to be used as diagnostic tools. Correlation of these molecular markers with functional relevance of particular isolates of AMF is further targeted for understanding how a specific isolate of AMF influences a particular crop.

### Genetic enhancement of rice for nitrogen fixation and higher yields

Rice is the most important food crop and its productivity relies heavily on the application of synthetic nitrogen fertilizers. However, continuous and excessive use of chemical fertilizers is negatively impacting the environment leading to eutrophication and generation of greenhouse gases contributing to climate change. In order to alleviate this problem, TERI has initiated a major flagship mission to develop self-fertilizing cereal crop by incorporating genetic networks to support *in planta* nitrogen fixation in rice. During 2017/18, the team has generated nearly 15 different rice lines, and presently evaluating their capabilities to support various processes associated with nitrogen fixation. In addition to the nitrogen fixation programme, TERI has ongoing research projects on genetic improvement of rice for enhanced phosphorus use efficiency and elevated photosynthetic activity for boosting crop yields. Several genetically enhanced rice lines are currently being examined for their improved agronomic traits and yield responses.

### High quality superior tissue culture plants

The Micropropagation Technology Park, a state-of-the-art facility established at Gwal Pahari almost three decades back with the generous support from the Department of Biotechnology Government of India, has complete infrastructural facilities to produce

TERI has been working at TRISHA, (TERI's Research Initiative at Supi for Himalayan Advancement) at the village Supi in Nainital district of Uttarakhand since its establishment in 2003. Our efforts encompass a strategy for enhancing land productivity by using sustainable biotechnological approaches and harmonizing modern technologies and traditional knowledge.

tissue-cultured plants ranging from modern laboratories and greenhouses to nurseries with an annual production capacity of 3 million. During the year 2017/18, approximately, 1.5 million healthy, disease-free and true-to-type plants of Banana G9 variety were produced under aseptic and controlled environment as per DBT guidelines. After proper hardening in high tech greenhouses and shade area, these plants were supplied directly to the farmers of the states of Uttar Pradesh, Gujarat, Maharashtra, and Bihar for plantation along with recommended package of practices and expert guidance from time to time. The farmers to whom these plants were supplied are overwhelmed with the performance of these plants and their yield.

### Enhancing livelihoods of marginal farmers using bio-innovations

TERI has been working at TRISHA, (TERI's Research Initiative at Supi for Himalayan Advancement) at the village Supi in Nainital district of Uttarakhand since its establishment in 2003. Our efforts encompass a strategy for enhancing land productivity by using sustainable biotechnological approaches and harmonizing modern technologies and traditional knowledge. TRISHA's initiatives have helped the local farmers to look beyond their conventional farming system and bring about successful diversification of crops. The farmers of the area have been able to overcome the adverse impact of climate change by adopting cultivation of medicinal and aromatic herbs, spices, millets, and pulse crops that require less input of water

as well as have an assured source of income round the year. It has also helped them in developing village-based micro enterprise capability for improving their economic gains.

In a project to promote cultivation of traditional crops of the region, cultivation of traditional crops was conducted in more than 1,500 plots in the region which led to increased production of 25 tonnes pulses and beans and 17 tonnes grains and millets with an average increase of 276% in acreage of land under highly nutritive traditional crops. To revive traditional cropping methods, analysis, and evaluation of the Barahnaja cropping system was carried out with identification of the most economical mixed cropping combination. Awareness was generated about nutritional qualities of traditional food with women self-help groups (SHGs) and schools. With increased consumption of millets and pulses, there was increased availability of nutritive elements. Around 150 low-cost water harvesting and storage structures were installed at farmer fields. Soil erosion was checked due to harvesting of rain water in these low-cost tanks. One training centre for farmers was built at Paharpani. Two passive solar greenhouses were installed and agronomic data was monitored for two seasons. To improve soil health and sustainable crop productivity, beneficial microbes were used for seed treatment. This considerably increased yields and also protein (+6%) and mineral nutrient contents (P, K, Cu, Fe, Zn, Mn) in crops as well as in soil (+ 25%–60%) as compared to uninoculated controls in finger millet, horse gram, kidney bean, and pea.

### Nanoproducts for agriculture

TERI-Deakin Nanobiotechnology Centre (TDNBC) is devoted to developing innovative nanobiotechnology-based solutions to address current challenges in the field of agriculture and environment. In the past few years, TDNBC acquired the expertise in the eco-friendly production of agriculturally important nanofertilizers (Zn, Fe, P, and many more in pipeline) and nanocarriers (Mesoporous silica and nanozeolite) to attain sustainable agriculture practices in the future. The eco-friendly and biological production process of nanofertilizers have been achieved successfully up to kilogram quantity and high use efficiency nature of nanofertilizer variants have been validated through the field trials with state agriculture university and industrial partners. During 2017/18, the following products have been developed:

- **Nano Zn-Fe biologically synthesized:** This is an innovative

product containing biologically produced agriculturally important nanostructured Zn & Fe micronutrients. These nanostructured Zn & Fe micronutrients have been functionalized with biological macromolecules for efficacy and enhancement of use efficiency. The Zn & Fe nanofertilizer is able to provide value-added solutions to maximize the natural potential of seed and crop in the field under biotic and abiotic stress conditions.

- **Nano Zn-Fe with mesoporous nanozeolite carrier:** This is a nanocarrier-based innovative product containing eco-friendly produced agriculturally important nanostructured Zn and Fe micronutrients. This product is able to gradually provide Zn and Fe micronutrients to mitigate the deficiency of Zn and Fe in crops.
- **Nano Zn, Fe, and P with mesoporous silica nanocarrier:** This product is designed through using multiple nanonutrients (P, Zn, Fe and Si) and has the capability to deliver high use efficiency nanonutrients to the seed or crop through better adsorption, diffusion and uptake process. The application of this product improves the overall plant physiology and health through the supply of adequate nutrients to the crop at all stages. Also, this product has the ability to improve plant mechanical strength which can reduce crop lodging.
- **Nano phosphorous biologically synthesized:** Specialized products developed to deliver phosphorous directly to the plant through seed priming and foliar fertilization approach. It is bioengineered to contain a high concentration of optimally-balanced phosphorus in the nanostructured stable form using biological macromolecules chelates. Its application plays a role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement, and several other processes in plants.

### Microencapsulation for increased shelf life of bacteria

Farmers are dissuaded from using non-sporulating Plant Growth Promoting Bacteria (PGPR) due to their low shelf life and requirement of high dosage application. In 2017/18, the encapsulated cell formulation was developed. Microencapsulated bacteria have several advantages over free cell formulations,

for example, encapsulation of cells protects them from biotic stresses and abiotic stresses (the inhibitory effect of toxic compounds), improves physiological activity, provides enhanced survival and supply of encapsulated nutritional additives, increases cell densities and preferential cell growth in various internal aerobic and anaerobic zones of encapsulated material. The results showed 90% survivability of microencapsulated *Bradyrhizobium japonicum* with natural polymer after microencapsulation. The co-inoculation of microencapsulated *B. japonicum* and mycorrhizae showed synergistic interactions and was found to be effective for enhancing the growth of soybean plant and nodulation. Moreover, seed coating with formulation of microencapsulated root nodulating bacteria, in close proximity to the plant root on germination, could increase the plant growth, nodulation, and yield.

### QTLs for Leaf curl virus resistance in chilli

Leaf curl virus disease starts appearing by curling and yellowing of the leaves and subsequently leads to stunted and bushy plants with very less or no fruiting. The severity of the problem could be realized from the fact that in recent years, farmers have withdrawn chilli cultivation at some locations in India due to this disease. The partial control of viral disease may be achieved with the application

of certain pesticides but complete and environmentally safer protection from the virus through host plant resistance is a more preferred and an effective option. To overcome the disease, natural resistance source found in the wild chilli accession was used and a mapping population was developed by crossing it to the high yielding chilli cultivar. Considering the economic importance of leaf curl virus resistance in Capsicum, identification of loci controlling this trait is important to develop leaf curl resistant high yielding varieties for the farmers of India. This project is expected to result in development of valuable material (breeding lines) as well as tools (molecular markers) for MAS (marker assisted selection) applications.

### Germplasm collection and genetic diversity assessment of Kadaknath: an indigenous poultry breed of Jhabua, Madhya Pradesh

Kadaknath is an indigenous poultry breed, native to Jhabua district of western Madhya Pradesh. It is the only black meat chicken (BMC) breed of India and one of the three BMCs in the world. Its black flesh is considered not only a delicacy of distinctive taste but also known for medicinal values. Kadaknath meat is higher in protein and low in fat content as compared to other breeds of chicken. The major problem in Kadaknath is its

shrinking base population and lowering of genetic diversity which may lead to its loss of germplasm. Considering these issues, it is important to capture the maximum genetic diversity in Kadaknath to conserve and make this breed sustainable in stressed environment, especially under the current regime of climate change. During 2017/18, work has been focused on germplasm collection, analysis of genetic diversity, and development of core germplasm for its future conservation and utilization.

## Forestry and Biodiversity

### Centre for Mycorrhizal Culture Collection

The Centre for Mycorrhizal Culture Collection (CMCC) is a Mycorrhizal Bioresources Centre which aims at conservation of Mycorrhizal biodiversity by means of collection, isolation, propagation, characterization, and maintenance of cultures under *in situ* conditions. The next generation germplasm bank now houses over 1,500 trap cultures obtained from various geographies and from these trap cultures we have been able to raise more than 4,248 monospore cultures representing a total of 816 different monospore lines maintained currently. Apart from these, there are around 250 different



Few representative species from CMCC

isolates of ectomycorrhizal fungi (EMF) obtained from different host from around the world. Both the EMF and AMF are being regularly characterized on the basis of their unique FAME signatures, rDNA sequences as well as well as their morphological features. Apart from this, the mycorrhizal isolates are characterized for their functionality and uniqueness in improving plant growth, ameliorating biotic and abiotic stress under greenhouse conditions. (<http://mycorrhizae.org.in/cmcc/>).

## Environment

### Green Belt Development on industrial dumps

During 2017/18, TERI developed green belt on red mud dump on an area of 8 acres at the MALCO Energy Ltd. Red mud or red sludge is a waste product generated during industrial production of aluminium. Red mud is composed of a mixture of solid and metallic oxides. It is highly basic with pH ranging from 10 to 13. In addition to iron, the other dominant components include silica, unleached residual aluminum, and titanium oxide. Mycorrhiza-based green belt development technology was deployed for plantation of *Parkinsonia aculeate*, *Suaeda maritime*, *Salvadora persica*, *Thespesia populnea*, and *Casuarina equisetifolia*.

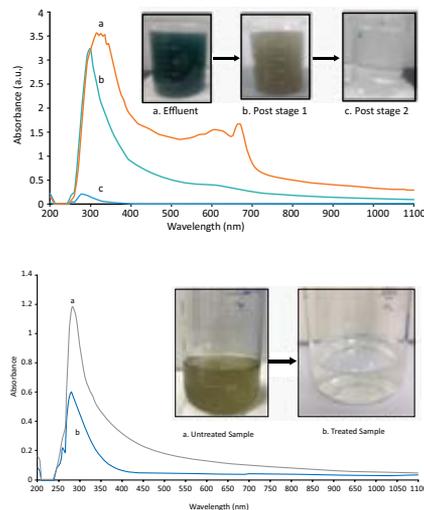
TERI carried out maintenance of a green belt covering an area of 20 acres at Tata Chemicals Ltd, Gujarat, developed earlier by TERI on chlor-alkali waste.



Status of chlor-alkali mixed waste dump (a) before and (b) after TERI's intervention

## Wastewater Treatment

TERI is working towards development and field implementation for complete end-to-end treatment of wastewater having high chemical oxygen demand (COD), total organic carbon (TOC), dissolved organics, non-biodegradable and persistent organic pollutants (POPs) from highly polluting industries, such as textile, dyeing, chemical, pharmaceuticals, etc., and sewage inlet streams. The technology is undergoing trials at pilot scale and is ready for technology transfer. The treatment involves use of nanotechnology in combination with Advanced Oxidation Processes (AOPs). We are aiming at clean, green, sludge free, highly resource and energy efficient, besides being superior technology to existing ones.



Without biological complete treatment of (a) two-stage textile wastewater leading to process water quality and (b) one-stage sewage inlet wastewater ready for reuse

### Energy

TERI has been involved in developing an improved-productivity outdoor algal growth system for biofuel production and in the last year, it successfully translated the higher productivities obtained at 1,800 L scale earlier to



Algal Growth System (10,000 L)

a larger 10,000 L scale system. The growth system is based on systematic distribution of outdoor sunlight that is 4–5 times in excess of saturation light intensities of algae. The system yields productivity 1.5–2.0 times higher than the standard system. This is pursued as a key step in translating the high lab yields to outdoor productivities for the development of algal biofuels. Efforts are on to set up an integrated production of algal biofuels and biocommodities on a larger scale to establish the economic viability of the overall process.

## Outreach

### NanoforAgri 2017

(Organizers: Dr Mandira Kochar, Dr Reena Singh, Dr Alok Adholeya)

TERI-Deakin Nanobiotechnology Centre (TDNBC), in partnership with The Department of Biotechnology (DBT), Ministry of Science and Technology, Govt. of India along with support from Science and Engineering Research Board (SERB), Govt. of India, Council of Scientific and Industrial Research (CSIR) and Indian Council of Agricultural Research (ICAR) has organized "International Conference on NanoBiotechnology for Agriculture: From Research to Innovation" on 20–21 November, 2017, at India Habitat Centre, New Delhi. During the conference, the "Zero Draft Policy on Regulation of Nanoproducts in Agriculture" was unveiled and released by Dr Suchita Ninawe, Scientist G and Adviser Nanobiotechnology, DBT. The Conference brought together renowned global speakers along with 175 participants and provided an interactive platform for budding young scientists from R&D institutes, academia, and the Industry from across the globe for the purpose of scientific discussion on current practices and future scope of nanotechnologies, to promote future collaborations for accelerated product development for agricultural applications, identify the innovation space.



Unveiling of Zero Draft Policy on Regulation of Nanoproducts in Agriculture” by Dr Suchita Ninawe, Scientist G and Adviser Nanobiotechnology, DBT in the presence of Dr Trilochan Mahapatra, DG, ICAR

### Stakeholder’s Consultative Meeting on “Innovations & Advancements in Nano biotechnology for Agriculture & Regulatory Policy Guidelines” on December 13, 2017 at TERI GRAM, Gurugram

(Organizers: Mr Wilfred Dias, Dr Braj Raj Singh, Dr Reena Singh, Dr Alok Adholeya)

This stakeholders meet brought together selected industries and key government officials and provided an interactive platform for industries and its research and development for the purpose of scientific discussion on current and future nanotechnologies, showcasing new technology snapshots, and to promote nanotechnology innovations and knowledge transfer.

The meeting also provided a platform for the top management from the industry and policymakers to participate with their inputs and suggestions and be part of the policy framing guidelines to the zero draft policy by TERI on “Nano products and its regulations”. Around 25 industries from nanotechnology sector participated and shared their experiences of commercializing nano products in the market.

### Video-conferencing cum Discussion Forum on innovation and advancements in “Next Generation Microencapsulation Technology For New Bacterial Formulation in Agriculture” & “Novel Micro Algal Isolates With Multiple Product Potential” on 8th February, 2018 at TERI GRAM, Gurugram

(Organizers: Mr Wilfred Dias, Dr Amritpreet Kaur Minhas, Dr K Dheeban Chakravarthy, Dr Pannalal Dey, Dr Reena Singh, Dr Alok Adholeya)

This meet brought together stakeholders from industries with the following aims:

- To showcase thematic areas through presentations as well as selected technology snapshots
- To provide an interactive platform for industries to take advantage from the achievements and get engaged in discussions and suggestions for customized technology development or transfer of existing technology or the product.
- Around 35 industries from agriculture, chemicals and fertilizers, biofuels, food and nutraceuticals sectors participated and contributed in terms

of their experiences and challenges faced in the thematic areas.

### Training Workshop on “Advanced Techniques in Mycorrhizal Research”

(Organizers: Dr Reena Singh, Mr T P Sankar, Dr Alok Adholeya)

TERI organized a three-day training workshop on “Advanced Techniques in Mycorrhizal Research” at TERI Gram, Gual Pahari, Gurugram from 21–23 February, 2018. The event was sponsored by the Department of Biotechnology, Government of India. The workshop aimed at imparting hands-on training in research techniques on mycorrhizal research so that the participants can apply them in their research programmes. The specific areas include:

- Basic work, involving isolation and identification of mycorrhiza
- Applied work, involving selection, culture and inoculation of arbuscular mycorrhizal fungi under nursery and field conditions
- Advanced techniques, involving molecular, biochemical, and bioinformatics tools; and
- Promoting understanding on the relevance of mycorrhizal research in the Indian context
- Exhibitions: To increase visibility of our agri-based products developed by farmers in Uttarakhand as TERI participated in a number of exhibitions at Dastkar Nature Bazaar, The Earth’s Collective as well as many schools and institutes.



Stall at an exhibition displaying agri-products as a part of providing market access to hill farmers



Training workshop on “Advanced Techniques in Mycorrhiza Research”



# SUSTAINABLE HABITAT



**T**he Sustainable Habitat Programme (SHP) has been envisioned to catalyse the 'Right to Sustainable Habitat' by mainstreaming principles of sustainability in the fields of buildings, transport, and cities. The Programme is based on the beehive model wherein institutional strengths of various centres of excellence (CoEs) are pooled-in to provide technical support to development agencies, including governments, at international, national, and sub-national levels, thereby creating a transformative impact.

Accelerating urbanization and its associated phenomenon of increased resource consumption, in India have unleashed unprecedented opportunities to embed resource efficiency and waste management in the buildings, transport, and cities sectors. For instance, *India Energy Outlook: World Energy Outlook Special Report 2015* estimates that three-quarters of the anticipated 2040 building stock, in India, is yet to be constructed. Integrating techniques of net-zero energy and waste and zero wastewater discharge in future developments, since the inception stage of projects, has three-fold benefits. First, it minimizes the long-term costs of these projects; second, it enhances resilience of the built environment and its mitigation potential; third, it aligns the socio-economic initiatives, such as the Smart Cities Mission, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), National Heritage City Development and Augmentation Yojana (HRIDAY), Pradhan Mantri Awas Yojana (PMAY), with the nationally determined contributions (NDCs), and the Sustainable Development Agenda 2030.

In order to nudge the country towards low carbon development pathways, it is imperative to assist nodal ministries/departments and local governance bodies in policy formulation and implementation. Towards this end, the SHP aims to create a network of CoEs that engage with government entities as knowledge partners for evidence-based policy research and analysis, development of green rating systems for buildings–transport–cities sectors, effective implementation and monitoring and training and capacity building. The SHP would provide a platform to the CoEs to come together in the form of Sustainable Habitat Alliance, with the objective to collate and upscale the knowledge created through them.

The Sustainable Buildings Division and the Transport and Urban Governance Division at TERI are stimulating the above vision through various initiatives. TERI is supporting the Andhra Pradesh Capital Region Development Authority to establish a green capital city, in the capacity of Sustainability Partner. Similarly, the cities of Dharamshala, Panaji, and Pune have empanelled TERI to guide their transition into smart cities. TERI is a Member of the State Commission on Urbanization, Government of Rajasthan. It has also served as a Member of the Advisory Committee of the National Mission on Sustainable Habitat. GRIHA, the national rating system for green buildings, has been acknowledged as the tool to evaluate reduction in emission intensity through buildings in India's NDCs submitted to the United Nations Framework Convention on Climate Change (UNFCCC).

The Ministry of Housing and Urban Affairs (MoHUA) recognizes TERI as a CoE in Urban Development and Management. TERI has also established a CoE on Energy Efficient Buildings, in collaboration with United Technologies Corporation. Recently, TERI partnered with Mahindra Lifespaces to create a CoE for Sustainable Habitat.

A study on 'State Energy Efficiency Preparedness Index', conducted recently by the Alliance for an Energy Efficient Economy (AEEE), in collaboration with the NITI Aayog, showcases that the states where TERI provided handholding support have secured a higher ranking as compared to other states. Such evidences bolster the ambition of the Sustainable Habitat Programme to be the 'Go to Action Think Tank' for the sub-national, national, and international development agencies for sustainable development of buildings, transport, and cities by 2022.

## GRIHA Council

Buildings contribute 35% to 40% of commercial energy use globally and (31% in India), along with greenhouse gas (GHG) emissions. Furthermore, buildings consume 365 billion units in India (total is 1,100 BU). Energy efficiency in buildings can save at least 25% of energy, that is, 91 BU of electricity annually translating to 74 million total carbon dioxide (tCO<sub>2</sub>). GRIHA rating was developed in response to climate change, increasing GHG emissions, and pollution.

