Restore Mother Earth

A Snapshot

भारतीय विज्ञान, प्रौद्योगिकी एवं नवाचार
India Science, Technology & Innovation

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RESTORE MOTHER EARTH

RESTORING OUR ECOSYSTEM: REIMAGINE. RECREATE. RESTORE

World Environment Day 2021 marks the launch of the United Nations Decade on Ecosystem Restoration, which aims to reverse the damage we have inflicted on nature. Ecosystems support all life on Earth. The healthier our ecosystems are, the healthier the planet - and its people. The campaign initiated by the United Nations aims to prevent, halt and reverse the degradation of ecosystems on every continent and in every ocean. We all must stabilize the climate; we must protect nature and reduce the pollution to create a world where the Sustainable Development Goals (SDGs) thrive. Restoring ecosystems is a remarkable solution. It slows climate change, brings back lost biodiversity, creates productive land for agriculture, provides jobs, restores nature's buffers against zoonotic diseases and pandemics, and helps vulnerable communities to adapt to the changing climate. It will only succeed if everyone plays a part.

However, ecosystem restoration alone will not solve all of our problems. We must stop further ecosystem destruction. This can be achieved by reforming agricultural practices, changing our strategies of building cities, decarbonizing our economies, and moving to circular economic models and restoration. All these can be a quick-acting solution and buy us time to make these transformations. People have realised this and, thus, the momentum for restoration is now growing.

For India, scaling up ecosystem restoration activities assumes national importance as it is one of the mega biodiverse countries of the world, holding four of the world's biodiversity hotspots. Owing to its diverse physical and climatic conditions, it accounts for nearly 8 per cent of the recorded species, with approximately 47,000 plant species and over 100,000

animal species. However, the pressure on ecosystems and biodiversity is also immense in India where, within 2.4 per cent of the world's land area, it supports 18 per cent of the global human population and accounts for 15 per cent of the world's livestock.

In India, restoration targets are reflected in several of its flagship programmes. Directly, the National Afforestation Programme (NAP) is focused on the rehabilitation of degraded forests and afforestation around forests. Further, the National Mission for a Green India (GIM) under the National Action Plan on Climate Change (NAPCC) aims to improve and increase tree cover as a climate adaptation and mitigation strategy. Similarly, the critical focus of the National Biodiversity Action Plan is to implement strategies for the reduction in rates of degradation, fragmentation, and loss of natural habitats. However, in achieving restoration both at pace and scale, there is an imperative need to overcome the various barriers to large-scale restoration.

Some of the primary barriers to the restoration process include limited awareness of societies about the adverse effects of ecosystem degradation as well as the benefits of investing in restoration. Further, the lack of funds, limited investment into long-term research, shortage of legislation and policies that incentivise ecosystem restoration, little technical knowledge and capacity for ecosystem restoration are the other significant challenges and impediments.

However, a well-defined framework of government policies and strategies are in place to overcome these ecological and socio-economic challenges. But to enhance the rate of ecosystem restoration, a diverse group of stakeholders, including civil society, academic institutions, women's groups, indigenous communities, youth, farmers' groups, and the marginalized — all need to be part of this restoration campaign.

The **India Science Technology and Innovation Portal** took a step forward to educate, make aware the society that a string of policies and strategies are in place to overcome these ecological and socio-economic challenges. These government initiatives need to be taken to the various stakeholders so that they can contribute to the mission of restoring our environment. We have consolidated most of the available programmes, schemes, current research, technologies, and patents related to the environment and climate change offered by governmental and private organisations. This knowledge product is the first step in seeking inputs on challenges and problems from different stakeholders in society. Scientists from some of the leading institutions of India have shared their views, research studies, and solutions they identified to combat the environmental challenges imposed by anthropogenic activities.

The COVID-19 pandemic has made us aware of one thing: our planet is precious, and its resources are finite. More than ever, now every step toward protecting the environment counts. Individuals have an integral role in ecosystem restoration through the right lifestyle choices and raising public awareness of its importance. It is the responsibility of each of us to **Restore Our Mother Earth**.

PROGRAMMES AND SCHEMES

Section Guidelines

Ministry of Earth Sciences (MoES)

Ministry of Environment, Forest and Climate Change (MOEF&CC), Govt. of India

Ministry of New and Renewable Energy (MNRE), Government of India

Office of the PSA, Government of India

Department of Biotechnology (DBT), Government of India

Others

Ministry of Earth Sciences (MoES)

ACROSS

Atmosphere & Climate Research-Modelling Observing Systems & Services

ACROSS is composed of the following sub-schemes.

Monsoon Convection, Clouds, and Climate Change (MC4)

Clouds are an integral part of monsoon convection and precipitation. Current understanding of the coupling of monsoon dynamics to convection and cloud processes is limited due to the

lack of observations and inadequate representation of cloud processes in climate models. The MC4 scheme was envisioned to improve the observational database and climate models for enhanced predictive understanding of monsoonal precipitation changes and their impacts in a warming environment.

High Performance Computing System (HPCS)

MoES is mandated to provide the nation with the best possible services of forecasting the monsoons and other weather and climate parameters, ocean state, natural disasters such as earthquakes and tsunamis, and other phenomena related to earth system. Improving these forecasts need high-performance computational resources, including modern supercomputers with vast parallel computing architecture with support from artificial intelligence and machine learning algorithms. The existing HPCS resources of 6.8 petaflops (PF) commissioned in 2018 has resulted in improved short-medium scale forecasts with the usage of high-resolution models. For further enhancing weather and climate prediction, rigorous developmental work has been undertaken at MoES institutes to provide high-resolution dynamical models with increased complexity and advanced data assimilation techniques which are highly computationally intensive.

Monsoon Mission (MM-II)

The Ministry of Earth Sciences (MoES), Government of India, launched the National Monsoon Mission (NMM) in 2012 (now referred as Monsoon Mission, MM), with a vision to develop a state-of-the-art dynamical prediction system for Indian monsoon rainfall on different time scales. In 2017, the first phase of monsoon mission (referred to as MM-I) was completed successfully. The seasonal prediction system with improved hind cast skill was handed over to IMD for operational forecasting and this modified model is referred as Monsoon Mission CFS (MMCFS). The extended range prediction system was also handed over to IMD for operational forecasting of active/break spells of monsoon and other weather events, up to 4 weeks in advance. The second phase of monsoon mission (MM-II), which began in September 2017, focuses on predicting weather/climate extremes and development of climatic applications based on monsoon forecasts, especially in the field of agriculture, hydrology and energy sector, while continuing model development activities. In MM-II, focus has been given to high-resolution short-range predictions, predicting extremes, and using forecasts to develop applications for agriculture, hydrology, disaster management, energy sector, etc.