The GRIHA rating system, conceived by TERI and supported by the Ministry of New and Renewable Energy (MNRE) has been recognized by the Government of India as a key guideline for construction of sustainable buildings across the country. The Government of India in 'India's Intended Nationally Determined Contribution' has recognized GRIHA as India's own green building rating. The key strength of this unique rating system lies in rigorous implementation through due diligence visits and proven performance of rated projects.

The GRIHA Council hosted its flagship GRIHA Summit with the theme 'Sustainable is Affordable' in December 2017. A new rating variant 'GRIHA for Affordable Housing' was also launched during the Summit. The rating was developed through consultative process with all stakeholders and is in line with the guidelines of the Pradhan Mantri Awas Yojna (PMAY).

Some of the key projects that received a 5 Star rating in 2017/18 include EIL Complex, Gurugram; Hostel Block - 1 & 2 For Manipal Integrated Services Pvt Ltd at Manipal County, Bengaluru, under the GRIHA rating variant. Also, South Asian University, New Delhi; Central University of Punjab, Bhatinda; and Indian Institute of Management, Udaipur, were also recipients of 5 Star rating under GRIHA Large Development rating variant. The



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Grape County Resort, Nashik, was also awarded a 5 Star Rating under the SVA GRIHA rating variant.

The fifth GRIHA Trophy was conducted at the 60th Annual Convention of National Association of Students of Architecture (NASA) at Kerala. The Sinhgad College of Architecture, Pune, won the first prize and was awarded their trophy at the World Sustainable Development Summit 2018.

## Sustainable Buildings—Delhi

The Sustainable Buildings—Delhi Group has been set up to facilitate development and mainstreaming of sustainable buildings in order to facilitate the efficient design of new buildings and improve the performance of existing buildings. The Centre has been offering sustainable design solutions for buildings of various complexities and functions for nearly two decades.

The Centre has undertaken several research and development activities and has set up a Centre of Excellence (CoE) with the support of Mahindra Lifespaces Developers Ltd (MLDL) to carry out research on energy efficient building envelopes and sustainable water use in habitats. Another CoE, set up in collaboration with United Technologies Corporation (UTC), works towards the development of an energy-use reporting framework for existing buildings, real time reporting of consumption, and identification and cost-benefit analysis of energy conservation measures. As a part of the recent research activities, the CoE has published *Guidelines of Glare Management for Artificial Lighting* which will help the building professionals to design glare-free spaces.

A project on 'Mainstreaming Sustainable Social Housing in India (MaS-SHIP)' was sanctioned by the United Nations Environment Programme (UNEP), consisting of four consortium partners (TERI, Oxford Brookes University [OBU], Development Alternatives, and UN-Habitat). The project aims to develop a 'Sustainability Index' for building materials and construction technologies for the affordable housing sector.

A Sustainability Cell has been set up for Andhra Pradesh Capital Region Development Authority (APCRDA) for incorporating green building/sustainability aspects in the upcoming new capital city of Amaravati, Andhra Pradesh.

A Sustainability Cell has been set up for Andhra Pradesh Capital Region Development Authority (APCRDA) for incorporating green building/sustainability aspects in the upcoming new capital city of Amaravati, Andhra Pradesh.



Inauguration of Mahindra TERI Centre of Excellence (CoE) by Mr Anand Mahindra, Chairman, Mahindra Group on June 12, 2018, at TERI Gwal Pahar



A study has been conducted for the development of Nationally Appropriate Mitigation Actions (NAMAs) for the buildings sector with UNEP. TERI as a technical partner with UNEP helped four Southeast Asian countries namely, Thailand, Vietnam, Indonesia, and the Philippines, to develop energy benchmark and greenhouse gas (GHG) mitigation scenarios through recommended measures for the buildings sector.

TERI, along with the Energy Efficiency Services Ltd (EESL), initiated a tri-generation feasibility study for the Pune airport. TERI acted as the technical arm of the EESL helping them in designing and proposing a feasible tri-generation system for the airport.

TERI has been sanctioned for the Uttarakhand Disaster Recovery Project funded by the World Bank and has set up a project monitoring unit (PMU) at Dehradun to support Government of Uttarakhand (GoU) in advancing and capacity building of local institutions to mitigate risks in various areas and by strengthening capacity through enhancement of disaster risk management. Building bye-laws and land use regulation has proven to be the most effective tools for reducing disaster and chronic risks in the developed world. TERI is trying to address and improve local building culture; the failure to establish an open and transparent uniform code development and implementation process, and the failure to invest in the development of efficient and effective building regulatory capacity. TERI is focussed to incorporate the resilience aspect in the building bye-laws as it is non-existent in the Indian building codes in details and hence, mapping all the international practices and aligning it with the Indian building conditions.

As part of capacity and awareness initiatives, TERI is organizing stakeholder retailer training programmes on the Standard and Labelling Scheme in partnership with Bureau of Energy Efficiency, Ministry of Power. This

TERI, along with Energy Efficiency Services Ltd (EESL), initiated a tri-generation feasibility study for the Pune airport. TERI acted as the technical arm of EESL helping them in designing and proposing a feasible tri-generation system for the airport.

programme aims to sensitize local retailers and institutions about the Standard and Labelling scheme (Star labelling scheme) launched by the Bureau of Energy Efficiency and raise awareness on the recent changes and updates of the scheme. The focus of the programme is to create a pool of trained retailers so as to generate a push to upscale the take-up of energy efficient appliances in the market. The project targets organizing workshops in Tier 2 and Tier 3 cities of India, majorly to reach out at the ground level and enhance the scenario of energy efficiency in India.

## Sustainable Buildings—SRC Group

Sustainable Buildings—SRC at TERI Southern Regional Centre is currently working with corporates, developers, and public sector units to provide consultancy services for design of energy

Under the funding of Department of Biotechnology, the area is researching on the design and engineering of cold storage containers using bio waste as an energy source. Two consultancy projects have achieved 4 star rating under the GRIHA rating system, for which the area provided green building design and GRIHA certification consultancy.

efficient buildings. The Centre has also been working on research projects with Government of India on energy efficiency, thermal and visual comfort for habitat and energy efficiency in cold storages.

In the year under review, the Centre initiated research on dynamic shading and radiant cooling technology funded by the Government of India, through the Department of Science & Technology. Under the funding of Department of Biotechnology, the area is researching on the design and engineering of cold storage containers using bio waste as an energy source. Two consultancy projects have achieved 4 star rating under the GRIHA rating system, for which the area provided green building design and GRIHA certification consultancy.

The area also organized R&D Summit which witnessed participation by nearly 200 professionals from the green building industry and paved the way for future collaboration with industry on research and development.

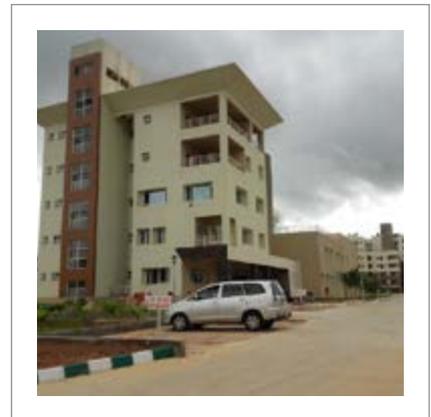
Institutional engagement to disseminate research work has been carried out in partnerships with educational institutes, such as NIT Trichy and MGIRED.

## Green building design consultancy

Sustainable Buildings- SRC completed two projects registered for Green building design and GRIHA certification, RHQ building for PGCIL in Bengaluru and Augmentation Laboratory for NARL in Gadanki.

Regional Head Quarter building (RHQ) and Augmentation laboratory for NARL were registered for Green building design and certification under GRIHA rating process. TERI, as green consultant for the project, facilitated the GRIHA certification process.

RHQ Office Building, located in Singanayakanahalli Bangalore has site area of 13787.32 m<sup>2</sup> and built-up area of 3,204 m<sup>2</sup>. The building has demonstrated



energy efficiency of 72.75% against GRIHA benchmark with EPI of 32.70 KWh/ m<sup>2</sup>/ year. The building saved 53.35% water for internal use and 44.74% in landscape. Around 76% of the living areas are day lit and low-energy materials have been integrated in the interior and exterior. With these measures, the building has achieved GRIHA provisional rating of 4 Stars.

The Augmentation Laboratory is located at NARL Campus in Gadanki has a site area of 1750 m<sup>2</sup> and built-up area of 3204 m<sup>2</sup>. The building has demonstrated energy efficiency of 73.63% against GRIHA benchmark with EPI of 36.91 KWh/ m<sup>2</sup>/year. Around 50 kWp of solar PV has been installed on site. The building saved 59.87% water on internal use and 46.33% for landscape and 73.1% of day-lit living area and green materials have been incorporated in the design. Owing to these measures, it has achieved GRIHA provisional rating of 4 stars.



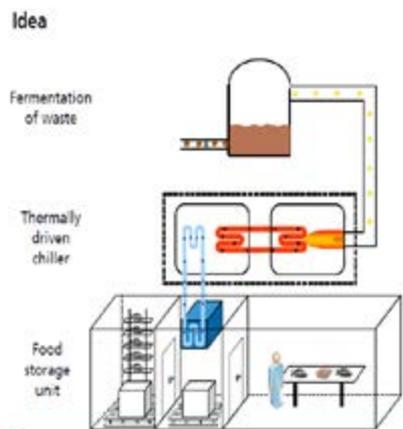
## Research

### Habitat Model for Efficiency and Comfort

Sustainable Buildings- SRC is currently working on a project, Habitat Model for

Efficiency and Comfort, funded by the Department of Science and Technology, Government of India. As the first task under this project, TERI is developing an affordable solution for external shading, 'Shade Smart' for residential and commercial buildings in India. This novel shading system will be able to reduce direct heat gain by 75% while allowing the admittance of natural light into the building. In collaboration with industry partners, TERI also aims to develop the commercialization plan for the product and establish its thermal and optical performance.

Under the second task, TERI is to explore the options of integration of low energy cooling strategies into conventional radiant cooling system with an attempt to downsize the chiller or eliminate the chiller completely. This will be followed by the demonstration of the same technique when applied to a demo habitat of 20 m<sup>2</sup> area. The second objective is to establish the thermal comfort criteria for buildings with radiant cooling systems.



Proposal submitted for DST's I-PHEE call- 14<sup>th</sup> May 2016

## Bigastore

In this project, supported by the Department of Biotechnology, the aim is to design cold storages using energy efficient strategies, such as:

- Absorption chiller as the cooling source which will derive the heat input from biogas produced from organic waste.
- Modelling the cold storage envelope with phase change material which will impact the cooling load and demonstrating the same.
- In order to fulfil the above mentioned tasks, TERI had collaborated with the German-based research institute, Fraunhofer.

## Outreach

The '2018 Sustainable Buildings R&D Summit on Innovations for the Built Environment' was organized by Sustainable Buildings- SRC from 8–10 March, 2018, at Bengaluru. The three-day summit brought together eminent scientists, corporates, academicians, developers, PSUs, and various other stakeholders under one roof, with the aim of fostering interaction and ensuring efficient collaboration within the sustainable building industry. The summit was inaugurated by Mr P Ravichandran, President, Danfoss; Mr Anjum Parvez, Secretary, Urban Development Department, Government of Karnataka; Dr Ajay Mathur, Director General, TERI; Mr Sanjay Seth, Senior Director, Sustainable Habitat Division, TERI; Mr Pronab Dasgupta, Distinguished Fellow, TERI; and Ms Minni Sastry, Associate Director, Sustainable Habitat Division, TERI. The keynote address was delivered by Dr N K Bansal, Ex-Vice Chancellor,

The Augmentation Laboratory is located at NARL Campus in Gadanki has a site area of 1,750 m<sup>2</sup> and built-up area of 3,204 m<sup>2</sup>. The building has demonstrated energy efficiency of 73.63% against GRIHA benchmark with EPI of 36.91 KWh/m<sup>2</sup>/year. Around 50 kWp of solar PV has been installed on site.

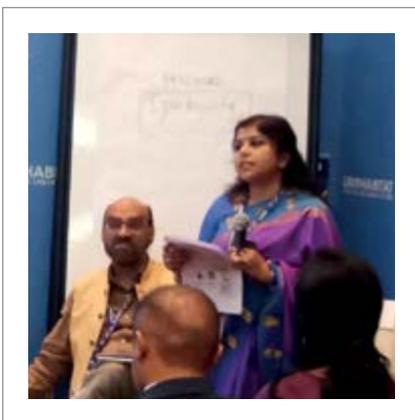


SMVD University, former Director and Senior Professor, Centre for Energy Studies at IIT Delhi. An exhibition on sustainable materials and technologies was also organized during the summit. On the last day of the summit, a field trip to sustainable building campuses was organized, wherein the participants visited Titan's New Headquarters and Infosys Campus in Bengaluru. The summit was attended by over 250 professionals from all over the country.

## Transport and Urban Governance Division

### Transport and Urban Governance Division

Urban areas play a pivotal role in the growth of the Indian economy and are projected to account for more than 50% of the country's population by 2050. In cognizance of the increasing importance of cities, TERI has a flagship programme on Urban Planning and Governance with a dedicated research centre focussing on urban issues. TERI provides technical assistance to urban local bodies (ULBs) in developing sustainable, smart, and resilient cities and places special focus



on strategic planning, sustainable urban infrastructure, and policy and governance frameworks. It delves into urban research and policy analysis for strengthening capacities and partnerships of cities for improved and informed decision-making in alignment with the global urban sustainability goals.

Given the significant role that the transport sector plays in promoting economic growth in both urban and rural areas, TERI has a dedicated Centre for Sustainable Mobility, which is focussed towards promoting low carbon sustainable transport that meets the mobility requirements of India's growing population. TERI undertakes energy and emission modelling of transport modes and sectors to evaluate the decarbonization potential of these modes and sectors and to prioritize them for mitigation measures. In order to support policy and decision making processes, TERI also undertakes research regarding the evaluation of existing and proposed policies in the transport space and makes recommendations to improve the implementation and effectiveness of such policies.

TERI works in collaboration with various stakeholders, including local, national, and international governments, public utilities, non-governmental organizations, bilateral and multilateral agencies, foundations, research institutes,

corporate and financial institutions, civil society, and academia and practitioners to bridge the existing knowledge gap and facilitate exchange of ideas. By developing research reports, articles, and policy briefs, TERI aims to influence the policy arena as well as fill knowledge gaps to promote sustainable and low carbon urban growth.

### Centre for Urban Planning and Governance

With cities facing rapid urbanization and associated challenges, the Centre

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CTRAM Event Railways, January 2018

for Urban Planning and Governance focusses on strategic planning, policy research, and capacity building to foster improved and informed decision-making for sustainable, smart, and resilient urban development. To this end, TERI is supporting ULBs, national and sub-national urban development agencies in India, and beyond, towards making liveable cities.

TERI contributed to the global discourse and curated sessions on implementation of the New Urban Agenda and SDG 11 in South Asian cities at HABITAT III and UN's World Urban Forum 9 in Quito and Kuala Lumpur, respectively. In India, TERI is conducting a series of national and regional policy dialogues to facilitate discussions on critical urban issues. As an empanelled consulting firm under the Smart City Mission and empanelled training agency under AMRUT for Government of India, TERI is supporting implementation of

national urban missions through capacity building programmes.

TERI is part of the Global Resilience Research Network (GRRN) and India Coordination Group of the International Urban Cooperation, with urban climate resilience as one of its key focus areas and is supporting Andhra Pradesh Capital Region Development Authority (APRCDA) to prepare a holistic climate change action plan for the new capital city of Amaravati.

### Centre for Sustainable Mobility

In the face of high population growth and rapid urbanization, the Centre focusses on policy analysis and emission modelling to develop the country's transport sector in an energy-efficient, environment-friendly, sustainable, and inclusive manner.

TERI has conducted detailed studies focussed on analysing the future

TERI is part of the Global Resilience Research Network (GRRN) and India Coordination Group of the International Urban Cooperation, with urban climate resilience as one of its key focus areas and is supporting Andhra Pradesh Capital Region Development Authority (APRCDA) to prepare a holistic climate change action plan for the new capital city of Amaravati.

prospects of electric mobility in India and, along with IIT-Delhi, has established





an Electro-Mobility Platform for knowledge sharing. In partnership with the World Bank and the International Transport Forum, TERI has developed a city-level model which evaluates the decarbonization potential of different transport investment strategies. TERI has also successfully completed a study on estimating the carbon footprint and enhancing climate resilience of national highways for the Ministry of Road Transport and Highways, Government of India. TERI has conducted a Life Cycle

Analysis of transport modes in India for the National Transport Development Policy Committee and has also evaluated the trends and economic benefits of Non-Motorized Transport for the All India Cycling Manufacturers' Association. To estimate the energy and emission impacts of High Speed Rail in India, TERI has conducted a detailed study for the Ministry of Railways and also undertakes studies to promote modal shift of freight movement towards rail. TERI also conducts road safety audits for the

Supreme Court Committee on Road Safety. TERI is a member of the Sustainable Low Carbon Transport (SLoCaT) partnership, a global partnership hosted by the United Nations Department of Economic and Social Affairs (UN-DESA), and is also a member of the Sub-Committee on Fuel Economy Norms for Medium & Light Commercial Vehicles, established by the Ministry of Petroleum & Natural Gas, Government of India.

# DOMESTIC AND GLOBAL OPERATIONS





**C**reating a broad network for continued and sustained research and analysis of the various facets of environment conservation requires dedicated work across several sectors from partners. TERI has been engaged in forging long-term linkages and partnerships with agencies and organizations, including the government, so that the effort towards a green tomorrow never ceases. In keeping with this agenda, TERI has established regional presence in various nerve centres of the country, supported by the headquarters in New Delhi. TERI's regional centres continued to generate interest in the field of energy, environment, and sustainable development in the year of reporting.

# Coastal Ecology & Marine Resources Centre, Goa

In its role as a multidisciplinary research centre, the Coastal Ecology & Marine Resources Centre (CEMRC), Goa, has been implementing research in the areas of marine and coastal resources, biodiversity mapping, and water resource management. Various environmental awareness, education and outreach projects and activities are also implemented at the Centre.

In the field of marine and coastal areas, the project was successfully carried out for livelihood diversification, woman empowerment, and entrepreneurship development of artisanal fishery to sustain fishery resources with support from Toyota Foundation, Japan. Under the National Cyclone Risk Mitigation Project (NCRMP) of the Government of India, the Environmental and Social Impact Assessment (ESIA) studies in Goa were successfully conducted for saline embankments in the two villages of Divar and Poinguinim. Another ESIA project, for underground electrical cabling in the village of Anjuna, is underway. Both the ESIA projects received funding from the World Bank through the government of Goa. With successful demonstration of crab cultivation to the fisher farmers of Goa, aquaponics and fish cage culture demonstrations have been initiated under sponsorship of NABARD. With the support provided by the Goa State Pollution Control Board (GSPCB), the determination of the persistence of pesticides in the various coastal ecosystems of Goa is being pursued. Projects related to mapping and inventorization of the biodiversity of coastal villages is being carried out with support from the Goa State Biodiversity Board (GSBB). With the support of

NABARD, the digitization of self-help groups from the six coastal *talukas* of Goa is in progress.

Underwater resource management, river bank filtration (RBF) projects have been competently completed for providing water for irrigation purposes under the sponsorship of the Ramboll-Environ Foundation, USA, and for domestic potability for four villages in Karnataka under support from the National Health and Medical Research Council (NHMRC), Australia. A presently ongoing RBF project, to be carried out in conjunction with filtration through a constructed wetland, has been funded by the Department of Biotechnology (DBT). Another project utilizing the RBF technology has been initiated at Davengere, Karnataka, with funding received from the Department of Science, Technology, and Environment (DSTE). Another current project, undertaken with support of the State Water Resources Department, analyses the implications of land-use change coupled with climate change on surface run-off through hydrological modelling.

In addition to the above-mentioned research projects, the Centre also regularly organizes various training programmes, seminars, and educational tours for schools to connect students to science, inspire environmental action, and increase exposure to different coastal habitats and traditional practices as well as sustainable technologies.

## Areas of Work

During the year under review, the CEMRC, Goa, undertook projects and activities in certain key areas; described in detail in this section.

### Mud Crab Aquaculture

Mud crab aquaculture is currently undertaken at relatively low densities compared to the other types of pond- or pen-based aquaculture. In India, the importance of live mud crabs as an export commodity has opened up great

Under the National Cyclone Risk Mitigation Project (NCRMP) of the Government of India, the Environmental and Social Impact Assessment (ESIA) studies in Goa were successfully conducted for saline embankments in the two villages of Divar and Poinguinim. Another ESIA project, for underground electrical cabling in the village of Anjuna, is underway.

opportunities for crab farming/fattening. At present, crab has good market demand and is anticipated to be the next potential sea food in the world market amongst the edible marine crustaceans after shrimp and lobster.

In order to introduce the concept of mud crab farming and to take up the activities in Goa, 18 entrepreneurs were selected for the training programme at Rajiv Gandhi Centre for Aquaculture (RGCA), Sirkali, Chennai. This was followed by the Demo pond in Goa in order to demonstrate crab farming to the other entrepreneurs to create awareness on the benefits and prospects of mud crab farming and impart the necessary training/demonstration in order to implement mud crab farming in the state.

### People's Biodiversity Register of Coastal Villages of Goa

The People's Biodiversity Register (PBR) of the coastal villages of Goa is a project supported by the GSBB. The PBR of Goa's coastal villages involves recording and inventorization, in consultation with





**Resource map and mapping activity**

the local people, of the occurrence of various species of flora and fauna and resources present in the area, which may be of local significance. This is also an attempt at recording the rapidly eroding knowledge of the medicinal usage of local plants and the occurrence and management practices of land races of cultivated crops. Thus, the PBR provides a platform through which members of a community may initiate steps towards better management of their biodiversity resources.

The development of the PBR is being facilitated in the coastal villages of Velim, Chorao, and Anjuna, along with Nuvem, and Raia, Goa, under the support of GSBB and GIZ-India.

**Environmental Impact Assessment and Preparation of Management Plan for Saline Embankment in Divar, Goa**

The Government of India has drawn up the National Cyclone Risk Mitigation Project (NCRMP) to address the cyclone



**Awareness talks on PBR at the ward and school levels**

Considering the vulnerability to cyclones and its associated events, Goa has been chosen as one of the states for coverage under the National Cyclone Risk Mitigation Project, Phase II.

risks in the country through short- and long-term measures (emphasizing on prevention, preparedness, and mitigation) with the assistance of the World Bank. The project is being implemented in the cyclone-prone coastal states and the union territories of India. Considering the vulnerability to cyclones and its associated events, Goa has been chosen as one of the states for coverage under the NCRMP, Phase II. One of the interventions proposed in Goa in



the Divar Island include construction/strengthening of saline embankments, to provide a resilient infrastructure that can withstand natural disasters such as cyclones. TERI, Goa, was chosen to conduct Environmental Impact Assessment and prepare management plan (Social and Environmental). A detailed study was conducted and an elaborate report was brought out that includes: (i) environmental set-up (physiography, geology, soil, hydrology, land-use distribution, time-series analysis using satellite images to examine change in the mangrove area); (ii) policy, legal, and institutional framework; (iii) baseline environment (micrometeorology, ambient air quality, noise levels, water, soil & sediment quality, floral and faunal diversity, presence of ecologically sensitive areas); (iv) valued environmental components; (v) analysis of alternatives (design options, vulnerability assessment, customized structural design); (vi) anticipated environmental impacts and mitigation measures (positive impacts of repair of bunds and negative impacts); (vii) Environmental Management Plan; and (viii) institutional arrangements. This study was based on primary and secondary data collection.

The positive impacts of strengthening the saline embankments/bunds will be as follows:

- Protection of agriculture lands from saline water intrusion, surge, and inundation
- Protection of habitation from surge and inundation
- Protection of the khazan lands
- Enhancement in the quality of life of the inhabitants

## TERI North-Eastern Regional Centre

The North-Eastern Regional Centre of TERI, established in August 1993, is completing 25 years of its existence in the region, during the year under review, where it has contributed in sustainable development through innovative research in the fields of agriculture and biotechnology and is also implementing projects related to rural extension and research activities. Over the years, the centre has formed collaborative partnerships with different government agencies and non-governmental institutions, thus transforming TERINE as a premier institute of the north-eastern region for issues related to sustainable

development. The centre as a whole works on a wide range of thematic areas, such as natural resource management, livelihood enhancement, sanitation, biodiversity conservation, algal biofuel, mycological research, etc. The centre is also extending its services in capacity-building of different stakeholders in the prioritized areas.

With the experience gained during evaluation of preparatory phase of IWMPs (Integrated Watershed Management Programmes) in Assam, the centre has been involved in Monitoring, Evaluation, Learning and Documentation (MELD) of IWMPs in Assam. The centre is consistently producing quality planting materials of economically important horticultural crops, such as black pepper, Assam lemon, and budded Khasi mandarin. In the field of sericulture, the centre has initiated a project on ericulture for upliftment of socio-economic conditions of rural women in tribal villages of Assam with input support and capacity building of rearers in producing DFLs and eri cocoons and also spinning of yarn. Additionally, the centre has also undertaken research activities related to ethnobotanical survey for anti-ulcer drugs. The centre has been providing consultancy services for livelihood generation for the river erosion victims in Kamrup (rural) districts in Assam through improved eri spinning and weaving and vegetable cultivation.

The biotechnological research of the Centre includes utilization of wastewater for algal biomass production and bioenergy (biodiesel and bioethanol) conversion. Phototrophic biofilm research facilitated adaptation conditioning of algal and bacterial association leading to an easier biomass harvest. In the molecular biology facility, research has been initiated for transcriptome-driven unculturable bacterial strains isolation for draught mitigation of tea. In the field of improved sanitation, the centre has installed 60 prefabricated Biotoilets with FRP (glass fibre reinforced polymers) materials in 60 schools of Assam, Mizoram, and Tripura. The biotoilet components include anaerobic microbial consortium charged anaerobic biodigester followed by horizontal subsurface flow constructed wetland for polishing wastewater discharge and comparing with pollution control board norms.

In the capacity-building initiative of the centre, TERI-NE with the support of

North Eastern Council (NEC), Government of India, organized training programmes for the government officials and NGO representatives in order to build their capacities in designing sustainable livelihood projects/programmes and ecotourism activities relevant to the northeastern region. The centre also concentrates on building the capacities of rural women in Eri silkworm rearing and spinning by providing need-based hands-on training.

## TRISHA, Mukteshwar

TERI's Research Initiative in Supi for Himalayan Advancement (TRISHA), situated at a height of 7,500 feet in Supi village of the Nainital district, Uttarakhand, is a distinct endeavour towards sustainable agriculture. Since agriculture is the main occupation, research and extension has been largely undertaken to improve the quality and quantity of agricultural produce. It involves:

- Diagnosing deficiencies and applying biotechnological tools for the improvement of nutritional, physical, and biological health of agricultural lands;
- Providing innovative solutions to increase yield by providing planting material of an array of high-value temperate crop varieties along with complete package of practices;
- Optimally enhancing resource-use efficiency;
- Increasing marginal farmers' capacities through training and demonstration;



*Vegetables growing in the passive solar greenhouse at TRISHA*

- Development of market linkages guaranteeing economic returns to the farmer by establishing value chains.

There are various facilities at Supi, including a soil-testing lab for farmer fields, vermicomposting unit, polyhouses and glasshouses, oil distillation unit, herbal garden, air quality monitoring unit, knowledge-cum-training centre, the Kumaon Vani facility (a community radio service for the local populace), and rainwater harvesting systems. There is also a passive solar greenhouse, which can facilitate vegetable production all year round under unfavourable climatic conditions. TERI has touched the lives of around 3,000 farmers in 25 villages in Ramgarh and Dhari blocks of the district to provide them end-to-end solutions for increasing their farm incomes. Hence, TERI has created a platform for enhancing livelihood security by eliminating intermediaries and thus, created a win-win situation for all stakeholders.



*Vegetables growing in the passive solar greenhouse at TRISHA*

# TERI Western Regional Centre

The Western Regional Centre (WRC), Mumbai, has successfully completed several projects in the core areas during the financial year 2017/18 which include 'Integrated Climate Smart Agricultural practices', Government of Maharashtra (GoM), Retrofitting of a Zilla Parishad (Z.P) School-Phase 2, Model Village-Livelihood Support and Nutrition Security, Compilation of the report on *Air Quality Status of Maharashtra 2016-17*, *Water Quality Status Assessment report of Maharashtra 2016-17*, Indoor Air Quality Study in the office premises at Capgemini Hyderabad, Environmental Status Report of Navi Mumbai 2016-17 and Environmental Audit for Deepak Fertilizers and Petrochemicals Corporation Ltd (DFPCL).

## Nutrition Security Division

The Nutrition Security Division has been working as part of TERI's WRC for the past 6 years. The division aims to promote sustainable methods and practices to address malnourishment, including micro-nutrient deficiencies in rural and urban areas, through innovative approaches. A few important achievements include the following:

- Devise short-term and long-term strategies to overcome malnutrition in consultation with District Health Officials.
- Developing a first-of-its-kind digital library and germplasm bank for wild edibles from Western region.
- Women empowerment—By providing livelihood options and training on integrating nutritive dietary sources.
- Developed suitable multimedia for wider project outreach.
- Established nutri-gardens by providing training and resources such as seeds, saplings, technology for treatment of grey water as alternate water source to tribal communities.

## Model Village: Livelihood and Nutrition Security

In the fourth phase (2017/18) of the project 'Pathardi- Towards a Sustainable village', inhabitants of Pathardi village, Palghar district, who were earlier dependent on rain-fed subsistence agriculture as their main livelihood were trained in livelihood avenues that were economically and environmentally sustainable with a special focus on



*A beneficiary with her goats*

women and youth. This additional income would not only provide them with a level of security and resilience to risks in case of unseasonal rain or droughts, but will also lead to an improved standard of living and overall well-being. Training workshops were conducted in goat rearing, bamboo cultivation and bamboo article making, poultry farming, and the women were encouraged to form self-help groups (SHGs). Around 72 women representing all the households in the village own at least one goat due to the seed funding provided to them for the same. The women are now confident and look forward to running successful businesses. The next phase of the project includes promotion and setting up of a food fortification and food processing business. A livelihood intervention, such as food processing would fulfill multiple objectives of introducing nutrient-rich food products, capacity building, and provision for an additional income source.



## Retrofit of Tribal Schools at Palghar District

TERI observed that the ZP primary schools in Pathardi and Botoshi did not have functional toilets, proper seating arrangements, kitchen facility, etc. The schools' abysmal conditions and lack of electricity prompted TERI to undertake retrofitting of these schools. TERI retrofitted 2 schools over 2 phases, thus ensuring better amenities, such as sanitation facilities, off grid electricity supply, learning aids for the students, and so on. The project successfully fulfilled the following objectives:

- Children have obtained a learning environment conducive for a decent primary education;
- A permanent school infrastructure including kitchen and storage space for current and future generations;
- Integration of sustainable solar technology for uninterrupted energy supply;
- Substantial contribution to overall well-being of the children.





Grains stored in classrooms before the retrofit in one of the schools

### Inclusion of Climate Smart Practices in Agriculture

The objective of this project, funded by the World Bank and Maharashtra Agricultural Competitiveness Project (MACP), GoM, was capacity building of Agriculture and Allied Departments' officers and field functionaries to plan and implement Integrated Climate Smart Agricultural Practices (ICSAP) in Maharashtra. Model extension projects (MEPs) were prepared and package of practices (PoPs) for 12 important crops were revised by TERI with inputs from the agricultural universities to incorporate climate smart approaches.

TERI also successfully organized four ICSAP training workshops conducted at Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri; Dr Balasaheb Sawant Konkan Krishi Vidyapeeth (BSKVV), Dapoli; Vasantnao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani; and Dr Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola.



Dr Nabansu Chattopadhyay, Deputy Director General of Meteorology, IMD, inaugurating the ICSAP Workshop at Pune

### Environmental Status Reports

#### Air Quality Status of Maharashtra 2016-17

The sixth consecutive report on *Air Quality Status of Maharashtra 2016-17* developed by TERI WRC was released on June 5, 2017 by Shri Ramdas Kadam, Hon'ble Minister of Environment, GoM, for the Maharashtra Pollution Control Board (MPCB). It provides a decadal overview and analysis of the quality of air recorded across all the Ambient Air Quality Monitoring Stations (AAQMS) in Maharashtra, documenting the daily, seasonal, and annual trend in concentrations of air pollutants, such as SO<sub>2</sub>, NO<sub>x</sub>, RSPM, CO, CH<sub>4</sub>, and ozone in Maharashtra through illustrations and graphical representations. It has been uploaded on the website of the pollution control board.

### Water Quality Status 2016-17

TERI WRC prepared a report on *Water Quality Status of Maharashtra 2016-17* through statistical compilation of water quality monitored over the past 10 years by MPCB across 294 Water Quality Monitoring Stations (WQMS) for both surface (176 on rivers, 36 on sea/creeks, 12 on drains, 4 dams) and ground water (29 bore wells, 32 dug well, 1 hand pumps, 1 tube well) resources. It was completed under the aegis of National Water Quality Monitoring Programme (NWMP) titled Global Environment Monitoring System (GEMS) and Monitoring of Indian National Aquatic Resources (MINARS).

### Indoor Air Quality Study at Caggemini, Hyderabad

Caggemini Technology Services India Ltd, in collaboration with TERI, took a proactive initiative, 'INHALE (Improving Indoor and Household Air through Lively Environment)' to execute practical strategies to improve the Indoor Air Quality (IAQ) and create a healthy working environment for employees. A pilot project to estimate the baseline IAQ as well as to understand the impact of indoor plants on IAQ was undertaken at Caggemini's Hyderabad campus.

TERI conducted IAQ monitoring for parameters of CO<sub>2</sub>, CO, TVOC's, PM2.5, PM10, temperature, and RH for a duration of one month.

### Environmental Status Report of Navi Mumbai 2016-17

WRC also successfully completed Environmental Status Reports for Navi Mumbai in Maharashtra. The report documents qualitative and quantitative status of the city's resources, such as water and air quality and also health status. It also present initiatives taken by the corporation to reduce stress on natural resources.

### Environmental Audit—Deepak Fertilizers and Petrochemicals Corporation Ltd (DFPCL)

WRC conducted an Environmental Audit for Deepak Fertilizers and Petrochemicals Corporation Ltd (DFPCL) wherein data was collated through pre-visit questionnaires, site visits, staff interviews, secondary data from the industry and Form V submitted to State Pollution Control Board (SPCB). The report comprised of an Environmental Audit

& a Hazardous Waste audit, studied as per Guidelines for Environmental Audit & Hazardous Waste (Management & Handling) Rules 2008 (Amendment in 2016) published by the Central Pollution Control Board (CPCB).

## TERI Southern Regional Centre,

### Bengaluru & Goa

TERI Bengaluru–Goa covers the southern states and territories through its network of various groups—Industrial Energy Group (IEG); Centre for Research in Sustainable Building (CESB); the Centre for Impact Evaluation and Energy Access, Bengaluru (CIEEAB); Resource Efficient Technology (RET); Environmental Education and Awareness (EEA) in Bengaluru SRC; and Coastal Ecology & Marine Research Centre (CE&MRC) based in Goa Centre.

IEG provides services to large energy-consuming industries in better conservation and optimal utilization through energy audit and

implementation assistance. During the year under review, the Group coordinated (a) verification audits of newly designated consumers under the PAT schemes II & III; (b) Mandatory energy audits; and (c) phase III of HAL's CSR initiatives with partnership of BESCOM. Taking up the project on design, installation, and commissioning of power gasifier of 600 kWp for Amazonia Rice Investment Guyana, a rice mill of Nand Persaud Company from the Berbice region, was a significant achievement.

The CIEEAB works with rural communities on aspects, such as renewable energy, watershed development, women empowerment, social inclusion, livelihoods, and efficient utilization of natural resources, particularly fuel sources.

The CESB is currently working with corporates, developers, and public sector units to provide consultancy services for design of energy efficient buildings. The Centre has also been working on research projects with Government of India on energy efficiency, thermal and visual comfort for habitat, and energy efficiency in cold storages.

RET, Bengaluru, is working on research and development (R&D) activities in the areas of development of biodegradable and environmental-friendly plastics for short and long-term applications. The group is well equipped with sophisticated testing equipments for polymer processing and testing services as per standard test procedures.

The EEA area at TERI is playing an effective role in preparing the youth and children by creating awareness and bringing in behavioural changes amongst the younger generation. The group is actively involved in training and delivering sessions to schools and colleges on issues of environmental concern.

The CE&MRC, Goa, which is attached to Southern Regional Centre, Bengaluru, is a multi-disciplinary research centre, and has been conducting both research and implementation in the areas of marine and coastal resources; biodiversity mapping; water technology and management and various activities in areas of environmental awareness, education, and outreach projects.

# GLOBAL OPERATIONS

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## TERI Japan

Since its establishment in 1998, TERI Japan has continued to promote relationships with Japanese institutions, universities, governmental agencies, and non-governmental organizations (NGOs) interested in emerging global concerns in the areas of energy, environment, and sustainable development. The bilateral relations between Japan and India continue to grow very rapidly in all areas, and particularly during the last few years, the relations have reached new heights. The Japan–India comprehensive economic partnership agreement has opened up new opportunities in the bilateral economic engagement.

TERI continues to have a close working relationship with the Institute of Global

Environmental Strategies (IGES), where the office of TERI Japan is located. IGES has the office of its own representative in India located in TERI, New Delhi.

Every year, senior officials from IGES participate in the World Sustainable Development Summit organized by TERI in New Delhi. TERI participates in the International Forum for Sustainable Asia and the Pacific (ISAP) that is organized annually by IGES in Tokyo. Both these occasions provide good opportunities for bilateral meetings between IGES and TERI to review and plan programmes and activities to be undertaken jointly in India and Japan.

Such collaboration between TERI and institutions in Japan is strengthened

further by the periodical visits of the Director General of TERI to Japan, during which consultations are held with various Japanese institutions to review and plan possibilities of joint collaboration. Earlier in the year, when the Director General visited Japan, extensive consultations with regard to collaborative activities were held with the Institute of Energy Economics Japan (IEEJ). During the recent visit of the Director General to participate in the Innovations for Cool Earth Forum (ICEF Forum), meetings were held with the New Energy and Industrial Technology Development Organization (NEDO), Mitsubishi Research Institute (MRI), and several other Japanese and foreign institutions participating in the Forum.

# SUPPORT SERVICES



# Communication Outreach and Advocacy Unit

The Communication Outreach & Advocacy Unit (COAU) serves as the organization's pillar of support and the crucial link for all its outreach activities. The Unit's primary focus is to ensure that the organization as a whole evolves to cater to multiple stakeholders that enable the establishment of resilient partnerships, effective collaborations, and long-term associations with the outside communities as well as across the multidisciplinary programmes within the organization. TERI's governing vision of a sustainable and viable future becomes a stronghold for the organization, especially for the COAU, to reach out to multiple stakeholders through various activities to share with them TERI's best practices.

The COAU has, over the years, formed robust links with diverse media agencies that have enabled TERI's multiple and varied activities to be covered extensively in various publications of all forms. COAU's healthy relationships with external media houses as well as platforms has allowed for an easy exchange of information and the establishment of a mechanized information dissemination system.

The COAU strives to share TERI's research and knowledge with varied audiences, including governments, youth, and the civil society. It is here that the COAU effectively uses its strong links with the media to ensure that through this, TERI's current work and research reaches discerning audiences who benefit from the expert knowledge and actionable policy work that is developed in-house. The Unit undertakes a plethora of engaging activities over the course of the year to encourage dissemination of knowledge and stronger communication with the research community and the media. Amongst these are regular thematic workshops and seminars for mid-level research professionals as well as sensitization workshops and facilitation of participation of journalists at key events. The Programme Cell of the organization that works within the COAU works as the backbone for every such event. They are responsible for the smooth execution of TERI's numerous events and workshops.

TERI's annual flagship event, the World Sustainable Development Summit (WSDS), organised within the COAU,

has been designed as a platform that facilitates meaningful dialogues that promote North-South cooperation and initiate discussions on strategies that would bridge the gap between the developed and the developing nations of the world. The WSDS promotes global equity, equitable distribution of natural resources, and pragmatic solutions to existing issues of climatic importance. An epitome of Track 2 diplomacy, the Summit platform provides an enabling atmosphere that encourages people-to-people dialogue; fosters understanding; cooperation and collective action to achieve the universal goals of sustainable development.

The Environment Education and Awareness area forms another wing of the Unit that works towards providing interesting education pedagogies that instil among the youth, consciousness of existing social structures within our society, cultural norms, economic realities, and global trends.