Atmospheric Observations Network

The scheme Atmospheric Observations Network of IMD is a continuing scheme primarily encompassing ongoing programs in an integrated manner aimed at sustenance of observational network. The measurement of various atmospheric parameters through surface, upper air, aircraft is a prime requirement for operating the meteorological services. Several major advanced technology-based equipments have been installed over the years. The maintenance and augmentation of these equipments is essential so that the benefit of technology upgradation is available on continuous basis. IMD needs upgradation & sustenance of observational network in order to achieve accelerated progress for providing top quality meteorological services to the society. IMD has been operating and sustaining several types of observational networks all over the country for monitoring the meteorological conditions and providing the meteorological data to weather forecasting and other uses.

Weather & Climate Services

The scheme Weather & Climate Services of IMD is a continuing Scheme primarily encompassing ongoing programs in an integrated manner aimed at providing efficient weather and climate services across. IMD provides services to weather-sensitive sectors viz. agriculture, irrigation, shipping, aviation, offshore oil explorations, etc. Over the years, specialized services have also been built for state-of-the-art monitoring, detection and early warning of extreme weather phenomena including tropical cyclones, severe thunderstorms, dust storms, heavy rains and snowfall events, cold and heat waves, etc

Upgradation of Forecast System

The proposed scheme Upgradation of Forecast System is aimed at improving the accuracy of weather forecasts to bring it at par with the international standards which will help many sectors like army operations, air operation, agriculture, tourism, mountaineering, aviation, roads and communications, power generation, water management, environmental studies, Sports & Adventure, Transport, Government Authorities, NGOs and Public in general.

Commissioning of Polarimetric Doppler Weather Radars (DWRs)

IMD presently operates a radar network most of which comprises of very old technology and are based on conventional analog systems, and therefore it is becoming obsolete with respect to the current and future generation DWRs. Moreover, the conventional radar products are incompatible with present day requirements of digital data on different parameters which can be directly used as inputs to weather prediction models. Induction of an adequate number of DWRs in the network would facilitate plugging the existing gaps in the meteorological observational network of radars, desirable for effective and efficient analysis and consequent forecasting, in particular at the mesoscale. The availability of countrywide weather radar coverage and its integration, including overlapping regions of the proposed network would provide adequate warning in the event of approach of Cyclonic Storms, Monsoon Depressions, etc. It would also provide vital information for nowcasting purposes on mesoscale convective weather developments anywhere in the country. Radar observations would also stimulate research on the dynamics and microphysics of convective weather phenomena. The data from these DWRs would also help in understanding key as well as major differences between super cell storms and ordinary storms. Besides, it is desirable to have a dual polarimetric facility to obtain additional information on hydrometeors and their quantification in clouds, classification of precipitating clouds, etc.

For more details:

https://moes.gov.in/schemes/atmospheric-climate-science-and-services

O-SMART

Ocean—Services, Modelling, Application, Resources and Technology

Oceans play an essential role in almost all aspects of human existence. They also aid scientific and technological explorations and breakthroughs. The Exclusive Economic Zone (EEZ) in India holds immense potential for scientific exploration with a wide variety of living and

non-living resources. This contributes to the economic development of the country in a big way yielding numerous societal benefits. Research and development programmes for oceans in India were initiated by the Department of Ocean Development (DOD) which was set up in 1981. The DOD was amalgamated with the Ministry of Earth Sciences (MoES) in 2006 given the importance of creating synergy between ocean development, earth sciences with atmospheric sciences and geosciences. Since then, innumerable scientific developments, field installations, demonstrations, and achievements have been accomplished by MoES in this field. It has helped develop several indigenous systems, devices, and techniques for implementing projects, under initiatives such as the Make in India. The Blue Economy embodies economic and trade activities that integrate the conservation and sustainable use and management of biodiversity, including maritime ecosystems, genetic resources, and activities that generate lower or no greenhouse gas emissions.

For more details:

https://moes.gov.in/schemes/O-SMART

PACER

Polar Science and Cryosphere

The world's polar regions and their contiguous oceans are attracting more interest than ever before. Once regarded as barren, inhospitable places where only explorers go, the north and south polar regions have been transformed into high profile sites of scientific research. Realizing the importance of Antarctica as a pedestal for scientific research, India launched the first of her Annual Scientific Expeditions to the Antarctica way back in 1981. This was followed by the country's successful entry to the realms of Southern Ocean research in 2004 and the Arctic, three years later. To cater to the requirements of the Indian scientists in both the polar regions, two stations (Maitri and Himadri) have been established to serve as living-cum-research bases in the Antarctic and Arctic respectively.

The focus areas of scientific studies in the Arctic and the Antarctic have been largely confined to earth, atmospheric and biological sciences. As regards the studies of the cryosphere, the research initiatives by Indian scientists in the Antarctic comprise monitoring of the glaciers in Dronning Maud Land, studies of ice dynamics and energy balance and climatic reconstructions from ice core analyses. Systematic studies of the cryospheric domain of the Arctic are as yet to be initiated. PACER encompasses the following six components.

a. Construction of polar research vessel
b. Construction of the third research base in Antarctica
c. Indian scientific endeavours in the Arctic
d. Polar expeditions-Antarctica
e. Replacement of Maitri station
f. Southern Ocean

For more details:

https://moes.gov.in/schemes/polar-science-cryosphere

SAGE

Seismology and Geosciences

Under the Seismology and Geosciences (SAGE) scheme of the Ministry of Earth Sciences (MoES), several important programmes and activities are implemented by MoES with its network of institutions. SAGE includes the following six activities:

a. Seismological monitoring and microzonation
b. Geodynamics and surface processes
c. Indian Ocean: deep ocean observations and dynamics of lithospheric evolution (International Ocean Discovery Program-IODP and geoid low)
d. Scientific deep drilling in the Koynaintraplate seismic zone
e. Seismicity and earthquake precursors
f. Setting up a facility for geochronology

For more details:

https://moes.gov.in/schemes/Seismology-and-Geosciences

REACHOUT

Research, Education, Training and Outreach

The primary mandate of the MoES is to provide the nation with the best possible services for weather, climate, ocean, coastal and natural hazards, sustainable harnessing of ocean resources, and exploration of the Polar regions. Therefore, it is essential to holistically address various aspects related to ocean, atmosphere, cryosphere, geosphere and biosphere processes and continuously upgrade knowledge through assimilation of new ideas and application of knowledge in the field of earth system sciences. This can be effectively done through nurturing Research and Development (R&D) in academic institutions and formulating mechanisms to translate the R&D into operational use. Moreover, the development of a skilled workforce and regular training in different fields of Earth sciences are also vital. To cater to the above-cited activities, MoES implements REACHOUT, which is an umbrella scheme of the following six sub-schemes:

a. Research and Development in Earth System Science (RDESS).
b. Outreach and awareness.
c. Knowledge Resources Center Network (KRCNet).
d. BIMSTEC Centre for Weather and Climate (BCWC).
e. International Training Centre for Operational Oceanography (ITCOocean).
f. Program for development of skilled workforce in Earth system sciences (DESK).