For our stakeholders who share TERI's vision of a common sustainable future, the Unit recurrently produces a vast body of communication material that focusses on scientific knowledge on energy and environmental issues, with a layered attention on the many human challenges that exist in tackling developmental concerns for dissemination both internationally and within the country. The Unit's work falls within the ambit of four major areas, allowing for a streamlined and efficient division of work. These areas include:

## World Sustainable Development Summit

The World Sustainable Development Summit (WSDS) is TERI's annual flagship event. It has in its journey of 17 years (2001-2018) become a focal point for global leaders and practitioners to congregate at a single platform to discuss

TERI's annual flagship event, the World Sustainable Development Summit (WSDS), organised within the COAU, has been designed as a platform that facilitates meaningful dialogues that promote North-South cooperation and initiate discussions on strategies that would bridge the gap between the developed and the developing nations of the world.

and deliberate over climatic issues of universal importance. The Summit series has emerged as the premier international event on sustainability, which focusses on the global future, but with an eye on the actions in the developing world which could bend our common future.

The WSDS has continued the legacy of the Delhi Sustainable Development Summit (DSDS) which was initiated in 2001 with the aim of making 'sustainable development' a globally shared goal. The Summit series has over the years brought together 47 heads of state and government, 13 Nobel Laureates, ministers from 76 countries, 1,600 business leaders, more than 1,800+ speakers, and over 12,000 delegates from across the world.

With the aim of widening the scope and outreach of the WSDS, a series of pre-events in the form of Regional Dialogues are held throughout the country, prior to the Summit. The discussions and deliberations held during the regional dialogues are brought forward to the main Summit stage where they are





further matured and discussed in-depth by experts and practitioners from relevant fields. Regional Dialogues for WSDS 2018 were held in the cities of Kolkata, Mumbai, and Bengaluru.

The 2018 edition of the Summit also featured an international dialogue which was held in Suva, Fiji, where TERI as 'Knowledge Partner' co-hosted with the Ministry of External Affairs, Government of India, the India-Pacific Islands Sustainable Development Conference on the theme of, 'Furthering the FIPIC Agenda through Sustainability Initiatives'.

The Summit agenda also focusses on hosting exclusive dialogue sessions in the form of plenaries. These sessions welcome senior dignitaries, government officials, corporate leaders, and academicians from all over the world to congregate on a single platform to deliberate over issues of global importance.

In appreciation of the potential that young minds of the world uphold and

recognizing the necessity of including their novel ideas and opinions into the mainstream of public policies, and development models, the WSDS offers a unique platform to undergraduate students to gain a first-hand experience of what goes behind the implementation of tactical strategies to combat the pressing environmental issues. They earn a chance to witness action-oriented dialogues and discussions amongst expert policy makers, government leaders, and acclaimed academicians during the Summit.

The 2018 edition of the WSDS had the honour of being inaugurated by the Hon'ble Prime Minister of India, Shri Narendra Modi, who echoed India's commitment to a sustainable planet, for us and for future generations, at the Summit stage. The WSDS 2018 witnessed participation from 21 countries, and the presence of over 250 speakers, 6 international ministers,

5 Indian ministers, and 15 exhibitors. Possibly the sole Summit on global issues taking place in the developing world, the WSDS now strives to provide long-term solutions for the benefit of the global community by assembling the world's most enlightened leaders and thinkers on a single platform.

### Environment Education and Awareness

The Environment Education and Awareness (EEA) team has been working towards educating the youth on issues related to the existing social structure, cultural norms, economic realities, and global trends. Through its presence in New Delhi, Guwahati, and Bengaluru, the team works with school and university students, faculties, heads of institutes, administrators, parents, corporate employees, ESD (Education for Sustainable Development) practitioners, government officials as well as members





of different educational boards and networks. The scope of the work for EEA is to educate and empower its target group by providing a platform to act for a sustainable tomorrow. The team implements field-based projects on climate change, waste management, energy, environment and water, sanitation & hygiene (WASH) issues.

EEA's flagship programme, 'GREEN Olympiad' is an annual international-level examination for school children being organized by the EEA since 1999. The examination serves the dual purpose of both testing the environment quotient of students as well as enhancing their understanding on various issues related to sustainable development. Students from across the country participate in this programme which also has a global outreach with participation of schools from Nepal, Singapore, Kenya, Indonesia, Iran, Bhutan, Sultanate of Oman, United Arab Emirates, Kuwait, Qatar, Kingdom of Saudi Arabia, Russia, Fiji, Mexico D.F., and the Bahamas, thus reaching out to more than 200,000 students annually.

The GREEN School, is another school initiative being supported by TATA Steel. It aims at creating awareness and an understanding about environment issues in school campuses in select locations in Odisha and Jharkhand. Environment activities with a holistic school approach are conducted with students of Classes VI to VIII. The focus is on creating curriculum linkages with a locale-specific approach.

Another challenging initiative, FLOW (Facilitating Learning on WASH), is supported by Bharti Infratel Ltd and aims to translate awareness and knowledge into action by educating school children on WASH issues. It also aims to provide access to safe water solutions for clean drinking water and for sanitation purposes to these schools through infrastructure interventions. Geographically, the project is spread out

to six cities in India namely, Bhubaneswar (Odisha), Ranchi (Jharkhand), Indore (Madhya Pradesh), Jammu (Jammu and Kashmir), Panipat (Haryana), and Guwahati (Assam).

Green Hackathon is an environment education initiative that aims to showcase solutions conceptualized by students to counter environmental issues through a special event to be held at RMZ Eco World, Bengaluru, on 14 December, 2018; the initiative is supported by the Werise & RMZ Foundation.

### Creative Content

The Creative Content group designs and implements activities to make TERI's knowledge accessible to its stakeholders through the production of films, videos, and digital content, and outreach through TERI's website, print, electronic, and social media. TERI's work on energy access in Bihar, sustainable habitat in

EEA's flagship programme, 'GREEN Olympiad' is an annual international level examination for school children being organized by EEA since 1999.

Amravati, and several initiatives such as the TERI-Mahindra Centre of Excellence to promote sustainable buildings, the partnership with the Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India, to set up a resource-efficiency cell, and setting up of an industry-led platform for waste management received wide attention across all media platforms. A number of researchers wrote opinion pieces in leading newspapers on topics, such as





**THE  
FUTURE  
WE WANT**

10

SHORT FILMS ON THE  
CHOICES WE CAN MAKE FOR  
A SUSTAINABLE FUTURE



energy transitions, air quality and health linkages, and disaster preparedness. The team also collaborated with a number of research projects to produce a wide range of videos on issues related to sustainability. The films were disseminated through YouTube channel and other social media platforms. A few films are listed as follows:

*The Future We Want:* A film series produced under a grant of Films Division,

Mumbai, highlighting 10 inspiring stories about individuals and communities in urban India who have adopted clean and sustainable lifestyles with regard to energy, waste, and biodiversity.

*Bountiful:* A short video on TERI-SDC's biomass-based power generating gasifier being used to enhance livelihoods for economically weak communities in Odisha and Madhya Pradesh



“The team successfully executed the 2018 edition of TERI’s flagship event WSDS.”

*Overcoming Malnutrition:* A video on TERI’s work in Palghar district in Maharashtra, highlighting how malnutrition can be defeated with local and sustainable solutions.

*Climate Change and Health Impacts:* A series of three videos ‘Fortifying against Climate Change’, ‘Millets to the Rescue’, and ‘Superfood for the Poor’ highlighted solutions to meet the growing challenges posed by climate change for public health.

TERI’s community radio team, Kumaon Vani, based out of Mukteshwar in Nainital, produced and broadcast, amongst other issues, a series on women’s health, environment education for children, and gender empowerment.

### Programme Cell

To complement its research agenda, TERI has organized a large number of conferences, training programmes, and seminars on diverse issues and topics. This also includes training and capacity building, exchange of experiences concerning best practices, and information dissemination. The Programme Cell at TERI functions under the Communication Outreach and Advocacy Unit to provide logistic support for all events within and outside TERI, to enable the maintenance of quality and cost effectiveness.

It is a dedicated team of professionals geared up to provide timely and quality support along with audio/visual set up for events, exhibitions, and social programmes.

The Programme Cell provides for services, such as drawing up preliminary budgets, online registrations, facilitation counter at airports, travel desk at the venue, hotel reservations, organized tours, special activities for spouses, side events, recreational activities and other pre- and post-conference activities, including transcription and documentation of proceedings. It also prepares the accounts statement as part of its post-conference protocol.

The team successfully executed the 2018 edition of TERI’s flagship event—WSDS.

# Growth, Diversification, and Commercialization Unit

The primary focus of Growth, Diversification, and Commercialization Unit (GDCU) is as follows:

- To build on TERI's existing strong relationships with bilateral, multilateral, and government agencies;
- To explore and develop linkages with new stakeholders, mainly corporates and foundations, thereby expanding the reach of TERI's research capabilities and output;
- Using TERI's strengths to create new cross-functional platforms with multi-year agendas that will appeal to a multi-stakeholder community;
- To promote and support the commercialization of TERI technologies, products, and services and support the scaling up of emerging technologies;
- To collaborate with Indian companies and other multinational corporations (MNCs) and work on sustainability challenges facing various industries.

Broadly, the mandate of GDCU is operationalized by the Technology Dissemination group, the TERI Council for Business Sustainability (TERI CBS), the International Implementation team, and the Ecotourism unit. These teams work closely with the research programmes and researchers at TERI to develop and provide an array of services in the fields of energy, environment, and sustainable development.

## TERI Council for Business Sustainability

TERI Council for Business Sustainability serves as the interface for TERI's research work to be connected to the corporate world. The Council is a network of Indian businesses 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. The member companies of the Council include the 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.

The Council co-creates business solutions with members 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, Management Development Programmes, 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.

## Technology Dissemination

The Technology Dissemination (TD) group in TERI is responsible for the systematic flow of TERI solutions from lab to industry. The TD group is primarily responsible for securing, maintaining, and working of the intellectual property of the organization. Over the past few years, TERI has developed a rich portfolio of intellectual property related to renewable energy technologies and biotechnology solutions with an immense potential to provide ecological and economic gain to industry and society.

Another key activity of the group is to develop strategic alliances and partnerships for the dissemination and application of technologies. The Group actively facilitates the framing and signing of commercial agreements for effective dissemination of technology.



In the past year, the Group has been actively engaged in identifying and tying up with suitable partners for oily sludge remediation treatment to complement the in-house capabilities of TERI with regard to remediation of contaminated soil. TERI has tied up with M/s Vivakor Middle East, Qatar, for providing treatment for oily sludge in Kuwait. The Group is also involved in identifying and pursuing technology transfer/out-licensing opportunities with industry for TERI technologies.

TERI has also tied up with Verde Institute, Japan, to collaborate for the promotion of clean technologies and



“ Limited understanding of climate change impacts across all sectors of the economy, and securing financial resources have been identified as the major challenges in achieving the NDCs. ”



resource-efficient processes in the region.

In order to promote TERI R&D capabilities and solutions, the TD group has actively participated in events and exhibitions to showcase TERI solutions. The TD Group is also looking to formally engage with M/s Messe Munchen (global exhibition organizers) to collaborate and conduct events on relevant topics with respect to the energy and environment.

### International Implementation

As countries progress on to the implementation phase of nationally determined contributions (NDCs), the key requirement is setting a benchmark for national development indicators as well as demonstrating the feasibility and achievability of the contributions submitted. Combined with regular reviews and the 'ratcheting up' of ambition, this practical experience of implementation will support progress towards a low-carbon pathway.

However, the fundamental challenge remains that many developing countries lack the appropriate institutional frameworks to support implementation along with inadequate local capacities in terms of technical know-how and access to finance.

Limited understanding of climate change impacts across all sectors of the economy, and securing financial resources have been identified as major challenges in achieving the NDCs. Efficient data collection, management and analysis is also required for proper implementation along with effective coordination of a multidisciplinary approach and a well-established government position on issues and policies will need to be strengthened to effectively address the impacts of climate change. There are significant data gaps that act as a constraint in decision making.

With this background, TERI has started a group on International Implementation to support the least developed and island nations in planning the implementation of its climate actions to successfully contribute towards achieving the country's NDCs. TERI already has an MoU in place with the Government of Fiji for assisting them to pilot its energy NDCs.

During 2017, energy efficiency and renewable energy projects were executed in the Caribbean, European, and Middle East regions. Replacement of utility water supply pumps at Sharjah Electricity & Water Authority

In the past years, the group has conducted numerous programmes for thousands of students coming from various institutions across the globe.

(SEWA) were completed and achieved energy efficiency, resulting in reduction in the number of pumps in operation. A project for the integration of dual fuel-fired biomass gasifier of 550kW for a rice mill at Guyana has been initiated and is in the installation stage.

### Ecotourism

The Ecotourism group of TERI has a specific plan to promote tourism in the country in a responsible and sustainable manner whilst involving the local community leading to the overall economic development of the area.

The group's key role is to conduct 'Eco-Educational Programmes' for educational institutions, sensitizing youth about various environmental issues with respect to the existing social structure, cultural norms, economic realities, and contemporary global trends. In the past years, the group has conducted numerous programmes for thousands of students coming from various institutions across the globe. As part of the programme, the Ecotourism group places maximum effort to minimize the gap between urban and rural India and develop a sense of responsibility amongst the participants towards nature and the local community.

Another key activity of the group is to sustainably run and manage all day-to-day activities at TERI's Himalayan Centre, nestled in Mukeshwar, Nainital. The group actively encourages private and public organizations to look for an escape from their metro life and explore suitable income-generation opportunities for the local community in the hills of Uttarakhand.

In order to promote Mukteshwar as a destination and upscale market of TERI's herbal products, the group has organized and also participated in numerous events and exhibitions in different parts of the country for overall economic and social development. The group has also joined hands with local government bodies and NGOs to encourage ecologically sustainable and financially viable ecotourism.



# Knowledge Management

## Library and Information Centre

TERI is a leading think tank research-based organization engaged in knowledge generation, creation, and global dissemination of its research and innovation on energy, environment, and sustainable development to both local and global stakeholders. The research and innovation strength of TERI is backed by innovative library and knowledge services, capturing and managing TERI's vast knowledge, and research data. The Knowledge Management Division supports TERI's research activities through a well-designed, state-of-the-art intranet-based knowledge management system.

The Library and Information Centre (LIC) caters to the knowledge needs of both TERI researchers and external users visiting the LIC by providing guidance and services through collecting, collating, and disseminating knowledge-based products and services using subscribed and open-access resources, which include books, reports, periodicals, and e-resources. Besides providing research and project assistance to TERI researchers and external users, the core competency of the LIC professionals also lies in proactive engagement in multi-stakeholder projects; conduct capacity-building programmes for external and internal research and information professionals; web content and database development; bring out peer-reviewed publications and knowledge products



TERI Library organizing WSDS thematic workshop on sustainable transport

on contemporary issues, and setting up specialized information centres on thematic areas, such as transport, renewable energy, and climate change, mycorrhiza, and climate change. During the year under review, the LIC executed projects from government and international organizations consisting of Database on R&D Equipment supported by the Department of Science & Technology, Mycorrhiza Information Centre supported by the Department of Biotechnology, developing Transport Statistical Database from International Transport Forum, Geneva, and ENVIS Centre on Renewable Energy and Climate Change from Ministry of Environment, Forest and Climate Change, Government of India. As part of ENVIS activities, TERI ENVIS Centre, hosted within the LIC, has disseminated scientific and technical information on various renewable energy, climate change, and environmental

issues. The ENVIS Centre also undertook various other activities, such as the Community-Driven Environmentally Sustainable Village Programme (CESVP) through environment surveys and sensitizing clean energy use in NCR villages at Dheerpur, Ghoga, and Singhola. Further to this, TERI ENVIS conducted solar rooftop benefit assessment survey of 200 resident welfare associations (RWAs) in Delhi and organized Swachh Abhiyan at Children's Park in New Delhi.

“The research and innovation strength of TERI is backed by innovative library and knowledge services, capturing and managing TERI's vast knowledge, and research data.”



Participating in Swachh Bharat Abhiyan under Environmental Information System (ENVIS) Project

Being an emerging capacity-building hub for research and knowledge professionals, the LIC organized a thematic workshop during the WSDS on 'Strengthening an Evidence-based Policy Framework for Sustainable Transport', on February 15, 2018, and 'Workshop on Digital Marketing and Role of Social Media to Build Smart Libraries 2.0' during 8–10 November, 2017.

## TERI Press

TERI Press, the publishing arm of TERI, is one of the India's leading publishers in the areas of environment, energy, and sustainable development. TERI Press publishes books, journals, and magazines on these topics at all levels. These range from children's books to higher education titles to professional reference books and magazines to journals. Keeping in view TERI's commitment to the dissemination of research and academic knowledge, in published form, TERI Press is dedicated to publishing quality books and has received both national and international recognition for its versatility and efficiency. With increasing social debate and educational emphasis on sustainability, there is a growing need for quality, environmental education content. TERI Press, in its endeavour to bring greater ecological awareness, has a wide range of print publications; widely accessible eBooks; and sophisticated, interactive e-learning products that cater to every type of reader and knowledge requirement on diverse areas of the environment. TERI children's books, produced under the imprint of Terrapin, not only engage and sensitize young minds with nature-centric knowledge



books but also encourage the habit of reading among children across India.

We work with academics across the globe to produce quality content and materials to improve learning outcomes for students and contribute to the development of the subject areas in which we publish. With over 400 published titles on energy, climate change, sustainable architecture, environmental studies for adults and knowledge books for children, TERI Press has been a valuable source for filling the learning gap on environment and sustainability.

Our environment magazines, such as TerraGreen and Energy Future, educate readers on key local and global environment issues. TERI Press also conceptualizes customized knowledge resources based on the needs and assessments of the target beneficiaries.

TERI Press is the most preferred publication partner for leading corporates and ministries, such as the Ministry of New and Renewable Energy, Government of India, BSES Rajdhani Power Ltd, Oil and Natural Gas Corporation, Gas Authority of India Ltd, and the Ministry of Environment, Forest and Climate Change, Government of India.



This includes undertaking environment-related projects to encourage an active social connect with the environment.

In fact, TERI Press is the most preferred publication partner for leading corporates and ministries, such as the Ministry of New and Renewable Energy, Government of India, BSES Rajdhani Power Ltd, Oil and Natural Gas Corporation, Gas Authority of India Ltd, and the Ministry of Environment, Forest and Climate Change, Government of India. With every carefully chosen and published title, quality has been the single major idea that drives TERI publications. TERI Press books and learning resources create a lasting impression and aim to make a positive difference.

# Project Management Unit

Projects are the mainstay of TERI. At any given time, hundreds of projects, ranging from research to implementation, would be underway. The Project Management Unit (PMU) is the institute's central hub and the objective of this Unit is to efficiently manage the projects—from their inception through to their conclusion.