The first three sub-schemes are implemented by the MoES headquarters. The remaining three schemes namely BCWC, ITCOcean and DESK are implemented by MoES institutes namely National Centre for Medium-Range Weather Forecasting (NCMRWF), Indian National Centre for Ocean Information Services (INCOIS) and Indian Institute of Tropical Meteorology (IITM). These sub-schemes aim to nurture research (including national and international collaboration); provide training on atmospheric science and oceanography to participants from

India and neighbouring countries, and to generate awareness about various facets of Earth system science amongst students, academicians and the public.

For more details:

https://moes.gov.in/schemes/research-education-training-outreach

DOM

Deep Ocean Mission

With a view to explore deep ocean for resources and develop deep sea technologies for sustainable use of ocean resources, Cabinet Committee on Economic Affairs (CCEA) approved the proposal of Ministry of Earth Sciences (MoES) on "Deep Ocean Mission" at an estimated cost of Rs. 4077.0 crore for a period of 5 years to be implemented in a phase-wise manner. Deep Ocean Mission with be a mission mode project to support the Blue Economy Initiatives of the Government of India. Ministry of Earth Sciences (MoES) will be the nodal Ministry implementing this multi-institutional ambitious mission. The technologies required for deep sea mining have strategic implications and are not commercially available. Hence, attempts will be made to indigenise technologies by collaborating with leading institutes and private industries. A research vessel for deep ocean exploration would be built in an Indian shipyard which would create employment opportunities. This mission is also directed towards capacity development in Marine Biology, which will provide job opportunities in Indian industries.

For more details:

https://moes.gov.in/schemes/dom

Ministry of Environment, Forest and Climate Change (MOEF&CC), Govt. of India

Externally Aided Projects (EAPs), Forest and Wildlife Division

The Externally Aided Projects Division of the Ministry deals with Externally Aided Forestry Projects in coordination with the State Governments, donor agencies (JICA, French Development Agency, GIZ, Kfw, World Bank, etc.) and other line ministries in the Government of India such as Ministry of Finance, Ministry of Home Affairs, Ministry of External Affairs, NITI Aayog, Ministry of Development of North Eastern Region, etc.

At present, there are 13 Externally Aided Projects dealt by this division under implementation in the country. The broad objectives of these forestry projects are to increase forest cover; improve biodiversity conservation; rehabilitate degraded forest areas; undertake soil and moisture conservation measures; launch measures for capacity building of forest officials and other stakeholders; create income & livelihood opportunities to fringe area forest

village people; and initiate other measures for sustainable management of forest and its resources.

For more details:

http://moef.gov.in/en/division/forest-divisions-2/externally-aided-projects-eap/introduction/

Scheme on Development and Promotion of Clean Technology and Waste Minimisation Strategies

In order to facilitate access to clean technology and its adoption by the small and medium scale industries in identified industrial activities that are in need of switch-over to cleaner technologies and waste management strategies, assistance in the form of grant-in-aid would be provided to autonomous institutions and statutory bodies under the Central and State Governments in the field of R&D, Extension or registered companies having healthy financial record, with in-house R&D units, preferably recognized by DSIR, and having tie up/ collaboration with industries/consortium for setting up pilot/demonstration projects for new technology/up-gradation of available technology. In such industrial clusters, 24 industrial sectors have been identified by the Ministry.

The proposals are invited through open advertisements in the important daily newspapers. Format of the proposal is available in the guidelines. The support from the ministry would primarily cover prototype development, cost of pilot plant, cost of process equipment development, test and evaluation of products, user trials, running cost (raw materials, consumables, hardware/ software tools, components/sub-assemblies for prototype, equipment for pilot plant, etc.), contingencies, travels and salaries for the consultants and supporting staff, etc. This does not include the cost of the land and building, which shall be provided by the project proponent/industry. The scale of assistance would be limited to 75 per cent of the project cost, excluding land and building.

For more details:

http://moef.gov.in/en/division/environment-divisions/clean-technology/clean-technology-scheme-guidelines/

National Adaptation Fund on Climate Change (NAFCC)

NAFCC was launched in 2015-16 by the Ministry of Environment, Forest and Climate Change (MoEFCC) to cover vulnerable sectors such as Water, Agriculture and Animal Husbandry, Forestry, Ecosystems and Biodiversity across the country. The overall aim of the fund is to support concrete adaptation activities which are not covered under ongoing activities through the schemes of the Central and state governments that reduce the adverse effects of climate change facing community, sector and states. The Fund is meant to assist national and state level activities to meet the cost of adaptation measures in areas that are particularly vulnerable to the adverse impacts of climate change.

For more Details:

https://cckpindia.nic.in/national-adaptation-fund-on-climate-change/

NATIONAL AFFORESTATION PROGRAMME (NAP)

It is the flagship scheme of National Afforestation & Eco-Development Board to provide support, both in physical and capacity building terms, to the Forest Development Agencies (FDAs) which, in turn, are the main organs to move forward institutionalization of Joint Forest Management (JFM). The FDA has been conceived and established as a federation of Joint Forest Management Committees (JFMCs) at the Forest Division level to undertake holistic development in the forestry sector with people's participation. This is a paradigm shift from the earlier afforestation programmes wherein funds were routed through the state governments. This decentralized two-tier institutional structure (FDA and JFMC) allows greater participation of the community, both in planning and implementation, to improve forests and livelihoods of the people living in and around forest areas. The village is reckoned as a unit of planning and implementation and all activities under the programme are conceptualized at the village level. The two-tier approach, apart from building capacities at the grassroots level, significantly empowers the local people to participate in the decision-making process.

For more details:

http://naeb.nic.in/documents/NAP_intro.htm

Ministry of New and Renewable Energy (MNRE), Government of India

Biogas Power Generation (Off-Grid) and Thermal Energy Application Programme (BPGTP)

Biogas Power Generation (Off-Grid) and Thermal Energy Application Programme promotes biogas-based decentralized renewable energy sources of power generation (Off-Grid) in the capacity range of 3 kW to 250 kW or thermal energy for heating / cooling applications from the biogas generation produced from biogas plants of 30 M3 to 2500 M3 size. It also seeks to process scientifically the organic wastes/ biomass waste as feedstock for the purpose of setting up of biogas plants.

The programme is also implemented by the State Nodal Agencies (SNAs) for Renewable Energy, Biogas Development and Training Centres (BDTCs), Khadi and Village Industries Commission (KVIC) and National Dairy Development Board (NDDB) in states where Agriculture and State Rural Development Departments are not in a position to implement the scheme.

The programme is beneficial for rural and semi-urban areas for meeting electrical and thermal energy demands, particularly for small dairy and poultry farms.