The PMU ensures that TERI's projects meet their budgetary and performance obligations and that at all times, the lines of communication between the donors/sponsors, implementation teams, and beneficiaries are well maintained and accessible. PMU, which functions

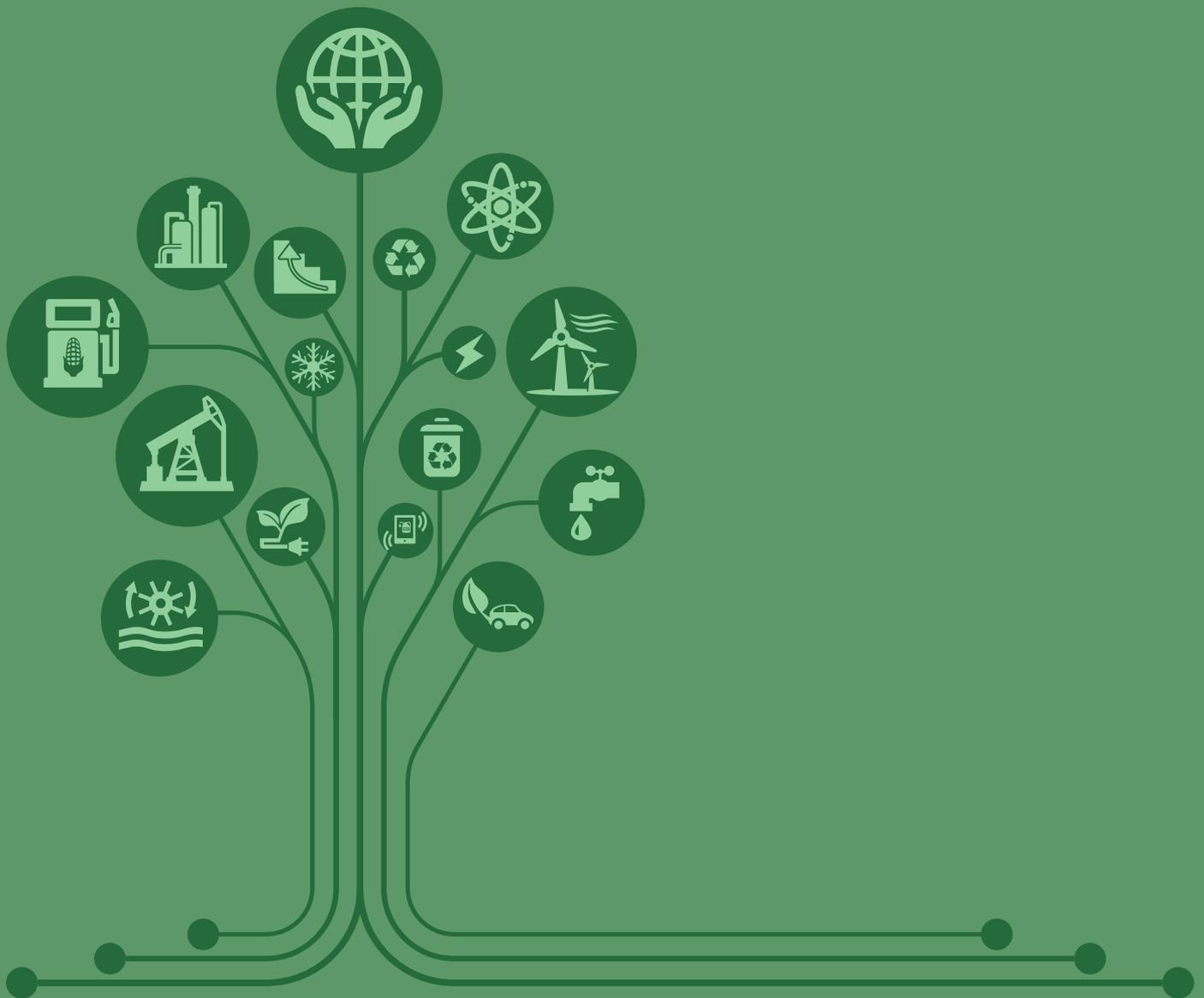
as a nerve centre of the institute, is responsible to respond to the needs of projects in a timely and effective fashion. The PMU's key responsibilities include the following:

- 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
- Research and editorial assistance
- Logistical support
- 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. However, PMU's role does not end here as it also ensures that all the projects are well documented and catalogued in TERI's knowledge repository.



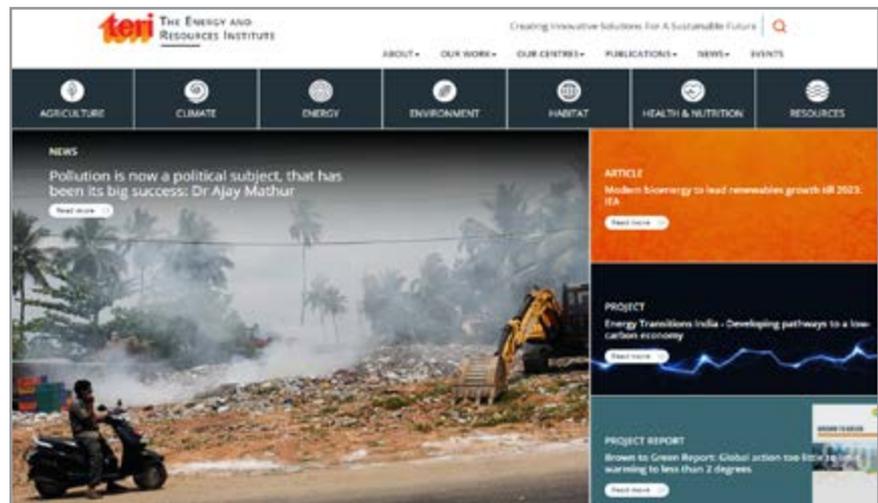
# SUPPORT UNITS



# Information Technology and Services

The Information Technology (IT) and Services Division positions themselves as enabler, catalyst or facilitator for strategic goals of the institute. The team planned and started to bring a paradigm shift to move IT from operations to a strategic partner in the business. The driving objective is to provide secure access to IT applications and services from anywhere, anytime, on any device to everyone. It is also aimed to make IT services flexible enough to change as per the need of the business and as well as of end users. The procurement model is being shifted from Capex to Opex to optimize cost and to provide opportunity to explore more applications and services within same budget.

The team supported in conceptualization of the TERI Research Enterprise Engine (TREE) by developing a prototype of the system to provide a digital workspace on cloud for all researchers. It is designed to bring most of the research functions starting from proposal development, contract negotiations, project planning and execution, till formal project closure into the system. All support functions related to projects, that is, documentation, communication, quality assurance, procurement, risk management, reviews & approvals, and linking with internal and external systems would be integrated to a single system.



An Enterprise Content Management System (ECMS) has been developed to manage and automate the lifecycle of content, including content collection, updation, review, and publishing on the TERI website. It ensures that the process is followed for each set of content to maintain consistency, quality, and integrity. Further, it has been planned to use ECMS to manage content for multiple websites and act as a repository for internal reference.

As part of the transition in communication strategy, the unit has revamped the TERI website with new theme-based architecture, in order to effectively connect and communicate with end-users. The website is completely responsive and has a unified technical architecture with streamlined content publishing mechanism using ECMS. The website is developed on a secure framework that can be expanded to accommodate any number of new websites. The TERI Enterprise systems, that is, finance, procurement, and invoice systems are made Goods and Services Tax (GST) compliant by carrying out the necessary changes and enhancements. The IT team supported administrative functions to handle challenges and make this transition of replacing multiple taxes levied by the central and state governments easier for them. The other key enhancements to systems include developing a dashboard for timesheets and an appraisal system for the administrative staff.

The TERI Unified Mobile Application (TERI-UMA) has been developed to provide as a single interface to access all enterprise mobile applications. Once downloaded, it requires single authentication to all its applications, which include People Search, Project Photo, Business opportunities, timesheet, etc., to use these while colleagues are on travel or at home, thus saving their precious time. India's National Rating

System for Green Buildings, that is, Green Rating for Integrated Habitat Assessment (GRIHA) is further enhanced by developing a module specifically for Existing Buildings (EB) and updating the GRIHA Evaluator system.

In addition, websites and mobile apps were developed for GRIHA Summit 2017 and the World Sustainable Development Summit (WSDS) 2018. The key project websites developed include Climate and Clean Air Coalition project website (<http://ccacindia.teriin.org/>); Sameeksha website (<http://sameeksha.org/>); Nationally Determined Contribution website (<http://www.ndcfootprints.org/>), Wild Edibles website (<http://wildedibles.teriin.org/>); etc. Besides, online surveys prepared for development of compendium of DSIR-recognized SIROs and Mainstreaming Sustainable Social Housing in India (MaS-SHIP).

End-to-end ultramodern IT infrastructure was set up at the newly constructed Nano-Bio Research Centre, replete with all the latest technologies, such as Network, Servers, IPBX, Wireless and Audio/Video communication tools, document management and printing system as service has also been extended to this new location. This building was inaugurated by the Prime Minister of India and Australia using the Internet of Things (IoT) technology from a remote location.

Taking a step towards cloud-based services, TERI has availed one of the leading audio & video collaboration services which has enabled us to conduct video conferences simultaneously from five different locations and each host has a capability to invite 25 participants.

A new HPC (Supercomputing) infrastructure with a maximum capacity of 11.82 Teraflops of speed, 308 cores of processing power, and 250 TB of storage is under implementation to meet the future requirements in the areas of climate, air, and water modelling.

# Human Resources

The objective of the Human Resource Division is to ensure a progressive environment for an engaged workforce and enable the work towards the realization of the vision and mission of TERI. With a vision to provide a growth-enabling environment to the diverse workforce, its role is not only to identify and acquire the desired 'talent' for TERI, but it also take initiatives for talent management and retention. There has been a strong focus towards laying a foundation in people processes to drive a merit-based pay for performance culture. The Human Resources division has been instrumental in introducing newer policies and procedures to encourage imbining TERI values in the organizational work systems. Facilitating learning and development initiatives for the staff as per the need and priorities of the business divisions as well as enhancing the engagement levels of existing employees through various employee-engagement activities are additional priority areas for the HR organization. Colleagues across the Institute are exposed to training programmes on a variety of behavioural and technical capability areas. These programmes aim at furthering leadership skills, enhancing personal effectiveness, sharpening interpersonal skills, and building people management skills. The outbound learning activities focus on promoting team dynamics at work and building a proactive approach for



generating new research ideas. TERI has a strong focus on encouraging cross-functional research activities, provide opportunities to professionals to contribute to and gain knowledge and expertise in areas other than their primary research area, thereby enhancing interdisciplinary work. The division organizes sports and cultural activities for TERI's employees and their families to strengthen employer-employee bonding and cultivate a culture of connect beyond work. There are channels and programmes, such as the periodic Town Hall Meetings and the Annual Vision Retreat which provide platforms for employees to be a part of organization building and play a key role in building an inclusive workplace by participating in cross functional team projects. The division caters to the ever-changing needs of the organization to develop new strategies to keep employees motivated and engaged.

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# Administrative Services

The Administrative Services Division provides the necessary administrative and maintenance support to all the facilities located at the TERI headquarters at the India Habitat Centre; its regional centres located at Bengaluru, Goa, Guwahati, and Mumbai; and the campuses at TERI Gram in Gurugram and TERI Himalayan Centre in Mukteshwar, Uttarakhand. The strength of the Division lies in its well-motivated, dedicated, and qualified staff that supports all operations of TERI round-the-clock. It maintains and runs all amenities and utilities meeting international standards. TERI's Quality Management System (QMS) is certified as

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per ISO 9001:2008 standards, its Health and Safety Management System as per BS OHSAS 18001:2007, and its Environment Management System as per ISO 14001:2004.

The Administrative Services also look 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 the opportunity to use its facilities to hold 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.

# PARTNERSHIPS AND NETWORKS



# PARTNERSHIPS AND NETWORKS

When trying to link policy, research, and practice, TERI recognizes the need to build collaborative partnerships and networks with the objective of sharing knowledge, enhancing technological capabilities, fostering innovation, building local capacities, and strengthening competitiveness. The Institute continues to team up with local, international and bilateral institutions, and research and academic institutions to promote sustainable interventions. Our research collaborations, MoUs, and partnerships, along with their areas of interest, through the year 2017/18, are listed in this section.

## Governments & PSUs

Partner	Profile	Focus Area	Type of Association
Agharkar Research Institute, Pune	Department of Science and Technology, Government of India	Microbial Biotechnology	Partnership Network
Andhra Pradesh Southern Power Distribution Company Ltd (APSPDCL)	Government of Andhra Pradesh	Solar PV grid integration studies, Demand Side Management (DSM), Energy Efficiency (EE)	TERI's partner utility in the MacArthur Foundation-funded project on technical studies on rooftop SPV grid integration. TERI also conducted four capacity-building programmes on DSM and EE for circle-level officials of APSPDCL.
Assam Forest Department	Government of Assam	Capacity Building for Assisting the State Project Management Unit in the implementation of JICA project	Capacity Building Support
Bangalore Electricity Supply Company Ltd (BESCOM)	Government of Karnataka	DSM and EE	TERI conducted four capacity building programmes each on DSM and EE for circle level officials of the utility.
Bengaluru Electricity Supply Co. Ltd	Government of Karnataka	R&D Summit 2018	Funding Support
Bharat Petroleum Corporation Ltd (BPCL)	Public Sector Undertaking	Bioremediation of oily sludge, contaminated soil	Funding Support
British High Commission	Diplomatic mission of the United Kingdom in India	Strengthening Corporate Green Leadership in India	Funding
BSES Rajdhani Power Limited	Government of India	Design & Implementation of Solar Rooftop Systems	Partnership
BSES Rajdhani Power Ltd (BRPL)	Public-Private Partnership	Battery energy storage systems (BESS), Solar PV grid integration studies, Electric vehicles (EVs)	BRPL is TERI's utility partner in the UI-ASSIST project. TERI and BRPL have signed a MoU for capacity building programmes and conducting research on solar rooftop PV, energy storage systems, EVs, DSM and EE and smart grid technologies.
Bureau of Energy Efficiency	Government of India	Energy Efficiency, Demand Side Management	Funding; TERI conducted training programme for circle level officers of 6 DISCOMS across the country on DSM
Bureau of Indian Standards (BIS)	Government of India	Standards on BESS and RE integration	TERI is a member in the BIS ETD-46 Sectional Committee on 'Grid Integration of Renewables' and ETD-52 committee on 'Electrical Energy Storage Systems'.

Partner	Profile	Focus Area	Type of Association
CAIRNS Energy Ltd, Gurgaon	Public Sector Undertaking	Microbial Biotechnology	Funding Support/ Partnership Network
Central Electricity Authority (CEA)	Government of India	Electric vehicles	TERI performed simulation and measurement studies on vehicle to grid concept and EV charging harmonics respectively to contribute to the technical report of the BIS ETD-51 standard on Electrotechnology in Mobility whose sub-committee on grid-related aspects of EV charging is headed by CEA.
Central Glass and Ceramic Research Institute, Khurja	Council of Scientific and Industrial Research, Government of India	Research on ceramic filters for wastewater treatment	Collaborative Research
Central Power Research Institute	Ministry of Power, Government of India	Research and developmental studies EMI shielding nanocomposites for power sector	Collaborative Research
Centre for Tropical Crops and Bio-commodities, Queensland University of Technology, Brisbane, Australia	Government of Australia	Microbial Biotechnology	Collaborative Project Partner
CESCOM	Government of Karnataka	DSM and EE	TERI conducted four capacity building programmes each on DSM and EE for circle level officials of the utility.
Chandigarh Renewal Energy and Science & Technology Promotion Society' (CREST)	Nodal body of the Department of Science and Technology, Chandigarh Administration, for promotion of RE in the union territory	Rooftop solar PV	TERI continued its association with CREST on a variety of innovative projects on solar PV like third-party inspection of rooftop PV plants.
Chhattisgarh Forest Department	Government of Chattisgarh	Carbon stock assessment of forests: Capacity building of the Chhattisgarh Forest Department	Capacity Building Support
Climate & Clean Air Coalition (CCAC)	Intergovernmental Coalition	Short-Lived Climate Pollutant (SLCP) Reduction from Municipal Solid Waste (MSW) Management	Implementing Partner in India
Coal India Limited	Public Sector Undertaking	Sanitation; Forest and agriculture-based livelihood activities	Funding
CSIR-Indian Institute of Chemical Technology (IICT), Hyderabad	Ministry of Science and Technology, Government of India	Microbial Biotechnology	Collaborative Project Partner
DBT-CIAB Center for Integrated and Applied Biosciences , Mohali	Department of Biotechnology, Government of India	Microbial Biotechnology	Funding Support
DBT-IOC Centre for Advanced Research on Bioenergy, R&D Centre, Indian Oil Corporation, Faridabad	Government of India	Microbial Biotechnology	Funding Support

Partner	Profile	Focus Area	Type of Association
Department of Biotechnology	Government of India	Energy efficiency in cold storage chain	Funding Support
Department of Biotechnology	Government of India	Ericulture for Upliftment of Socio-economic Conditions of Rural Women in Tribal Villages of Assam	Funding Support
Department of Biotechnology	Government of India	Ethnobotanical Survey of Indigenous Plants and their Pharmacological Screening for Anti-ulcer Potential	Funding Support
Department of Biotechnology	Government of India	Local Treatment of Urban Sewage Streams for Healthy Reuse	Research Collaboration
Department of Biotechnology	Government of India	DBT-CoE - Production of pyrolytic oil from algal paste	Funding
Department of Chemical Engineering, for Process System Computations, Curtin University, Perth, Western Australia	Government of Australia	Microbial Biotechnology	Collaborative Project Partner
Department of Horticulture, Bihar	Government agency	Micropropagation of Banana	Supply of plants
Department of Science and Technology	Government of India	Energy Efficiency in Habitat	Funding Support
Department of Science and Technology, Government of India	Central Govt. Department	Funding support	Dissemination of Renewable Energy Technologies
Department of Science and Technology (DST)	Government of India	Design and Development of biomass solar electricity and cooling solutions for Rural India	Funding
Energy Efficiency Services Ltd	Government of India	Energy Efficiency, Load Research	Funding Support
Finnish Meteorological Institute	Government of Finland	Meteorology	Funding
Finnish Meteorological Institute, Helsinki, Finland	Government of Finland	Microbial Biotechnology	Collaborative Project Partner
Flood and River Management Agency of Assam (FREMAA)	Government of Assam	Livelihood enhancement for river erosion victims	Funding Support
GAIL India Ltd	Public Sector Undertaking	Microbial Biotechnology	Funding support
GITA	Public-Private Partnership	Water Use Efficiency	Funding
Global Innovation & Technology Alliance	Government of India	Water Use Efficiency	Funding
Goa State Biodiversity Board	Government of Goa	Biodiversity	Support for Projects
Goa State Pollution Control Board	Government of Goa	Pollution	Funding Agency/ Collaborative Research
Green Chemistry Centre of Excellence, Department of Chemistry, University of York, Heslington, York, United Kingdom	Government of United Kingdom	Microbial Biotechnology	Collaborating partners and jointly organized Indo-UK Joint Workshop (granted by Government of UK)

Partner	Profile	Focus Area	Type of Association
Gujarat Energy Development Agency (GEDA)	Government of Gujarat	Energy Efficiency	Partnership
Gujarat Industries Power Company Ltd	Government of Gujarat	Developing action and monitoring plan for reclamation of mine-degraded lands and addressing socio-economic and livelihood issues of fringe populations of Vastan Lignite Mine of GIPCL, Mangrol, Surat	Policy Support
Gulbarga Electricity Supply Company Ltd (GESCOM)	Government of Karnataka	DSM and EE	TERI conducted four capacity building programmes each on DSM and EE for circle level officials of the utility.
Haryana Renewable Energy Development Agency (HAREDA)	Government of India	Examine the Detailed Project Reports (DPRs) for setting up of biomass based power projects as envisaged in the Bio-Energy Policy 2018	Funding
Helmholtz Centre for Environmental Research, Leipzig, Germany	Government of Germany	Microbial Biotechnology	Collaborative Project Partner
Hindustan Petroleum Corporation Ltd (HPCL)	Public Sector Undertaking	Bioremediation of oily sludge, contaminated soil	Funding Support
INBIGS, ONGC Jorhat	Public Sector Undertaking	Microbial Biotechnology	Funding Support
India Smart Grid Forum (ISGF)	Public-Private Partnership (PPP) initiative under the Ministry of Power, Government of India	Smart grids	Institutional Member under Working Group – 5 on Renewables & Micro-grids
Indian Bureau of Mines	Government of India	Conducted national workshop titled 'Remediation of Mined-Out Areas and Abandoned Mines-Status & Strategies'	Collaborative Research
Indian Council of Forestry Research and Education (ICFRE)	Government of India	Mid-career training programme for senior IFS officers	Training Support
Indian Institute of Technology (IIT), Delhi	Government of India	Microbial Biotechnology	Collaborative Project Partner
Indian Institute of Technology (IIT), Delhi	Academic Institute	Wastewater Treatment	Collaborative Research
Indian Institute of Technology (IIT), Guwahati	Research Institute	Microbial Biotechnology	Collaborative Project Partner
Indian Institute of Technology (IIT), Madras	Government of India	Microbial Biotechnology	Partnership Network
Indian Institute of Technology, Mandi, Himachal Pradesh	Research Institute	Microbial Biotechnology	Collaborative Project Partner
Indian Oil Corporation Ltd	Public Sector Undertaking	Bioremediation of oily and acidic sludge	Funding Support
Indian Oil Corporation Ltd (IOCL)	Public Sector Undertaking	Bioremediation of oily sludge, contaminated soil	Funding support
Indira Gandhi National Forest Academy (IGNFA)	Government of India	Mid-career training programme for senior IFS officers	Training Support

Partner	Profile	Focus Area	Type of Association
Institute of Advanced Studies for Science and Technology (IASST), Guwahati	Department of Science and Technology, Government of India	Microbial Biotechnology	Collaborative Project Partner
Institute of Reservoir Studies, ONGC, Ahmedabad	Public Sector Undertaking	Microbial Biotechnology	Partnership network
Indian Renewable Energy Development Agency (IREDA)	Government of India Enterprise	Funding support	Need Assessment for CSR Activities
Karnataka Forest Department	Government of Karnataka	Forest and biodiversity	Funding
Karnataka Renewable Energy Development Ltd	Government of Karnataka	R&D Summit 2018	Funding Support
Karnataka State Pollution Control Board	Government of Karnataka	Pollution	Funding Agency
Karnataka Watershed Department	Government of Karnataka	Watershed Management	Funding
Kerala State Electricity Board Ltd (KSEB)	Government of Kerala	DSM and EE	TERI conducted four capacity building programmes each on DSM and EE for circle level officials of the utility.
Lawrence Berkeley National (LBNL)	Independent laboratory of the Department of Energy, Government of USA	Demand forecasting and electric vehicles	TERI's partner institute in the US for the UI-ASIST project
Maharashtra Forest Department	Government of Maharashtra	Preliminary study on implementation of FRA and vulnerability of forests and forest dwelling communities in Maharashtra	Collaborative Research
Ministry of Environment, Forest and Climate Change	Government of India	Environment, Evaluation of the scheme on biosphere reserves namely Nanda Devi, Gulf of Mannar, Khangchendzonga, Kachhch, and Manas	Funding Support
Ministry of External Affairs	Government of India	Energy Efficiency, Training Programmes	Funding Support, Partnership, Training Programmes
Ministry of External Affairs	Government of India	Renewable Energy	Funding support and partnership
Ministry of Micro, Small and Medium Enterprises	Government of India	Energy Efficiency in MSME Sector	Knowledge Support
Ministry of New and Renewable Energy	Government of India	Implementation of National Level RPO Portal for RPO monitoring.	Funding
Ministry of Power	Government of India	Environmental and Social Impact Assessment	Funding Agency
Nagaland Forest Department	Government of Nagaland	Assess the biodiversity status of CCAs in Nagaland, carrying out GEF Satoyama project titled 'Mainstreaming Community-Conserved Areas for Biodiversity Conservation in Nagaland'	Policy Support
National Health and Medical Research Council (NHMRC)	Australian Government	Expert body Supporting health and medical research	Support for Projects

Partner	Profile	Focus Area	Type of Association
National Institute of Interdisciplinary Science and Technology (NIIST), Thiruvananthapuram	Ministry of Science and Technology, Government of India	Microbial Biotechnology	Funding Support
National Institute of Technology	Government of India	Alternate energies	Collaboration on Research Projects
National Renewable Energy Laboratory (NREL)	Independent laboratory of the Department of Energy, Government of USA	Power system balancing, scheduling and dispatch	TERI's partner in the ETC India project for the work related to power system balancing requirements in 2030.
National Thermal Power Corporation Ltd	Public Sector Undertaking	Water Audit, Water Use Efficiency	Funding
National Water Mission, Ministry of Water Resources	Government of India	Water Use Efficiency	Funding
NHPC Ltd	Government of India	Valuation of the socio-economic and environmental costs and benefits of hydro power projects in India: Case study of two selected projects, including Bhakra Nangal project and the URI project	Collaborative Research
NITI Aayog	Government of India	Water and Energy; Consultancy for Impact Assessment-II of HP Mid Himalayan Watershed Development Project	Funding & Consultancy Support
North Eastern Council	Government of India	Capacity building Programme for Assisting State Government Officials in Designing Sustainable Livelihood Programmes	Funding Support
Northern Railways	Government of India	Water Audit	Funding
Norwegian Ministry of Foreign Affairs	Government of Norway	Designing a REDD-plus pilot project in India	Collaborative Research
Norwegian Water Resources and Energy Directorate	Government of Norway	Water resources, Energy	Partner
NTPC Energy Technology Research Alliance (NETRA)		Water Use Optimization	Collaborative Research
Oil and Natural Gas Corporation (ONGC) Ltd	Public Sector Undertaking	Bioremediation, Consultancy for soil fertility improvement	Funding support
ONGC Energy Centre	Government of India	Battery, Fuel cell and Supercapacitor as Bulk Energy Storage Options: Study on Technological Advancements and Market Readiness	Funding
Oil India Ltd (OIL)	Public Sector Undertaking	Bioremediation of oily sludge, contaminated soil, Microbial Biotechnology	Funding Support
Oil India Ltd, R&D Center, Duliajan, Assam	Public Sector Undertaking	Microbial Biotechnology	Funding Support
ONGC Energy Centre	Government of India		Funding

Partner	Profile	Focus Area	Type of Association
ONGC Energy Centre, ONGC Laxmi Nagar, New Delhi	Public Sector Undertaking	Microbial Biotechnology	Funding Support
South Delhi Municipal Corporation	Government of India	Third party quality assurance for four biogas plant in South Delhi Municipal corporation	Funding
State Institute of Panchayat and Rural Development (SIPRD)	Government of Assam	Rural Development	Funding Support
State Level Nodal Agency (SLNA), Soil Conservation Department	Government of Assam	Monitoring, Evaluation, Learning and Documentation of projects implemented under Integrated Watershed Management Programmes (IWMPs)	Funding Support
Surat Municipal Corporation	Government of India	Preparation of tender document, technical and financial bid evaluation	Funding
Surat Municipal Corporation (SMC)	Government of Gujarat	Smart Cities	TERI provided consultancy and technical support, including third-party inspection services for solar PV plants installations in Surat
Swedish Environmental Protection Agency	Government Agency, Sweden	India-Sweden Strategic Approach to Integrated Management of Bio-waste and Non-ozone Depleting Substance- non-HFC alternatives	Funding
Tamil Nadu Generation and Distribution Corporation Ltd (TANGEDCO)	Government of Tamil Nadu	DSM and EE	TERI conducted four capacity building programmes each on DSM and EE for circle level officials of the utility.
Tata Steel Ltd, Jamshedpur	Public Sector Undertaking	Microbial Biotechnology	Funding Support
Temper University of Technology, Helsinki, Finland	Government of Finland	Microbial Biotechnology	Collaborative Project Partner
Tribal Cooperative Marketing Development Federation of India (TRIFED)	Government of India	Estimating minimum support price for 50 minor forest produce	Collaborative Project Partner
USAID	Government of USA	Water and sanitation, Gender equality, Agriculture	Funding
Uttar Pradesh Forest Department (UPFD)	Government of Uttar Pradesh	Preparation of Afforestation and Reforestation CDM PDD, facilitation of validation, registration and verification; Monitoring and capacity building of UPFD staff on monitoring; Biodiversity and socio-economic assessment of protected areas in Uttar Pradesh, Monitoring and Evaluation of Advance Soil Work and Plantations undertaken by Uttar Pradesh Forest Department	Policy Support
Uttarakhand Biodiversity Board	Government of Uttarakhand	Development of State Biodiversity Strategy and Action Plan (SBSAP) of Uttarakhand	Policy Support
Water Resources Department	Government of India	Water Resource Management	Funding agency

Partner	Profile	Focus Area	Type of Association
Watershed Development Department, Government of Karnataka	State Government Department	Funding support	Monitoring, Evaluation, Learning and Documentation of KWDP II project

## Research & Academic Institutions

Partner	Profile	Focus Area	Type of Association
Abt Associates	International research and consulting	Climate change research; Disaster Risk Reduction research	Collaborative research
Adelphi	International Research Organisation	Climate change research	Collaborative research
Automotive Research Association of India	Research Institute - Indian	Vehicle and air pollution research	Collaborative research
Birla Institute of Technology & Science	Indian Institution	Water Remediation	Collaborative Research
BMS Institute of Technology	Academic Institute	Reviews, Course work, Workshops	Visiting Faculty
Centre for Energy, The University of Western Australia, Perth, Australia	University	Microbial Biotechnology	Collaborative Project Partner
Centre for Materials for Electronics Technology	Research Institute	Logger and Sensors	Collaborative Research
Chhatrapati Sahu Ji Maharaj University, Kanpur, Uttar Pradesh	State Academic Institute	Medicinal plants	Project Partner
Climate Policy Initiative (CPI)	Independent think-tank and consultancy organization headquartered in the UK	Power system flexibility	TERI's partner in the ETC India project for the work related to flexibility requirements for the power system in 2030
CSIRO Energy Transformed Flagship, North Ryde, New South Wales	Australian Research Institute	Microbial Biotechnology	Collaborative Project Partner
DBT-ICGEB Center for Advanced Bio-energy Research, Center for Genetic Engineering and Biotechnology, New Delhi	Research Institution	Microbial Biotechnology	Funding Support
DBT-ICT Centre for Energy Biosciences, Institute of Chemical Technology, Mumbai	Research Institution	Microbial Biotechnology	Collaborative Project Partner
Delft University of Technology, Netherlands	University	Wastewater Treatment	Collaborative Research
Department for International Development, UK	Academic and Research - India	Air pollution	Funding
Environmental Management Policy & Research Institute (EMPRI)	Research Institute	Forest and Biodiversity	Funding Agency/ Collaborative Research

Partner	Profile	Focus Area	Type of Association
EXXONMobil, USA	Research and Engineering – International	Air pollution research	Funding
Finnish Meteorological Institute, Finland	Academic and Research - International	Atmospheric pollution research	Collaborative research
Helsinki Environmental Research, Helsinki, Finland	Institute	Microbial Biotechnology	Collaborative Project Partner
ICAR-Indian Agriculture Research Institute	Research Institute	Crop productivity	Collaborative research
ICAR-National Initiative of Climate Resilient Agriculture	Research – National	Climate resilient agriculture	Funding
ICIMOD	International Research Organization	Climate change research	Collaborative research
IL&FS Environment	Advisory and project development services	Environmental Management, Geo-spatial, Energy Conservation and Carbon Business	Collaborative research
Indian Agricultural Research Institute, New Delhi	Research Institute	Genetic modifications to improve biological nitrogen fixation for augmenting nitrogen needs of cereals	Collaborative Research
Indian Oil Corporation R&D, Faridabad	Research	Vehicle and air pollution research	Collaborative research
INESC TEC, Portugal	International R&D Institute	Science & Technnology	Collaboration on Research Projects
Institute for Advanced Sustainability Studies, Potsdam	International Research Organisation	Energy, Climate and air quality, oceans and arctic research, air pollution	Collaborative research, funding
Institute for Global Environmental Strategies	Research Institution	Capacity building on climate change, Energy efficiency	Collaborative Research
International Growth Center (IGC)	Research Centre	Solid Waste Management	Funding Support
International Water Management Institute (IWMI)	Research Organization	Research on Water Issues	Collaborative Research
London School of Hygiene & Tropical Medicine (LSHTM)	University	Health Research	Collaborative Research
Maharashtra Energy Development Agency (MEDA)	Research Institution (under Government of Maharashtra)	Energy Efficiency	Partnership
Mahatama Gandhi Institute of Rural Energy and Development (MGIRED)	Academic Institute	Academic course work, reviews	Visiting Faculty
Metropolia Institute of Technology, Helsinki, Finland	Institute	Microbial Biotechnology, Air pollution related to vehicular emission	Collaborative Project Partner
Monash University	International University	Research on Infectious Disease, Epidemiology, Public Health and Preventive Medicine	

Partner	Profile	Focus Area	Type of Association
Motilal Nehru National Institute of Technology (MNNIT), Allahabad	Institute	Microbial Biotechnology	Collaborative Project Partner
National Environmental Engineering Research Institute (NEERI), Nagpur	Research Institute	Environmental pollution, wastewater	Collaborative Research
National Institute of Environmental Health Sciences	Research Institute	Health Effects	Funding Support
National Institute of Hydrology	Research Institute (under Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India)	Hydrology	Collaborative Research
National Oceanic and Atmospheric Administration (NOAA)	Research Institute	Climate Change	Funding Support
Netherlands Institute of Ecology (NIOO-KNAW), Netherlands	Research Institute	Wastewater	Funding Support
New Energy and Technology Development Organisation	Research Institution	Energy Efficiency, Smart Grids	Partnership
NIT Trichy	Academic Institute	Academic course work, reviews	Visiting Faculty
NITK, Surathkal	University	Consultancy	Collaborative Research
North Carolina State University (NCSU)	University	Consultancy	Collaborative Research
North Eastern Regional Institute of Water & Land Management	Academic Institute (under the Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India)	Watershed Management	Project Partner
Norwegian Institute for Urban and Regional Research - HiOA	International Research Organisation	Climate change research	Collaborative research
Norwegian Institute for Water Research - NIVA	International Research Organisation	Climate change research	Collaborative research
Nottingham Trent University	University	Sustainable Mobility	Collaborative Research
Perspectives Climate Group GmbH	International research and consulting	Climate change mitigation, carbon markets, NAMA	Collaborative research
PIK- Germany	International Research Organisation	Climate change research	Collaborative research

Partner	Profile	Focus Area	Type of Association
Renewables Academy (RENAC)	International Research Organisation	Training and capacity building on renewable energy and energy efficiency	Collaborative research
Sardar Patel University, Bakrol, Anand, Gujarat	Research Institute	Microbial Biotechnology	Collaborative Research
Tempere University of Technology, Finland	Academic and Research - International	Sensor development for Atmospheric pollution measurement	Collaborative research
The Energy Conservation Center, Japan	Research Institution	Energy Efficiency	Funding
UNEP DTU	International Research Organisation	Climate change mitigation, MRVing policies/actions	Collaborative research
Uni Research- Norway	International Research Organisation	Climate change and global teleconnection research	Collaborative research
University of Agricultural Sciences, Bengaluru	University	Agricultural Sciences	Collaborative Research
University of Algarve, Portugal	University	Marine and Coastal Research	Collaboration on Research Projects
University of California, San Diego, USA	Academic Institute - International	Impact of indoor air pollution on health	Funding support and research partner
University of Eastern Finland	University	Partnership for the mid-career training programme for IFS officers	Collaborative Research
University of Guelph, Canada	University	Climate Change and Water Resources Management	Collaborative Projects
University of Guyana	University	Feasibility study for the bio-diversity centre at the University of Guyana	Collaborative Research
University of Leicester, UK	Academic Institute - International	Air pollution and health	Funding
University of Maribor, Slovenia	University	Chemistry and Chemical Engineering	Collaborative Research
University of Rhode Island	International University	Water Resources Management	Collaborative Research
University of Salerno, Italy	University	Wastewater Treatment	Collaborative Research
University of Trans-disciplinary Health Sciences and Technology (TDU)	Research Institute	Ecology	Collaborative Research
Wageningen University & Research, The Netherlands	University	Wastewater Treatment	Collaborative Research
Wageningen University and Research	University/ Research Organisation	Climate change research	Collaborative research
Washington State University (WSU)	Academic Institution	BESS at distribution level	WSU is the US lead of the UI-ASSIST project consortium of which TERI is a research partner
Yale University	University	Partnership for the mid-career training programme for IFS officers	Training Support

## Banks & Financial Institutions

Partner	Profile	Focus Area	Type of Association
GIZ	Funding Agency	Conducted Situation Analysis and Capacity Needs Assessment vis-à-vis Human Wildlife Conflict in India under The Indo-German Project, 'Human Wildlife Conflict Mitigation' being implemented by MoEFCC and GIZ India; Rooftop solar PV promotion	Collaborative Research; TERI, with support from GIZ, provided Project Management Consultancy (PMC) support for rooftop solar PV plants installation to one of the distribution utilities in Madhya Pradesh. TERI, along with GIZ, also helped in launching the 'Dwarka Solar City' initiative in Delhi
Japan International Cooperation Agency (JICA)	Funding Agency	Carrying out JICA-funded projects in Uttar Pradesh, Arunachal Pradesh, etc.	Funding Support
NABARD	Development Bank	Capacity building	Support for Projects
United States Agency for International Development (USAID)	International Funding Agency	Water, Sanitation and Hygiene (WASH)	Funding Support
YES Bank	Bank	Circular economy; Knowledge partnership for YES Bank Natural Capital Awards	Knowledge Partner
Ramboll- Environ Foundation, USA		Environmental, health and social issues	
The World Bank	International Financial Institution	Consultancy services for baseline survey for UDWDP and GEF-SLEM project in Uttarakhand and MHWDP in Himachal Pradesh; Climate Change; NDC implementation	Funding Support

## Domestic & Multinational Corporations

Partner	Profile	Focus Area	Type of Association
Cenergist	Corporate	Energy efficiency	Partner
CharIn (Charging Interface Initiative e.V.)	Association of automotive manufacturers and other organizations for development and promotion of CCS	Combined Charging Standard (CCS) EV charging standard	TERI is an associate member of CharIn and spearheaded the organization of the First CharIN EV India Seminar
Chem Fab Ltd	Corporate	Carbon sequestration through plantation activities at Chem Fab Ltd	Partner
Deccan Chemicals Pvt Ltd	Corporate, India	Capacity Building	Funding Agency
Hindalco Industries Ltd	Corporate, India	Reclamation of back filled area of bauxite mines through afforestation activities at HINDALCO, Lohardaga, Jharkhand	Collaborative Research
ITC	Corporate, India	Development of Clonal Propagation Techniques	Collaborative Research
Jain Irrigation Systems Ltd	Corporate, India	Manufacturers of drip and sprinkler irrigation systems and components, Irrigation Water Use Efficiency	Collaborative Research

Partner	Profile	Focus Area	Type of Association
Lavasa Corporation Ltd	Corporate	Biodiversity compliance document prepared for Lavasa	Collaborative Research
Marico Industries	Industry	Circular economy	Funding Support
Nirmal Seeds Pvt. Ltd.	Industry	Mycorrhiza Technology	Collaborative Research
ONGC-TERI Biotech Ltd (OTBL)	Corporate	Bioremediation of oily sludge, contaminated soil, MEOR	Funding Support
Ramboll- Environ Foundation, USA	Corporate, Foreign	Environmental, Health and Social Issues	Support for Projects
Reliance Industries Ltd	Corporate, India	Bioremediation of oily sludge, contaminated soil	Funding Support
SABMiller India	Corporate, India	Manufacturers of beverages	Collaborative Research
SB Industrial Engineering Pvt Ltd	Corporate	Bioremediation of oily sludge, contaminated soil	Funding Support
Tetra Pak India Pvt. Ltd.	Corporate, India	Waste Management	Funding Support
The Indian Woods Products Company Ltd	Private Company	Feasibility Study for Potential Applications of Waste Generated from Gambier during Catechin Extraction	Funding
Toyota motor corporation	Automotive manufacturer	Air pollution research	Funding
Transtech Green Power Ltd, Jaipur	Industry	Animal feed development from microalgae	Collaborative Research and demonstration
United Breweries Limited (UBL)	Corporate, India	Pond rejuvenation	Funding

## NGOs & Foundations

Partner	Profile	Focus Area	Type of Association
Adelphi Research, Germany	Not-for-profit research institute	Policy analysis and strategy consulting	Collaborative Research and Partner in Field Implementation
Austria Recycling Verein zur Förderung von Recycling und Umweltschutz in Österreich (AREC), Austria	Not-for-profit research institute	Research in resource efficiency and recycling	Collaborative Research and Partner in Field Implementation
Bloomberg Philanthropies, USA	National Philanthropic Trust	Developing strategies for control of air pollution	Funding
BVRio Institute	International civil non-profit association	Carbon markets	Collaborative research
CDP Worldwide	Not-for-profit research Institute	Climate change mitigation, carbon pricing	Collaborative research
Centre for Fly Ash Research and Management	Not-for-profit organization	Commercialization of fly ash based flame retardant nanocomposites	Partnership
Deutsche Gesellschaft für Internationale Zusammenarbeit	Not-for-profit organization	Resource Efficient and Cleaner Production (RECP)	Funding Support
Dhaka Chamber of Commerce & Industry (DCCI), Bangladesh	Not for profit trade organization	Promote private sector enterprises and businesses with advocacy, awareness and policy inputs to government	Collaborative research and partner in field implementation in Bangladesh