For more details:

https://mnre.gov.in/bio-energy/schemes

New National Biogas and Organic Manure Programme (NNBOMP)

The New National Biogas and Organic Manure Programme's aim is to provide clean cooking fuel for kitchens, lighting and meeting other thermal and small power needs of farmers/ dairy farmers/ users, including individual households, to improve organic manure system based on bio-slurry from biogas plants in rural and semi-urban areas by setting up of small size biogas plants of 1 to 25 cubic metre capacity. It also aims to mitigate drudgery of women and save time for them for other livelihood activities, reduce pressure on forests and accentuate social benefits. Also, it seeks to improve sanitation in rural and semi-urban areas, including linking sanitary toilets with cattle dung biogas plants, and provide slurry (liquid / semi-solid or dried) produced by biogas plants as an organic enriched bio-manure to help reduce use of chemical fertilizers such as urea. In addition, it seeks to link biogas slurry with enrichment units such as vermicomposting, Phosphate Rich Organic Manure (PROM) plants and other organic enrichment facilities as a source of value addition to biogas plant slurry.

The Programme also aims to meet 'lifeline energy' needs for clean cooking as envisaged in "Integrated Energy Policy" of NITI Aayog (erstwhile Planning Commission) and help in combating and reduction in causes of climate change by preventing emissions of Green House Gases (GHGs) such as carbon dioxide and methane into the atmosphere.

For more details:

https://mnre.gov.in/bio-energy/schemes

Programme on Energy from Urban, Industrial, Agricultural Wastes/ Residues and Municipal Solid Waste

The Ministry of New and Renewable Energy, Government of India, launched the programme "Energy from Urban, Industrial, Agricultural Wastes/Residues and Municipal Solid Waste" with the following objectives:

- To promote the setting up of projects for recovery of energy in the form of biogas/ bio-CNG / power from urban, industrial and agricultural waste and captive power and thermal use through gasification in industries
- To promote the setting up of projects for recovery of energy from municipal solid waste (MSW) for feeding power into the grid and for meeting captive power, thermal and vehicular fuel requirements.
- To promote biomass gasifiers for feeding power into the grid or meeting captive power and thermal needs of rice mills/other industries and villages.
- To create conducive conditions and environment, with fiscal and financial regime, to develop, demonstrate and disseminate utilization of wastes and residues for recovery of energy.

For more details:

https://mnre.gov.in/waste-to-energy/schemes

Office of the PSA, Government of India

Deep Ocean Exploration

The aim of the 'Deep Ocean Exploration' mission of the Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC) is to scientifically explore the deep oceans towards improving our understanding of the blue frontier. The information from this mission will address issues arising from long-term changes in the ocean due to climate change. The focus areas cover the development of technologies for deep-sea exploration and exploitation of living (biodiversity) and non-living (minerals) resources; development of underwater vehicles and underwater robotics; development of ocean climate change advisory services; technological innovations and observational methods for sustainable utilisation of marine bio-resources; offshore-based desalination techniques; and renewable energy generation.

The **Deep Ocean Mission** consists of the following **seven major components**:

- To address issues arising from long-term changes in the ocean due to climate change
- To develop technologies for deep sea exploration of living (biodiversity) and non-living (minerals) resources
- To develop underwater vehicles and underwater robotics
- To provide ocean climate change advisory services
- To identify technological innovations and conservation methods for sustainable utilisation of marine bio-resources
- To develop offshore based desalination techniques
- To develop renewable energy generation techniques

For more details:

https://www.psa.gov.in/mission/deep-ocean-exploration/39

Department of Biotechnology (DBT), Government of India

Environmental Biotechnology Programme

The focus of the Environmental Biotechnology programme of DBT is to support research and development (R&D) programme in the areas relevant to waste management & environmental improvement and development & demonstration of wastewater-specific effective bioremediation options like natural attenuation to bio-stimulation, bio-augmentation or a combination of filtration, phytoremediation and microbial degradation, bio-restoration technologies for restoration of degraded ecosystems.

The project proposals are being accepted round the year. Researchers can submit the project proposal in these priority areas through DBT online project Management System (eProMis) without waiting for a specific call for proposals.

For more details: Environmental Biotechnology | India Science, Technology & Innovation

https://www.indiascienceandtechnology.gov.in/programme-schemes/research-and-development/environmental-biotechnology

Energy Science & Waste to Value

The Department of Biotechnology has been promoting R&D for biofuel technology development, recognizing the need for clean and renewable energy for transportation. The Government of India has recently in June 2018 announced a new policy on Biofuels and an indicative target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel is proposed by 2030. Department has taken significant efforts in this direction with a major focus on 2nd generation biofuels. A platform created to connect more than 200 Scientists working in the Biofuel area.

The Energy Bioscience Division has been promoting cutting-edge research in Biofuel areas through the Centre of Excellence, extramural projects, fellowship schemes and international co-operation. Capabilities developed in Systems and Synthetic Biology with demonstrated laboratory work. International cooperation in Biofuel is strengthened through Mission Innovation and Biofuture Platform.

For more details: Energy Science & Waste to value | Department of Biotechnology

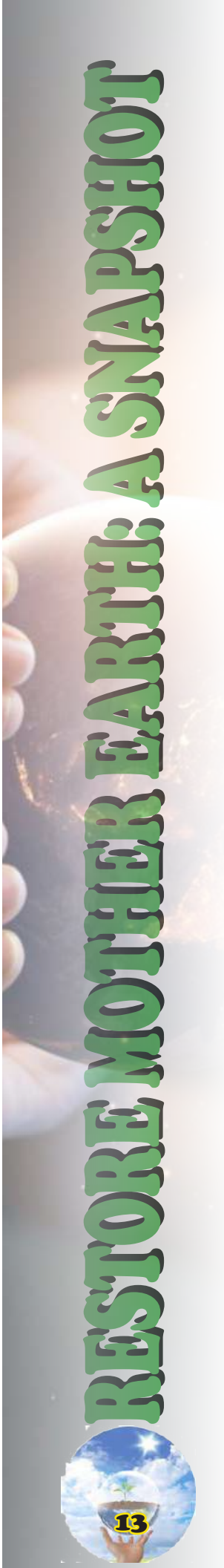
https://dbtindia.gov.in/schemes-programmes/research-development/energy-environment-and-bio-resource-based-applications-1

Forest Biotechnology Programme

Considering the multidimensional importance of forest areas, the Department of Biotechnology initiated this programme in the Financial Year 2018-2019 with the aim to supporting Research and Development (R&D) in the area of Forest Biotechnology. Efforts have been made by the Department through specific calls for research proposals to encourage R&D programs in emerging areas of Forest Biotechnology aiming at conservation of forests; promoting sustainable use of bioresources, such as medicinal plants, tree-borne oil seeds, resin and wax yielding plants; developing tools for mitigation and adaptation of climate change impacts; and enhancing carbon sequestration by the forest vegetation using state-of-the-art biotechnological approaches.

For more details: Forest Biotechnology | Department of Biotechnology

https://dbtindia.gov.in/schemes-programmes/research-development/energy-environment-and-bio-resource-based-applications



RESTORE MOTHER EARTH: A SNAPSHOT

Marine, Microbial Resource, Secondary Agriculture and Food Processing Programme

DBT initiated the programme with the overall aim to support R&D projects in all the related areas of bioresources and secondary agriculture biomass biotransformation, bioresource systems analysis, and technologies associated with conversion or production of value added products and processes from natural resources. Researchers can submit the project proposal in these priority areas through DBT online project Management System (e-ProMis) without waiting for a specific call for proposal.

For more Details:

http://dbtindia.gov.in/schemes-programmes/research-development/energy-environment-and-bio-resource-based-applications-3

Marine Bioresource programme and Blue Economy

DBT has taken initiatives to establish a state-of-the-art "Virtual Centre of Excellence for Marine Biodiversity and Biotechnological Interventions" for exploring ocean resources towards their sustainable use for economic growth, improved livelihoods and employment generation in the country. The main goal of the proposed Centre will be to rapidly escalate India's research capabilities in modern marine biology and biotechnology so as to capitalise on our vast marine biodiversity in a sustainable manner. It will be dedicated to fundamental and applied marine biological research and will also provide an interface between research and commercialization of technologies through incubator facilities for start-up companies. In order to achieve these goals rapidly and effectively, the Centre will actively network and collaborate with leading MoES and CSIR institutes working in this area and international agencies with complementary expertise.

For more Details:

https://dbtindia.gov.in/schemes-programmes/research-development/energy-environment-and-bio-resource-based-applications-2

DBT - Energy Biosciences Overseas Fellowships

DBT "Energy Biosciences Overseas Fellowships" is a flagship scheme of the Department for bringing back the scientists of Indian origin who are working outside the country in the field of energy biosciences. Energy Biosciences Chairs are for the senior scientists who are desirous of pursuing, complementing and enhancing quality of R&D in energy related biosciences in Indian institutions. Currently, four overseas Fellows and two Chairs have been working at various host institutions. Several processes in different areas of biofuels, enzymes, and bioenergy at various Indian institutions are being developed by Fellows enriching the R&D in the bioenergy field. This programme is coordinated by DBT-ICT Centre for Energy Bioscience, Mumbai.

For more details:

https://dbtindia.gov.in/schemes-programmes/building-capacities/international-fellowships/dbt-energy-biosciences-overseas

Others

Paramparagat Krishi Vikas Yojana

The Ministry of Agriculture & Farmers' Welfare (MoA&FW) started a scheme with the aim to develop sustainable models of organic farming through a mix of traditional wisdom and modern science to ensure long-term soil fertility and resource conservation and help in climate change adaptation. It primarily aims to increase soil fertility and thereby helps in production of healthy food through organic practices without the use of agro-chemicals.

For more Details:

https://pgsindia-ncof.gov.in/pkvy/index.aspx

National Innovations on Climate Resilient Agriculture

National Innovations on Climate Resilient Agriculture (NICRA) is a network project of the Indian Council of Agricultural Research (ICAR), which was launched in February 2011. The project aims to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration. The research on adaptation and mitigation covers crops, livestock, fisheries and natural resource management. The project consists of four components, viz., Strategic Research, Technology Demonstration, Capacity Building and Sponsored/Competitive Grants.

For More Details:

http://www.nicra-icar.in/nicrarevised/index.php/home1

Jal Jeevan Mission

Jal Jeevan Mission of Department of Drinking Water & Sanitation under Ministry of Jal Shakti, which is being implemented in partnership with the states, seeks to enable every household in villages to have functional tap connection by 2024. The rural drinking water supply is a complex subject with various social, environmental and technical challenges like geo-genic and anthropogenic water quality issues, long-term potable water supply in harsh edapho-climatic conditions and disaster-prone areas, measurement and monitoring of water service delivery, behaviour change management, cost-effective grey water treatment and reuse, etc. Thus, given the challenges and the knowledge gaps being faced while implementing Jal Jeevan Mission with speed and scale, along with the future of rural water security, there is a pressing need for significant research and innovation in the

water supply sector. Now, more than ever, National Jal Jeevan Mission will be supporting, promoting and cultivating research and innovation to solve the issues faced by the water supply sector in the rural areas.

National Jal Jeevan Mission is inviting proposals from young minds, researchers, academia, entrepreneurs, and start-ups working in this sector to provide cost-effective solutions and fill knowledge gaps. Furthermore, the Department/ National Mission/ SWSM will conduct action research and concurrent evaluation studies for adopting evidence-based technical intervention to manage rural water supply efficiently, effectively and economically.

For more Details:

https://jaljeevanmission.gov.in/

RESEARCHES & TECHNOLOGIES

Environmental Research is a multidisciplinary academic field which systematically studies human interaction with the environment, and provide quality and novel information about anthropogenic issues of global relevance and applicability in a wide range of environmental disciplines, and demonstrating environmental application in the real-world context.

The following list will provide scientists, environmentalists and ecologists with up-to-date information on research, strategies, techniques and recent developments with respect to prevention and protection of the environment from different pollutants and prediction of future climate change that may have adverse effects on humans and other biological and ecological constituents.

The research projects and technologies includes wide spectrum of topics in this field, including Geosciences, Environmental sciences, Geology, water and soil contamination, geological hazards, environmental impacts, land use management, industrial minerals, waste management, earth sciences, environmental data and information and information systems, broadcasting of knowledge on various techniques, methods approaches that aims at improvement and remediation of the environment as habitat for life on earth.

Project Title	Principal Investigator	Start Date	Implementing Agency
Ecology and Recovery of critically endangered Vulture species in Pong Dam Protected Area (PA) and its Eco Sensitive Zone (ESZ) in district Kangra, Himachal Pradesh	Dr Gautam Talukdar, Scientist, Wildlife Institute of India (WII), Dehradun	2019	Wildlife Institute of India (WII), Dehradun
Securing habitats for threatened mountain ungulates through robust population assessment and conservation planning	Dr Vishnupriya Kolipakam, Scientist, Wildlife Institute of India (WII), Dehradun	2019	Wildlife Institute of India (WII), Dehradun
An integrated approach for conservation of Takin (Budorcas taxicolor) in North East India: Linking species ecology and traditional ecological knowledge	Dr Gopi G V, Scientist, Wildlife Institute of India (WII), Dehradun	2019	Wildlife Institute of India (WII), Dehradun
Assessment of Disease Prevalence in Ungulates in Protected Areas of North East India	Dr S Sathyakumar, Scientist, Wildlife Institute of India (WII), Dehradun	2019	Wildlife Institute of India (WII), Dehradun
Assessing fine scale distribution pattern, population and habitat status of northern Swamp deer (Rucervus duvauceli duvauceli) across upper Gangetic Plains of north India	Dr Samrat Mondol, Scientist, Wildlife Institute of India (WII), Dehradun	2019	Wildlife Institute of India (WII), Dehradun
Assessment of LFG recovery, utilization and reduction in GHG emission at Madurai Landfill site, Tamil Nadu, India.	Dr D Brindha, Assistant Professor, Thiagarajar college of Engineering, Madurai	2019	Thiagarajar college of Engineering, Madurai
Quantification of the Economic and Ecological Services of Eco-tourism as a Livelihood Option for the Sustainability of the Rhino Population in Manas Tiger Reserve, Assam	Dr Ajay Kumar, Scientist, Rain Forest Research Institute, Jothat, Assam	2019	Rain Forest Research Institute (RFRI), Jothat, Assam