Partner	Profile	Focus Area	Type of Association
International Crops Research Institute for the Semi-Arid Tropics, Andhra Pradesh	Not-for-profit organization	Agricultural research for development in Asia and sub-Saharan Africa	Collaborative Research
Jnanodaya Grameena Vidya Trust, Chickballapur, Karnataka	Non-governmental organisation	Project partner and Field Support	Field Support for Monitoring, Evaluation, Learning and Documentation of KWDP II project
Konrad-Adenauer-Stiftung (KAS)	Think Tank/ Consulting Agency	Expert body supporting health and medical research	Conducted a background study on 'Reforming Global Architecture of Marine Resource Security: An Indian Perspective'
Krishi Rasayan Group, Kolkata	Not-for-profit organization	Research on development and field trials of encapsulation and sustained release of micronutrients	Collaborative Research
MacArthur Foundation	Funding Agency	Transparency framework around GHG inventories	Grantee
MS Swaminathan Research Foundation, Chennai	Foundation	Agricultural Research	Collaborative Research
NASSCOM	NGO	R&D Summit 2018	Funding Support
National Cleaner Production Center (NCPC), Sri Lanka	Non-profit Organization	Consultancy and advisory services, information dissemination, training and capacity building, policy advocacy	Collaborative research and partner in field implementation in Sri Lanka
Oxford Policy Management limited	Research Institute	Climate Change	Collaborative research
SaciWATERS—South Asia Consortium for Interdisciplinary Water Resources Studies	NGO	Water Research	Knowledge Partner
Shakti Sustainable Energy Foundation	Funding Agency	Climate change, Low carbon development	Funder/Grantee
Shakti Sustainable Energy Foundation (SSEF)	Foundation	Energy Efficiency, Demand Side Management, Climate Policy, Power, Distribution utilities forum	Partnership/ Funding; Distribution utilities forum and development of an open source tool for projection of demand profile
Society for Environmental and Economic Development Nepal	NGO	Solutions for enhancing productivity, preventing industrial pollution, better working environment, and improving the quality of life	Collaborative Research and Partner in Field Implementation in Nepal
STENUM Asia Sustainable Development Society (STENUM Asia), India	Not-for-profit research institute	Consulting in resource efficiency for industries	Collaborative Research and Partner in Field Implementation
Wellcome Trust	Foundation	Health research	Funding Support

## Multilateral & Bilateral Organizations

Partner	Profile	Focus Area	Type of Association
Big Solar Ltd	International organization	Unique low cost scalable PV Technology	Funding
Climate Technology Centre and Network	Multilateral Organization	Climate Change	Collaborative Partner

Partner	Profile	Focus Area	Type of Association
COPPE	Multilateral Organization	Energy, Environment	Project Partner
Deutsche Gesellschaft Fur Internationale Zusammenarbeit (GIZ)	International Organization	Study of Mini Grids in India	Funding
European Commission	Multilateral Organization	Energy, Environment	Funding Support
European Union	Multilateral Organization	Resource Efficiency	Resource efficiency in sectors of interest
Germanwatch e.V.	International organization	De-Risking Investment in Solar Energy	Funding
India Energy Storage Alliance (IESA)	Alliance of major organizations in energy storage	Energy storage	TERI is a member of the IESA
International Centre for Integrated Mountain Development (ICIMOD)	Multilateral Organization	Events on REDD+ and Carbon Financing	Collaborative Research
International Council for Local Environmental Initiatives	International Organization	Design, Supply, Installation and Commissioning of 2 tonnes/day capacity bio-methanation plant	Funding
International Finance Corporation	Multilateral Organization	Development of GHG Calculator for Distributed Rooftop Solar PV Projects, Energy efficiency in SME	Funding
International Institute for Applied Systems Analysis	Multilateral Organization	Energy, Environment	Project Partner
International Network for Bamboo and Rattan Organization (INBAR)	Multilateral Organization	Feasibility study on livelihood and market potential of Bamboo in north east India	Collaborative Research
International Union for Conservation of Nature (IUCN)	Multilateral Organization	Best practices for watershed development in Indian Himalayan region	Collaborative Research
Norwegian Ministry of Foreign Affairs	Foreign Ministry, The Kingdom of Norway	Feasibility study - Biomass Gasifier, Heat Engine for Micro-Grid	Funding
PBL Netherlands Environmental Assessment Agency	Multilateral Organization	Energy, Environment	Project Partner
Swiss Agency for Development and Cooperation	Bilateral Organization	Promoting Energy Efficiency in the MSME Sector	Partnership Agreement
U.S. Environmental Protection Agency	Multilateral Organization	GHG Mitigation	Funding Support and Partnership
U.S. Environmental Protection Agency (USEPA)/ Abt Associates	International Organization	Advancing Agricultural Biogas Projects: Technology, Policy and Financing Options	Funding Support and Partnership
United Nations Development Programme (UNDP)	Multilateral Organization	Energy efficiency; State Biodiversity Strategy and Action Plan under BIOFIN project	Funding Support and Partnership
United Nations Framework Convention on Climate Change	Multilateral Organization	Jointly conducted three events on land degradation in WSDS 2018	Partnership Agreement
United Nations Industrial Development Organization (UNIDO)	Multilateral Organization	Energy efficiency, Renewable energy	Funding Support and Partnership
World Health Organization (WHO)	Multilateral Organization	Energy policy for Clean Household Energy & Health	With support from WHO, TERI conducted assessments for Energy policy for Clean Household Energy & Health Country

# KNOWLEDGE CONTRIBUTIONS



# REPRESENTATION IN NATIONAL AND INTERNATIONAL EXPERT GROUP COMMITTEES

- Adholeya A. Chairman, Expert Committee — Biological Agents for Agriculture, DBT (Department of Biotechnology), Ministry of Science & Technology, New Delhi.
- Adholeya A. Chair, Policy Committee. International Mycorrhiza Society, Canada ([www.mycorrhizas.org](http://www.mycorrhizas.org)).
- Adholeya A. Member, International Advisory Board for Bloomsbury Qatar Foundation Journals, Qatar, since 2010.
- Adholeya A. Member, Editorial Board International Journal of Ecology & Development (IJED), published by Indian Society for Development and Environment Research (ISDER), Roorkee, India.
- Adholeya A. Member, Editorial Board Indian Journal on Microbiology published by The Association of Microbiologists of India, IARI, India.
- Adholeya A. Member, Experts Committee on the application of nanotechnology in agriculture and medicine, Department of Biotechnology, Ministry of Science and Technology, Government of India, New Delhi.
- Adholeya A. Member, Working Group on implementation of National Policy on Biofuels, Ministry of New and Renewable Energy, Government of India, New Delhi.
- Adholeya A. Member, Sectoral Innovation Council for the Fertilizer Sector, Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government of India, New Delhi.
- Adholeya A. Secretary, International Symbiosis Society.
- Adholeya A. Member, The Economic Research Institute of ASEAN and East Asia (ERIA).
- Adholeya A. Member, The Advisory Committee to the Executive Board of the Louis Dreyfus Foundation.
- Akashdeep. Member, Environment Cell, New Delhi Municipal Council.
- Anshuman. Technical Advisory Committee (TAC) of National Institute of Hydrology (NIH) (Under Ministry of Water Resources, Government of India).
- Anshuman. Member of Sectional Committee for Water Quality for Industrial Purposes under the Bureau of Indian Standards (BIS).
- Anshuman. Advisor, High Level Advisory Council of Aquatech organised by Amsterdam RAI & IWA (the International Water Association).
- Anshuman. Jury Member, Water Digest Water Awards, organised by Water Digest and UNESCO.
- Bansal K C. Member, Executive Council, National Academy of Agricultural Sciences, NAAS, 2017.
- Bansal K C. Special Invitee, National Advisory Board on Management of Genetic Resources, Ministry of Agriculture, Government of India.
- Bansal K C. Member, Research Advisory Committee, National Academy of Agricultural Research Management, ICAR, 2018.
- Bansal K C. Member, Research Advisory Committee, NRC on Grapes, ICAR, 2017.
- Member, Review Committee, National Transgenic Crops Project, NRC on Plant Biotechnology, IARI, 2018.
- Bansal K C. Member, Quinquennial Review Team, National Institute of Abiotic Stress Management, ICAR, 2018.
- Bansal K C. Member, Quinquennial Review Team, National Institute of Biotic Stress Management, ICAR, 2018.
- Bansal K C. Member, Governing Society, Punjab Biotechnology Incubator, Government of Punjab, 2017.
- Bansal K C. Member, Editorial Board, Plant Biotechnology Journal (Impact Factor: 6.3), Wiley-Blackwell Publishers, England, 2017.
- Bhadwal Suruchi. UNDP-NCSP Regional Roster of Expert on Vulnerability and Adaptation.
- Bhadwal Suruchi. Member Working Group on Climate Change and Environment for the XIIth V Year Plan (2012-2017), constituted by the Planning Commission.
- Bhadwal Suruchi. Peer Review Committee Member of the Climate Monitor Group.
- Bhadwal Suruchi. Member “Expert Group on Climate Change and Health” constituted by the Ministry of Health and Family Welfare.
- Bhadwal Suruchi. Lead Author for the IPCC Special Report on Climate Change and Land.
- Bhadwal Suruchi. Lead Author for the IPCC AR6 Report on Impacts, Vulnerability and Adaptation.
- Balakrishnan M. 2015-till date. Expert member for DST Water Technology Initiative Programme.
- Balakrishnan M. 2017-till date Expert member for DST Engineering & Technology Development under Women Scientists Scheme-B (WOS-B).
- Balakrishnan Malini and Batra V S. Member of Chemical Division Council of Bureau of Indian Standards (BIS).
- Bhardwaj Saurabh. PMC member, NICES-ISRO committee, TERI representative.
- Bhardwaj Saurabh. Life time patron and member, Indian Meteorological Society.
- Bhattacharjya S. Member of the Bureau of India Standard Committee on Trade and Environment.
- Das P. Expert Committee Member, CSIR to review proposals submitted under Focused Basic Research (FBR) and Niche Creating Project (NCP) categories of Chemical Theme “Chemicals (including Leather) and Petrochemicals (CLP).
- Das P. Member, Sub-Committee on ‘Biomass to Drop-in Fuel & Biomass to Bio Crude for Co-Refining’ under Working Group of Biofuel, MoP&NG in 2018
- Datta Alekhya. Alternate member from TERI, BIS ETD-46 Committee.
- Datta Alekhya. Alternate member from TERI, BIS ETD-46 Committee.
- Datt D. Apex Committee on State of Environment Public Procurement, Ministry of Environment Forest and Climate Change, Government of India.
- Datt D. Steering Committee Member of Asia-Europe Foundation.
- Dehadani A. Alternate Member— Core Committee Member for Revision of IEQ Standard, ISHRAE.

- Dhingra S. Member, Project Appraisal Committee constituted by Ministry of New and Renewable Energy for evaluating and recommending proposals for biomass based power, bagasse based co-generation projects
- Dhingra S. Member, Expert Committee constituted by NAFED for management of farm waste/ residues
- Dhingra S. Member, Study Steering Committee constituted by TIFAC for overall steering and guidance of the study on 'Biofuels – Current status and R & D Roadmap'.
- Dkhar N B. Association of Polar Early Career Scientists, India.
- Dkhar N B. Enjoyment of Glaciers Group.
- Dkhar N B. Indo-French Water Network.
- Dkhar N B. europe.mtnforum.
- Dkhar N B. International Society for Environmental Information Sciences.
- Dkhar N B. Asia-Pacific Chemical, Biological & Environmental Engineering Society (APCBEEES).
- D'Souza F. Member of Technical Advisory Committee (TAC) of Goa State Pollution Control Board (GSPCB), Goa (2013 –2017).
- Garud S. Life member, Solar Energy Society of India since 1986, Member of Indian Standards Expert committee on Solar Energy
- Ghate A T. March 2016–2020. Member. G-3 Committee: Reduction of Carbon Footprint in Road Construction and Environment constituted by the Indian Roads Congress.
- Ghate A T. December 2017-Present. Member (on behalf of TERI). Sub-Committee on Fuel Economy Norms for Medium & Light Commercial Vehicles, Ministry of Petroleum & Natural Gas (MoP&NG), Government of India.
- Ghate A T. 2017–2018. Member. Committee constituted by DHI and NATRiP on Incentive Structure under Phase II of FAME Scheme.
- Ghate A T. June 2016–November 2017. Member. International Scientific Committee (ISC) of CODATU 2017.
- Ghate A T. July–November 2017. Member. Peer Review Committee for the Research Symposium organized as part of the Urban Mobility India (UMI) Conference and Expo organised by Ministry of Urban Development, Government of India.
- Ghate A T. March 2016–2017. Member. G-4 Committee: Mechanization & Instrumentation Committee constituted by the Indian Roads Congress.
- Jasrotia Shivakshi. Program Committee Member (ACSTM-Dubai).
- Jasrotia Shivakshi. Active Lifetime Member (ProsPER.NET).
- Kumar S, Member, CED-30, Sectional Committee, BIS.
- Kumar A, Member, Interim Administrative Cell of International Solar Alliance (ISA)
- Kumar A. Member, Governing Council of National Institute of Solar Energy (NISE).
- Kumar A. Member, Advisory Committee of ONGC Energy Centre for Appraisal of R&D Programme in Clean Energy
- Kumar A. Member, "R&D Project Appraisal Committee" of MNRE for solar thermal and solar PV projects
- Kumar A. Member, Expert Panels constituted by ONGC and IOCL for developing solar cooking solutions to suit all variety of Indian type cooking.
- Kumar A. Life Member, Solar Energy Society of India
- Manuja S. 2018- till date. Member of International Solid Waste Association (Austria).
- Manuja S. February–April 2018. Member of Technical committee for organizing the 8th Regional 3R forum for Asia and the Pacific, Ministry of Housing and Urban Affairs.
- Manuja S. 2017-till date. Member. Technical Working Group- Climate bonds (UK).
- Mathur R. Lead Author for the Sixth Global Environment Outlook (GEO6).
- Mathur R. Lead Author for IPCC AR6 Report.
- Nitya N. Member PMEAC (Economic Advisory Council to the Prime Minister) Committee on Road map for Blue Economy and National Integrated Ocean Policy.
- Pal P. Member, Empanelment Committee for Empanelment of Energy Auditors on PCRA's Panel. Petroleum Conservation Research Association (PCRA).
- Pal P. Member, Panel of experts on Waste Heat Recovery, under the UNIDO-BEE project on 'Facility for Low Carbon Technology Deployment (FLCTD)'
- Panandiker Pai A. Member, Goa State Expert Appraisal Committee (SEAC) Endorsed by Ministry of Environment, Forest and Climate Change (MoEF&CC), New Delhi—2013 to 2017.
- Pandey S. 2007–till date. Member, Research Advisory Committee of Central Pollution Control Board.
- Pandey S. 2007–till date. Member, Standard Setting Committee on Waste constituted by Bureau of Indian Standards (BIS).
- Pandey S. 2012–till date. Member, Expert Group on Critically Polluted Area constituted by Ministry of Environment, Forest and Climate Change, Government of India.
- Pandey S. 2015–till date. Member, Expert Advisory Committee on Waste Management Under Technology Systems Development Programme of DST.
- Pandey S and Manuja S. 2017-till date. Member of Technical Working Group on Waste Management – Climate Bonds Initiative, UK.
- Pandey S. Life Member. Indian Association for Environment Management.
- Pant D. Resource Person, Swachh Bharat Mission by National institute of Urban Affairs, Ministry of Housing and Urban Affairs
- Patil K. Member of International Women's Water Nexus Technical Committee, of EWRI.
- Ramanathan K. Principal member from TERI, BIS ETD-46 Committee; Member, Standing Advisory Committee, DERC.
- Reddy V. Member State Expert Committee, Karnataka State Action Plan for Climate Change EMRI, Karnataka.
- Saxena A K. Principal member from TERI, BIS ETD-52 Committee.
- Sehgal M. 2017. DHFW Delhi Action Plan for Climate Change and Health.
- Sehgal M. 2017. National Steering Committee (NSC) of TNA Climate Change Project - Health sector.
- Seth S. Member–Stakeholder Committee of 'EPD India Programme Operator' representing GRIHA Council (Institute for Certification and Quality Mark, [ICMQ] India).
- Seth S. Principal Member–Core Committee Member for Revision of IEQ Standard, ISHRAE.
- Seth S. 23 February 2017-till date. Member - Constitution of Technical Committee for Commercial Buildings sector under PAT Cycle-III (Bureau of Energy Efficiency, Ministry of Power, Govt. of India), New Delhi.
- Seth S. 21 June 2017-onwards. Member - Constitution of technical committee for empanelment/re-

- empanelment of Energy Service Companies (ESCOs), Bureau of Energy Efficiency, Ministry of Power, Government of India, New Delhi.
- Seth S. 4 August 2017-onwards. Member–Technical Committee for EESL–Ozone Cell, MoEF&CC’s HPMP \*Hydrochlorofluorocarbon Phase-out Management Plan) Project, Energy Efficiency Services Ltd, New Delhi.
  - Seth S. 25 August 2017 onwards. Member–Steering Committee of Development of Residential Building Energy Conservation Code (Bureau of Energy Efficiency, Ministry of Power, Government of India), New Delhi.
  - Seth S. 11 September 2017 onwards. Advisory Member of Board of Studies Committee, School of Architecture and Planning, KIIT University,
  - Seth S. 27 December 2017 onwards. Member–Advisory Committee for the Sustainable Buildings R&D Summit, March 2018, TERI.
  - Seth S. 8 February 2018 onwards. Principal Member - Building Construction Practices Sectional Committee (CED 13), Bureau of Indian Standards (BIS), New Delhi.
  - Seth S. Member - SCP Clearinghouse, UN Environment for MaS-SHIP Trust Fund Project, 15.12.17 onwards.
  - Seth S. 22 August 2017 onwards. Project Advisory Board Member of Learn-BPE (Learning Building Performance Evaluation) for Improved Design and Engineering, Royal Academy of Engineering, United Kingdom.
  - Sethi G. Member, Screening Committee of Petroleum Conservation Research Association (PCRA).
  - Sethi G. Member, Energy Management Sectional Committee of Bureau of Indian Standards (BIS).
  - Sethi G. Member, Examination Advisory Committee for Energy Managers and Energy. Auditors, Bureau of Energy Efficiency, Ministry of Power, Government of India.
  - Sethi G, Member, Steering Committee on Technology and Quality Up-gradation support to MSMEs, Ministry of MSME, Government of India.
  - Shardul M. Member: Alliance of CSOs for Clean Energy Access (ACCESS).
  - Shardul M. Representative: for SDSN-Youth in South-Asia, UNSDSN-Youth.
  - Shardul M. Member: Capacity Building Hub for SE4All.
  - Seth S. 25 April 2017 onwards. Advisory Board Member - Glass Academy Foundation, Chennai, Tamil Nadu.
  - Singh R. 2017 - Present. Member, India Coordination Group of the Compact of Mayors (CoM/ India) facilitated by International Urban Cooperation and European Union Delegation (EUD) to India.
  - Singh R. 2018 - Present. Member, Working Group on ‘Environment’ for the Delhi National Capital Region (NCR) Plan Review being conducted by NCR Planning Board.
  - Singh R. 2018- Present. Expert Member of the Study Group on Environment for National Capital Region Planning Board (NCRPB).
  - Singh R. 2016- Present. Member of Working Group in Asia Pacific Ministerial Conference on Housing & Urban Development (APMCHUD) for Disaster Resilience and Climate Change.
  - Vyas Shashank. Member, IEEE Smart Grid Working Group on Big Data Analytics and Machine Learning.

## REPRESENTATION IN NATIONAL AND INTERNATIONAL JOURNALS

- Bhattacharya Sailaja, Malini Balakrishnan, Vidya S Batra. Reviewer for various Elsevier, Wiley, and Springer international journals.
- Manuja S. Member. Review Panel, *Journal of Packaging Technology & Research*, Springer International Publishing.
- Manuja S. Member. Review Panel, PHI Learning Pvt Ltd.
- Pandey S. Member. Editorial Board, *ICE: Waste and Resource Management*.
- Pandey S. Member. Review Panel, *Waste Management*, Elsevier.
- Sehgal M. Global Health Action.
- Sehgal M. *Journal of Environmental Pollution and Control (JEPC)*.
- Sehgal M. Reviewed BMJ Open.

# HUMAN CAPITAL AND INFRASTRUCTURE FACILITIES



# HUMAN CAPITAL

At TERI, we consider all TERI-tes to be of utmost value and the key resource for success of the Institution. The synergy brought about by our human resources is a result of the freedom and flexibility that the Institute provides to its research professionals.

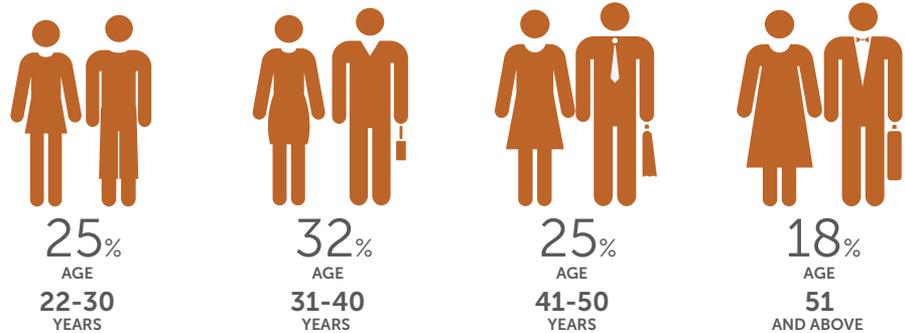
TERI fosters a culture, which respects diversity in age, gender, and education, and realizes that each individual is unique and that each one brings a fresh perspective and their own skill sets to the table, which in turn helps TERI build a collaborative culture.