Assessment of Changes for the Conservation and Management of Sathyamangalam Tiger Reserve	Prof S Jayakumar, Pondicherry University, Puducherry	2019	Pondicherry University, Puducherry
Emerging infectious disease in birds across a gradient of alien invasive trees mapped using Remote Sensing, on Shola Sky Islands	Dr Robin Vijayan, Assistant Professor, Indian Institute of Science Education and Research (IISER), Tirupati	2019	Indian Institute of Science Education and Research (IISER), Tirupati
Ecological assessment of endemic and threatened laughing thrushes of the Western Ghats to develop conservation plan for securing their population and habitats	Dr S Babu, Scientist, Salim Ali Centre for Ornithology and Natural History, Coimbatore	2019	Salim Ali Centre for Ornithology and Natural History, Coimbatore
Population Status, Ecology, and Conservation of the Indian Swiftlet Aerodramus unicolor in the Western Ghats, West Coast and Offshore Islands of Maharashtra	Dr Manchi Shirish S, Scientist, Salim Ali Centre for Ornithology and Natural History, Coimbatore	2019	Salim Ali Centre for Ornithology and Natural History, Coimbatore
Design, Development and Evaluation of Indigenous Sensors Based Air Quality Monitoring System and Data Analysis using Deep Learning	Prof R Rani Hemamalini, St. Peters Institute of Higher Education and Research (SPIHER), Chennai	2019	St. Peters Institute of Higher Education and Research (SPIHER), Chennai
Sustainable utilisation of Industrial waste materials for the development of cementless ferrocement precast panels for Impact load	Dr Mohana, Assistant Professor, Mepco Schlenk Engineering College, Tamil Nadu	2019	Mepco Schlenk Engineering College, Tamil Nadu
Development of low energy- low carbon ECO cementitious binders via synergistic use of low graded industrial wastes for sustainable development	Rajesh Kumar, Central Building Research Institute (CSIR- CBRI), Roorkee	2020	Central Building Research Institute (CSIR- CBRI), Roorkee

Project Title	Principal Investigator	Start Date	Implementing Agency
Development of performance improved precast lightweight composite materials using solid wastes	Dr Rajni Lakhani, Central Building Research Institute (CSIR- CBRI), Roorkee	2020	Central Building Research Institute (CSIR- CBRI), Roorkee
Tracking and assessment threats of highly critically endangered scaly giant (Manis pentadactyla) with special reference to sensitization of local communities for its long-term conservation in north-eastern states of India	Dr Janmejay Sethy, Assistant Professor, Amity University, NOIDA	2020	Amity University, NOIDA
Microbial communities in changing climatic regime: Analysis of primary and secondary risk factors	Dr Vartika Mathur, Assistant Professor, Sri Venkateswara College, University of Delhi	2020	Sri Venkateswara College, University of Delhi
NIR Light reflective Nano composite plastering mortar/coating towards climate change adaptation in buildings	Dr K Jeyasubramanian, Mepco Schlenk Engineering College, Tamil Nadu	2021	Mepco Schlenk Engineering College, Tamil Nadu
Scientific Communication for Awareness among the school students on water conservation and sanitation	Er Sanjai Singh, Director, Center of Technology and Entrepreneurship Development (CTED), Uttar Pradesh	2020	Center of Technology and Entrepreneurship Development (CTED), Uttar Pradesh
Hands on activities/ demonstration of energy, water and Environmental conservation techniques for students in schools of Chamoli district in Uttrakhand	Dr Bhartendu Kumar Chaturvedi, University of Petroleum and Energy Studies (UPES), Uttrakhand	2020	University of Petroleum and Energy Studies (UPES), Uttrakhand
Awareness among SC and ST Children towards Water Conservation	Dr Chandrasekar, CEO, E G S Pillay Engineering College (EGSPEC), Tamil Nadu	2020	E G S Pillay Engineering College (EGSPEC), Tamil Nadu

Rain water harvesting and other methods of water conservations	Pranay Shukla, Chief functionary officer, Rural Development Foundation, Gujarat	2020	Rural Development Foundation, Gujarat
Creating awareness on "Water conservation and Management" to the rural school students community in Coimbatore district	Dr T V Arjunan, Professor, Coimbatore Institute of Engineering and Technology (CIET), Tamil Nadu	2020	Coimbatore Institute of Engineering and Technology (CIET), Tamil Nadu
Scientific Communication on Climate Change & Global Warming	Rudraa Nayak, Society For Entrepreneurship Environment and Human Resources Development, Odisha	2020	Society For Entrepreneurship Environment and Human Resources Development, Odisha
Outreach Activities to Promote Scientific Temper regarding Sustainable Development among School Students of SC/ST community in Chakrata, Tyuni and Kalsi tehsil of Uttrakhand	Dr Bhartendu Kumar Chaturvedi, University of Petroleum and Energy Studies (UPES), Uttarakhand	2020	University of Petroleum and Energy Studies (UPES), Uttrakhand
Water Sanitation and Science Literacy in Sawai Madhopur and Jodhpur district	Dr Rakhi Mehta, Green Tomorrow Society, Rajasthan	2020	Green Tomorrow Society, Rajasthan
Science outreach for community based water resource management (CBWRM) in water scarce tribal region of Shakargarh block of Prayagraj District	Buddh Vilas, Disha Samajik Sansthan, Uttar Pradesh	2020	Disha Samajik Sansthan, Uttar Pradesh
Response of land surface processes on simulation of Indian summer monsoon	Prof P V S Raju, Amity University, Jaipur	2018	Amity University, Jaipur
Characterization of flow structure in rotating convection with superimposition of vertical & horizontal heat fluxes	Prof Sridhar Balasubramanian, Indian Institute of Technology (IIT) Bombay	2018	Indian Institute of Technology (IIT) Bombay

Project Title	Principal Investigator	Start Date	Implementing Agency
Innovative & efficient algae-based system to reduce carbon dioxide emissions: A possible remedy to climate change	Dr Kiran Bala, Associate Professor, Indian Institute of Technology (IIT) Indore	2018	Indian Institute of Technology (IIT) Indore
Microphysics of Cloud droplets and Aerosols: Experimental and computational study	Prof Jaywant H Arakeri, Indian Institute of Science (IISc), Bangalore	2018	Indian Institute of Science (IISc), Bangalore
Developing a Virtual Soil Moisture methodology using Optical/Thermal and Microwave Satellite Imagery for surface Soil Moisture Mapping	Dr Kishan Singh Rawat, Sathyabama Institute of Science and Technology, Chennai	2019	Sathyabama Institute of Science and Technology, Chennai
Assessment of Carbon Storage and Floral Diversity of Sacred Groves in three Districts of Southern Kerala, supported by Technology Assisted Information Management	Prof P K Shaji, Environmental Resources Research Centre (ERRC), Thiruvananthapuram	2019	Environmental Resources Research Centre (ERRC), Thiruvananthapuram
Development of QCL-based robust and portable infrared spectrometer for measurements of HONO at atmospheric levels and probing HONO production in trace quantities in some laboratory reactions	Prof Tapas Chakraborti, Indian Association for the Cultivation of Science (IACS), Kolkata	2019	Indian Association for the Cultivation of Science (IACS), Kolkata
Kinetic investigations of Reactions of Criegee Intermediates with C1-C3 carbonyl compounds and carboxylic acids in the Earth's atmosphere	Prof B Rajakumar, Indian Institute of Technology (IIT) Madras	2019	Indian Institute of Technology (IIT) Madras
Strengthening of MP State Knowledge Management Centre on Climate Cell	Mr LokendraThakkar, Scientific Officer, Environmental Planning and Coordination Organization (EPCO), Bhopal	2019	Environmental Planning and Coordination Organization (EPCO), Bhopal

Vulnerability Profiles for India: State and District Level	Dr Shyamasree Dasgupta, Indian Institute of Technology (IIT) Mandi	2019	Indian Institute of Technology (IIT) Mandi
Climate change impact mitigation for a climate resilient habitat	Dr Ashalata Devi, Associate Professor, Tezpur University, Tezpur	2019	Tezpur University, Tezpur
Centre for Excellence in Climate Change	Prof Shakil Ahmad Romshoo, Professor, University of Kashmir, Hazratbal	2019	University of Kashmir, Hazratbal
Sustainable Water Resources in Eastern Himalaya	Prof T G Sitharam, Indian Institute of Technology (IIT) Guwahati	2019	Indian Institute of. Technology (IIT) Guwahati
DST's Centre of excellence on Water resources, Cryosphere and climate Change studies	Dr Anil Kumar Misra, Associate Professor, Sikkim University, Gangtok	2019	Sikkim University, Gangtok
Impact of climatic and anthropogenic forcing's on geodiversity and ecosystem services of Uttarakhand Himalayas: Implication for sustainable policy development	Prof Y P Sundriyal, Professor, Hemvati Nandan Bahuguna Garhwal University, Garhwal	2019	Hemvati Nandan Bahuguna Garhwal University, Garhwal
Assessment of socio ecological vulnerability to climate change among agroforestry managers along an altitude gradient in the Eastern Himalayas Assessment of socio ecological vulnerability to climate change among agroforestry managers along an altitude gradient in the Eastern Himalayas	Dr Arun Jyoti Nath, Assistant Professor, Assam University, Silchar	2019	Assam University, Silchar
Net ecosystem production and carbon dynamics of forest ecosystems in North East India in relation to altitude and latitude gradient: Implications for carbon sink management	Prof Uttam Kumar Sahoo, Forestry Mizoram University, Aizawl	2019	Mizoram University, Aizawl

Project Title	Principal Investigator	Start Date	Implementing Agency
Climate Change and Sustainability of Agricultural Practices and Livelihoods in Eastern Himalayas: Case Studies in Northeastern Region, India	Prof Ratul Mahanta, Gauhati University, Guwahati	2019	Gauhati University, Guwahati
Climate change impact assessment on some threatened taxa and their possible regeneration and conservation strategies to support rural livelihoods in a part of the Eastern Himalaya	Prof Bhaben Tanti, Gauhati University, Guwahati	2019	Gauhati University, Guwahati
Long-term ecological monitoring of forest plots in Mizoram, Northeast India	Prof Shri Kant Tripathi, Mizoram University, Aizawl	2019	Mizoram University, Aizawl
Assessment of Variability in Glacier melt and Snowmelt Runoff under Projected Climatic Scenarios for Data Scarce Himalayan River Basins	Dr Aditi Bhadra, Associate Professor, North Eastern Regional Institute of Science and Technology (NERIST), Itanagar	2019	North Eastern Regional Institute of Science and Technology (NERIST), Itanagar

For more info, visit :

https://www.indiascienceandtechnology.gov.in/research?field_area_id=2378

PATENTS

Patents are a record of the technological inventiveness and commercial activities of a nation. They are of essential interest of many engineers and scientists, particularly those in academe who may develop new products and processes and who wish to protect their intellectual property or inventions.

Following list provides an avenue by which innovations and solutions may be easily shared to accelerate and facilitate implementation to protect the environment and perhaps lead to further innovation. And to encourage cooperation and collaboration between businesses that pledge patents and potential users to foster further joint innovations and the advancement and development of solutions that benefit the environment

RESTORE MOTHER EARTH: A SNAPSHOT

Title	Inventor	Implementing Agency
Insecticidal Compounds from Nothapodites Foetida and Process for the Extraction thereof	Swati Pramod Joshi; John Pereira; Phool Kumar Patanjali; Sunita Sharad Kunte; Kiran Babasaheb Sonawane; Suresh Gurappa Mummigatti; Sumithra Devi Sanna; Krishnaiah Eraiah Hullukere; Seema Chaudhary	National Chemical Laboratory (CSIR-NCL)
A process for production of various shapes and sizes of high purity monodispersed iron oxide from waste chloride pickle liquor	Kamala Kanta Sahu; Archana Agrawal; Devabrata Mishra	National Metallurgical Laboratory (CSIR-NML)
Process of spontaneous dewatering of feed solution using salt bitterns as draw solutions	Pushpito Kumar Ghosh; Dibyendu Mondal; Sanna Kotrappanavar Nataraj; Alamuru Venkata Rami Reddy; Sumesh Chandra Upadhyay	Central Salt & Marine Chemicals Research Institute (CSIR-CSMCRI)
Electrode and process for preparing the electrode and devices thereof	Krishnamoorthy Kothandam	National Chemical Laboratory (CSIR-NCL)
Improved anaerobic digester for household organic wastes	Vattackatt Balakrishnan Manilal	National Institute for Interdisciplinary Science and Technology (CSIR-NIIST)
Improved v-trough solar concentrator system for enhanced power output form conventional photovoltaic array powering a community scale reverse osmosis desalination unit	Subarna Maiti; Pushpito Kumar Ghosh; Sodankur Thimmannabhat Rajan; Sohan Lal Daga; Jitendra Narsinhbhai Bharadia; Kairavi Gaurav Vyas; Pratap Shashikant Bapat; Pankaj Arvind Patel; Sanat Kumar Natvarlal Patel; Labhubhai Manajibhai Kachadia; Gaurang Shambhuprasad Trivedi; Praful Kalubhai Harsora; Hitesh Mohanbhai Tadvi	Central Salt & Marine Chemicals Research Institute (CSIR-CSMCRI)
A biodegradable and eco-friendly dust suppressant chemical for unpaved haul roads and stock pile, blasted material handling in mines and other dust prone areas	Pandey Jai Krishna; Trivedi Shrenik Madhusudan; Trivedi Rushay Shrenik; Jani Urja Falgun; Vyas Bhavtosh Rajnikant; Kumar Ajay	Central Institute of Mining and Fuel Research (CSIR-CIMFR)