Our strength lies in the diversity of our people and we respect the fact that their different views and ideas help us stimulate our minds intellectually. TERI encourages its researchers to work on cross-functional and cross-divisional basis because it realizes that the interdisciplinary approach, the exchange of best work practices, and the concerted effort in thought and action leads to the desired outcome, which in turn enhances sponsor and client satisfaction.

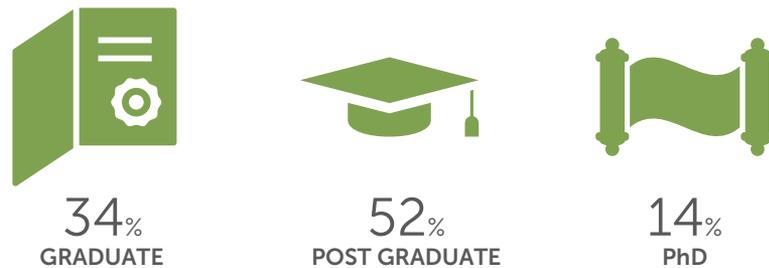
## GENDER



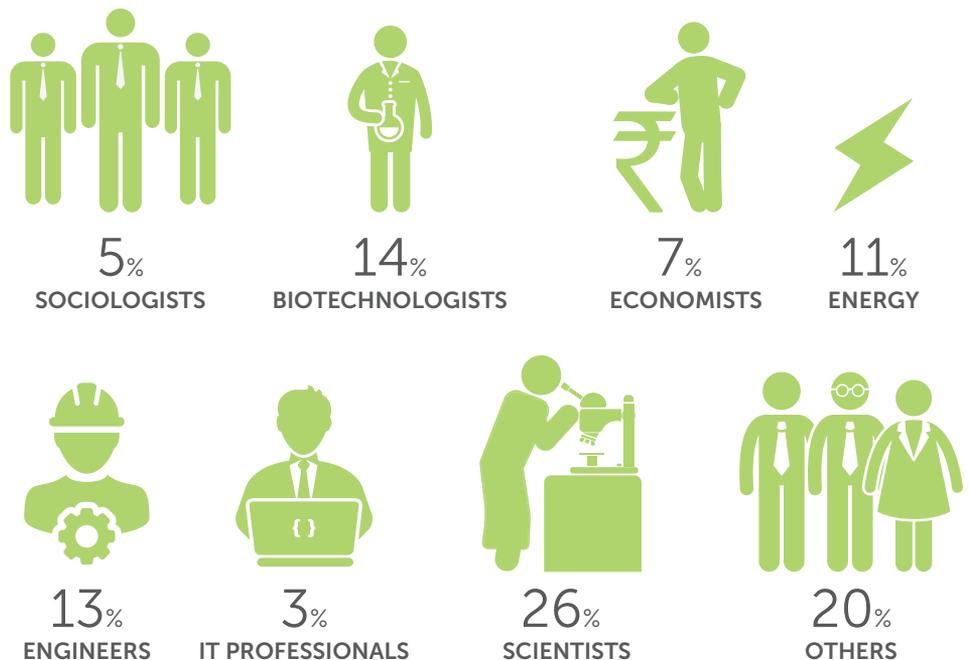
## AGE DISTRIBUTION



## QUALIFICATION



## SPECIALIZATION



# INFRASTRUCTURE FACILITIES

An Institute of the calibre and spread of TERI requires the presence of 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 towards greater success and achievement in the year 2017/18.



## 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 green-houses 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.

## Film and Television Unit

The Film and Television Unit has been producing some award-winning documentaries and owns the basic infrastructure to execute a film or television shoot end-to-end. It has been constantly producing high-quality DV output meant for television broadcast and theatre screenings.



## In Vitro 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.

## Solar Lighting Laboratory

The Solar Lighting Laboratory is involved in design customization, lab- and field-based performance assessment, and training on distributed generation-based systems for various applications. These include solar lighting systems, solar multi-utility charging stations for charging lanterns, mobile phones, and e-bikes.





## 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.

## 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.



## Plant Genetic Transformation and Functional Genomics Laboratory

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

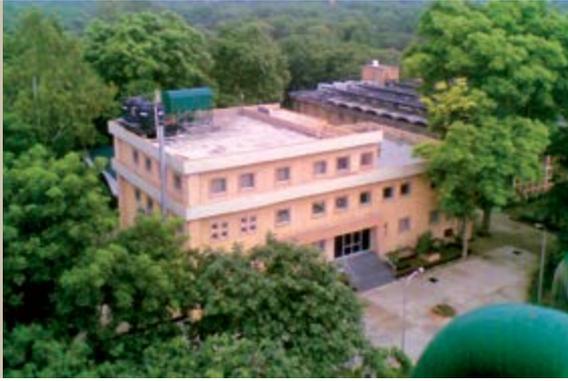
## TERI-Deakin Nanobiotechnology Research Centre

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.



## 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.



## Fermentation Technology and Research Centre

The Centre is a state-of-the-art fermentation facility with a pilot-scale platform to carry out studies. It has a series of fermentors 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. The facility also has the necessary analytical infrastructure for quality control and analysis of various fermentation products.

## Supercomputer to Enhance Climate Modelling Capabilities

TERI has acquired supercomputing facility to boost its activities on climate modelling. The supercomputer consists of 512 cores that can draw a peak performance of 5.5 T Flops. Total RAM is 1,000 GB with 32TB of storage space and about 24TB of backup storage. Models posted on the HPC system are CESM, CCSM, NorESM, WRF, and PRECIS.



## 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 state-of-the-art field sampling, monitoring equipment, and analytical instruments. The laboratory provides multi-disciplinary water quality and quantity monitoring, testing, and related services.

## Microbial Biotechnology Laboratory

The laboratory is an experimentation facility for the exploration of microbial diversity to provide biotechnological solutions in the field of environmental restoration and biofuels. The facility has state-of-the-art molecular biology set up with automated facility and real-time PCR systems. Infrastructure for both aerobic and anaerobic microbiology facility is available. The laboratory is supported by analytical facility that is equipped with necessary GC (with TCD and FID), GCMS, HPLC (with diode array and RI detector) systems with other requisite instrumentations.



## Solar Power Pack

It is an integrated solar multi-utility charging station for charging lanterns, mobile phones, and e-bikes.



## 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.

## 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.



## Library and Information Centre

The 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

The Energy and Resources Institute (TERI) and Somfy India Pvt Ltd have come together 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.

# APPENDICES





# CONTRIBUTION TO JOURNALS AND PROCEEDINGS

## Energy

### Industrial Energy Efficiency

- Ghosh A M, Gopal E N, Vasudevan N, Energy Efficient Downdraft Kiln for Small-scale Refractory Industries Proceedings of the International Symposium to Promote Innovation & Research in Energy Efficiency (INSPIRE 2017).
- Gopal E N and Ghosh A M, Shedge N, Sharma V, and Pal P. 2018. Energy efficient technologies and best operating practices for Improving resource efficiency in small scale foundry (INSPIRE 2017).
- Kumar S, Sharma P, Vaidyanathan G, and Yap N. 2017. Diffusion of cleaner production innovation - case study of Varanasi brick cluster. *Eastern International Journal of Entrepreneurship and Innovation Management India* 21 (4/5).
- Kumar S, Sharma P, and Vasudevan N. 2018. Modernization of Indian Brick Manufacturing Sector: Use of Energy Efficient Technologies Proceedings of the International Symposium to Promote Innovation & Research in Energy Efficiency (INSPIRE 2017).

- Rao G R Narsimha, Kumar S Satish, and Ahmed Sabreen. 2017. Corporate Social Responsibility for Sustainable Educational Institutes organized by National Design and Research Forum.
- Rao G Rudra Narsimha. 2018. Energy Efficiency in Indian Sugar Industries, Industrial Cogeneration India. Vol. 48, No. 10-15
- Rao G. Rudra Narsimha and Dusa Rahul Raju. 2018. Energy Efficiency Contrivances under Aspects of Climate Change Mitigation in Thermal Power Plants.
- Vijay Mohan R and Sharma Yatharth. 2018. Capacitor Banks and its Effect on Power System with High Harmonics Loads, IEEE, April.

### Renewable Energy Technologies

- Das P and Bhatnagar A. 2018 Different Feedstocks and Processes for Production of Methanol and DME as Alternate Transport Fuels. In A Singh, R Agarwal, A Agarwal, A Dhar, and M Shukla (eds) *Prospects of Alternative Transportation Fuels*. Energy, Environment, and Sustainability. Springer, Singapore, 2017, pp. 131–165.

- Goel A, Devraj S, Acharya M, and Mudgal A. 2017. Renewable Energy, *TERI Energy & Environment Data Diary and Yearbook (TEDDY) 2016/17*. New Delhi: TERI.
- Mudgal A. 2017. Analysis of Different Solar Photovoltaic Technologies for Micro-Grid Application in Various Climatic Zones with Seasons of India. 2017. Paper published in *International Journal in Smartgrid and Clean Energy*.
- Mudgal A. 2017. Design of Microcontroller Based I-V Plotter Using IGBT Electronic Load. Paper published in Power Electronics, Intelligent Control and Energy Systems (ICPEICES), IEEE International Conference.
- Mudgal A. 2017. Biomass assessment study in Junagadh, Gujarat. 2017. Article published in *Electronic Newsletter on Renewable Energy and Environment (eNREE)*. New Delhi: TERI.
- Riihelä A, Kallio V, Devraj S, Sharma A, and Lindfors A V. 2018. Validation of the SARAH-E Satellite-Based Surface Solar Radiation Estimates over India. *Remote Sens.* 10: 392.

## Electricity And Fuels

- Surat India's Leading 'SMART-SOLAR CITY'; MNRE *Akshay Urja*, July–October 2017, 11 (1 & 2).
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- 22/11/2017, Minni Sastry, "Urban Heat Island Studies for Bangalore", presented at Workshop on Smart City-Sustainable Urbanisation, at Taj Gateway, Bangalore, organised by Consulate General of the Federal Republic of Germany
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- Akanksha Modi & Kiriti Sahoo, National Conference on Reviving Regional Wisdom in Architecture – 2018, Evaluation of Thermal Comfort in Natural Ventilated Houses at Various Location in Warm and Humid Climate Zone, organised on 9th -10th March 2018, at Poornima University, Jaipur.

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- Subudhi S. 2017. Keynote Lecture: 'Microbial bioremediation of xenobiotic contaminated environment: A sustainable and eco-friendly process. Preconference workshop Organized by Department of Zoology, Miranda House College, Workshop: Understanding our Environment: Human Interference, INSCR2017, under the agencies of DBT Star College Scheme, New Delhi.
- Subudhi S. 2018. Keynote Lecture: Managing waste in sustainable manner: Closing the loop for moving towards zero waste future'. Symposium on Safety Measures & Laboratory Ethics, Under star DBT Star College Program, New Delhi.
- Subudhi S. 2017. Mission Innovation challenge workshop on "Converting Sunlight Innovation Challenge". Mission Innovation India first workshop IC#5 organized by Department of Biotechnology, Ministry of Science and Technology, Government of India, New Delhi.
- Subudhi S. 2017. 'TERI's lead on Biofuel production domain'. Indo-Finland Joint Workshop: Traffic and Air Quality In India: Technologies and Attitude', under the support form department of Biotechnology, Ministry of Science and Technology, Government of India.
- Subudhi S *et al.* 2018. TUT joint international poster presentation on 'Understanding Link between Traffic and Air Quality in India, First Results of TAQIITA Project: Chemical Characterization of Exhaust Particles from Passenger Cars. NOSA-FAAR Aerosol Symposium held in 2018 in Helsinki, Finland.
- Subudhi S. 2017. 'Microbes as cell factory for clean fuel production through biological route'. INSCR International Conference, 2017, Role of Microbe-Plant-Animal Interactions in Human Health, New Delhi.
- Subudhi S. 2017. Mission Innovation challenge workshop on "Sustainable Biofuels". Mission Innovation Challenge Workshop IC#? Sustainable Biofuels organized by Department of Biotechnology, Ministry of Science and Technology, Government of India, International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi.
- Subudhi S, Datta A, and Lal B. 2017. Indo-Finland Joint workshop on Workshop on 'Traffic & Air Quality in India: Technology & Attitude' Partners: TERI (India) and FMI, TUT,

MUT (Finland), Sanctioned by DBT, Ministry of Science and Technology, Government of India.

## Natural Resources and Climate

### Coastal Ecology and Marine Resources Centre, Goa

- D'Souza F, Giriyan A, Patil K, Gad S, de Souza C, Gaonkar C, Badesab S, Shetkar R, D'Costa A, Lobo A S, Kumar A, Untawale A G. 2017. Ecological observations of Mangroves at Dr Salim Ali Bird Sanctuary, Choroa. "Silver Jubilee National Conference on Mangrove Ecosystem" 26–27 July, NIO, Goa.
- D'Costa A, Shetkar R, Naik S, Padwalkar G, D'Souza F, Giriyan A, Gad S, Lobo A S. 2017. Small UAV technology for mapping mangroves species biodiversity. "Silver Jubilee National Conference on Mangrove Ecosystem" 26–27 July, NIO, Goa.
- D'Souza F. 2017. Creating Clean, Green and Healthy India. Seminar on "Swacch Bharat." ONGC, IPSHEM, Goa, 22 September.
- D'Souza F. 2017. Fresh and Coastal water conservation. Presentation at Water Technology Training Programme, on 15 December. Organized by National Technical Teachers Training & Research Institute (NITTTR), Porvorim, Goa.
- D'Souza F. 2018. Marine biological resources: SDG14. Resource Dialogue about "Marine Resources – Sustainable development through geopolitics and trade" in Mamallapura, Chennai, from February 28 to March 2.
- D'Souza F. 2018. Sustainable Living Talk on World Water Day: 'Nature for Water' seminar co – organised by The International Centre Goa and The Institution of Engineers (India) Goa State Centre, 22 March.
- D'Souza F, Giriyan A and Shetkar R. 2018. Abundance, Structure and Diversity of Mangroves in Marine Protected Area, Choroa, Goa. National conference on "Coastal Wetlands of India", Ratnagiri, 17–18 March.
- D'Souza F and Gaonkar S. 2018. Microplastic pollution in Coastal Ecosystem of Goa. National Conference on Changing Environment: Challenges, Solutions

and Strategies held at Dhempe College of Arts and Science, Miramar, Goa, India, March 8–9.

- Giriyan A, D'Souza F, Gad S, and Patil K. 2018. An Assessment of Green Mussel *Perna viridis* Fishery in Goa: Prospects of conservation of species through farming practices. National Conference on Changing Environment: Challenges, Solutions and Strategies held at Dhempe College of Arts and Science, Miramar, Goa, India, March 8–9.
- Giriyan A and Garg S. 2018. Preliminary isolation of Arsenic tolerant Biofilm forming bacteria from Mangrove sediments. National Conference on Changing Environment: Challenges, Solutions and Strategies, Dhempe College of Arts, Science, Miramar, Goa, India, March 8–9.
- Pai Panandiker, Ashwini. 2018. Examining the impact of mining on surface and groundwater: Case study of Salaulim Reservoir, Goa. Received best paper award at 50th Indian Water Works Association Annual Convention held at Panjim, Goa. Panandiker P, Honnungar A V, Venkatesh B, and Machineni N. 2018. Isolating the impacts of climate change using QSWAT model on Uguem river streamflow at Goa, India, International SWAT Conference at Indian Institute of Technology (IIT) Chennai, January 12–14.
- Patil K. 2017. Green Technologies for Sustainable development, Green Initiative Programme. Organised by Dhempe college of Arts and Science Miramar, Goa, 26 July.
- Patil K, Boving T, D'Souza F, and Gad S. 2018. Acceptance of Riverbank Filtration Technology by the farming community of Goa, at National Conference on Changing Environment: Challenges, Solutions and Strategies held at Dhempe College of Arts, Science, Miramar, Goa, India, March 8–9.

## Social Transformation

- Govindan M. 2017. Research Opportunities in India: Gender and Energy. Workshop at Warwick University, United Kingdom.
- Govindan M. 2017. Gender in SDG7. Conference at Incheon, South Korea.

- Govindan M. 2017. Community of Practices: Gender and Energy. Workshop at Loughborough University, United Kingdom.
- Govindan M. 2017. Gender and Energy Ethics: Insights from Indian Policy and Practice. Workshop at Endhoven, The Netherlands. Govindan M. 2017. Does technology justice lead to gender justice? Insights from solar PV Mini grids in Chhattisgarh, India Conference at Durrham University, United Kingdom.
- Govindan M. 2017. Unbundling the complexities of electricity-empowerment linkages. Conference, Delhi.

## Sustainable Habitat

- Behal M. 2017. Presentation on the 'Role of building materials and construction technologies in mainstreaming sustainable and resilient housing' in session on 'Rethinking construction materials for sustainable future', 9th GRIHA Summit, New Delhi.
- Behal M. 2017. Presentation on the 'Technical and regulatory nuances of green buildings' organized by Lucknow Management Association in collaboration with Indian Institute of Architects, UP chapter, IIT Roorkee Alumni Association.
- Behal M. 2017. Participated in workshop on U.S.-India Joint Center for Building Energy Research and Development (CBERD).
- Behal M. 2017. Round Table Discussion on "India Housing Construction Technology Challenge", New Delhi, under the Chairmanship of Secretary, Ministry of Housing & Urban Affairs, Government of India.
- Behal M. 2017. Participated in workshop on "Technology Evaluation for Green Housing Scale Up in India", with the support of the Sustainable Housing Leadership Consortium (SHLC).
- Behal M. Participated in Stakeholder Consultation - Resource Efficiency in the Building and Construction Sector in India. A joint project by European Union on Resource Efficiency Initiative (EU-REI) for India. Implementation by a consortium led by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) with TERI, Confederation of the Indian Industry (CII), and adelphi.

- Behal M. 2017. Presentation on the project “Mainstreaming Sustainable Social Housing in India” at India Pavilion at COP 23, Bonn, Germany.
- Sharma D. 2017–18. Attended Bureau of Energy Efficiency Technical Advisory Committee for Energy Conservation Building Code for residential sector.
- Sharma D. 2017–18. Attended EESL Knowledge Sharing Workshop on Tri-generation.
- Sharma D. Attended International Energy Efficiency Training Week, Paris.
- Singhal A. 2017. Speaker in National Workshops on HCFC Phase-out Management Plan (HPMP) for India.
- Organized in association with Ministry of Environment, Forest and Climate Change, Government of India, EESL, and TERI.
- Singhal A. 2017. Presented as a keynote speaker in 13th International HVAC&R Technology Symposium organized by Turkish Society for HVAC and Refrigeration (TTMD).



# FINANCIAL SUMMARY



# FINANCIAL SUMMARY 2017/18

## INFLOWS (₹ in Lacs)



94.71%  
₹16,358.50  
INCOME FROM  
PROJECTS



3.71%  
₹640.55  
INCOME FROM  
INVESTMENTS



1.10%  
₹190.18  
SALE OF  
PUBLICATIONS



0.48%  
₹83.65  
INCOME FROM  
OTHERS

TOTAL **100%** (₹17,272.88)

## OUTFLOWS (₹ in Lacs)



40.55%  
₹7387.62  
SALARIES



1.79%  
₹326.61  
EQUIPMENTS



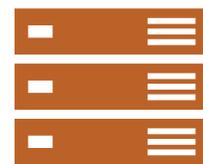
1.16%  
₹210.67  
BUILDINGS



45.02%  
₹8202.97  
TRAVEL, RESEARCH  
MATERIAL



6.60%  
₹1201.77  
RENTAL, UTILITIES,  
INFRASTRUCTURE  
AND MAINTENANCE



4.88%  
₹889.44  
ADMINISTRATIVE  
EXPENSES

TOTAL **100%** (₹18,219.08)

## **Vision**

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Creating Innovative Solutions for a Sustainable Future

## **Mission**

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**T**ackle issues of concern to Indian society, and the world at large, and develop innovative and cost effective solutions

**E**nhance networking for sustainable interventions

**R**ealize potential for national and international leadership as a knowledge-based agent of change in the fields of energy, environment, other natural resources, and sustainable development

**I**nspire and reach out to diverse stakeholders for realizing a shared vision of global sustainable development, which could be translated into action



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