Eco-friendly process for the isolation of biopolymers from agricultural residues	Rout, Prasanta Kumar; Nannaware, Ashween Deepak; Prakash, Om; Rajasekharan, Ram	Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP)
Calcium silicate hydrate anion exchange membrane useful for water electrolysis and fuel cells and a process for the preparation thereof	Swaminathan Jayashree; Ravichandran Subbiah; Davidson Donald Jonas; Sozhan Ganapathy; Vasudevan Subramanyan; Vengatesan Singaram; Muralidharan Srinivasan	Central Electro Chemical Research Institute (CSIR-CECRI)
A novel process for preparation of synthetic hydrotalcite from industrial waste	Maheshkumar Ramniklal Gandhi; Jatin Rameshchandra Chunawala; Satish Hariray Mehta	Central Salt & Marine Chemicals Research Institute (CSIR-CSMCRI)
Solar fuels and a hybrid process thereof based on biomimetic carbonation and photocatalysis	Rayalu Sadhana Suresh; Chakrabarti Tapan; Joshi Meenal Vivek; Mangrulkar Priti Ashok; Labhsetwar Nitin Kumar	National Environmental Engineering Research Institute (CSIR-NEERI)
An improved process for the recovery of manganese as ferro-silico-man-gamese from leached sea nodule residue	Ranajit Kumar Jana; Sanjay Agarwal; Navneet Singh Randhawa; Satadal Ghorai; Jagannath Pal; Shyamal Kumar Maity; Jayanta Konar	National Metallurgical Laboratory (CSIR-NML)
A novel fluidized bed reactor for treatment of waste water	Ganesan Sekaran; Sekar Karthikeyan; Ramasamy Boopathy; Asit Baran Mandal	Central Leather Research Institute (CSIR-CLRI)
Advanced cement free composition for concrete and panels and method of preparation thereof	Sitaram Amritphale, Sudhir; Verma, Sarika; Akram Khan, Mohammed; Padmakaran, Prabha; Anshul, Avneesh; Das, Satyabrata	Advance Material and Process Research Institute (CSIR-AMPRI)
Anaerobic gas lift reactor (AGR) for the treatment of organic solid waste	Anupoju Gangagni Rao; Yerramsetti Venkata Swamy	Indian Institute of Chemical Technology (CSIR-IICT)
Advanced non-toxic radiation shielding materials from tailored brine sludge and a process for the preparation thereof	Amritphale, Sudhir Sitaram; Anshul Avneesh; Verma Sarika; Khan, Mohammed Akram; Das, Satyabrata	Advance Material and Process Research Institute (CSIR-AMPRI)
Process for the detection and adsorption of arsenic	Luwang, Meitram Niraj; Ghosh; Debasish	National Chemical Laboratory (CSIR-NCL)

Title	Inventor	Implementing Agency
A pharmaceutical composition for the treatment of multidrug resistant Novel assay for detection of fluoride ions	Debanjan Guin; Satsihchandra Balkrishna Ogale; Pooja Singh	National Chemical Laboratory (CSIR-NCL)
A Zero Emission Chrome Training Process for Leather Making	Victor John Sundar; Chellappa Muralidharan	Central Leather Research Institute (CSIR-CLRI)
A Process for Decomposition of Organic Synthetic Dyes Using Semiconductor-Oxides Nanotubes Via Dark Catalysis	Shukla Satyajit Vishnu; Warrier Krishna Gopakumar; Babu Babitha Kunnathuparambil	National Institute for Interdisciplinary Science and Technology (CSIR-NIIST)
A Device for Suppression of Dust Produced During Blasting of Coalface in Board Pillar Mining	Kashyap Sudhir Kumar; Tewari Subhashish	Central Institute of Mining and Fuel Research (CSIR-CIMFR)
A Process for the production of Geopolymer Cement from Fly Ash and Granulated Blast Furnace Slag, Co-polymer Cement made thereby and process of making products thereof.	Kumar Sanjay; Kumar Rakesh; Mittra Balai Kumar; Mehrotra Surya Pratap	National Metallurgical Laboratory (CSIR-NML)

To know more patents related to environmental sciences, ecology and atmosphere, visit:

https://www.indiascienceandtechnology.gov.in/innovations/patents?field_ministries_tid=All&combine=Environment

MISSION, POLICIES & PROTOCOLS

The awareness and attention towards the environment require protection of water, air, soil and land resources. Mother Earth can be restored by preventing land degradation, rapid industrialization, urbanization, depletion of natural resources etc. Thus, to save the world, many national and international environment agreement, laws, missions, policies are formulated from time to time. These Environmental Law plays a very crucial and important role in regulating the use of natural resources and in protecting the environment. They also regulate or manage human impact on the environment in an effort to protect it.

Section Guidelines

Policies

1. **Guidelines for Revised Scheme on Research & Development (R&D) for Conservation & Development (2017-2020)**
2. **National Environment Policy 2006**
3. **National Action Plan on Climate Change (NAPCC)**
4. **National Mission for Sustaining the Himalayan Eco-System (NMSHE)**
5. **National Mission on Strategic Knowledge for Climate Change**
6. **National Mission on Himalayan Studies (NMHS)**
7. **Policy Brief on Sustainability of Tourism in IHR under Climate Change – Analyses of Policy Options**
8. **Policy Briefs- Understanding Mountain Peoples**
9. **National Mission for Green India (GIM)**
10. **Rebuilding Nature as a response to COVID-19 for expediting economic recovery process**

11. Mending the broken relationship with Nature post-COVID-19
12. Policy Guidance for Restoring Biodiversity and the Natural Capital

International Environment Agreement

1. UN Conference on Human Environment, Stockholm
2. Vienna Convention
3. Montreal Protocol
4. Basel Convention
5. The Earth Summit
6. Kyoto Protocol
7. UN World Summit on Sustainable Development, Johannesburg
8. Copenhagen Climate Change Conference
9. United Nations Climate Change Conference, Doha
10. The Paris Agreement

Policies

1. Guidelines for Revised Scheme on Research & Development (R&D) for Conservation & Development (2017-2020)

The R&D Scheme for Conservation and Development is a Central Sector scheme, which is implemented by the Ministry of Environment, Forest & Climate Change (MoEF&CC). It is an important step towards addressing environmental problems by taking measures for conservation and protection of environment in a sustainable manner. Such an objective has to be realised by building indigenous capacities; strengthening manpower in multidisciplinary aspects; generating information for taking policy decisions, preparedness and basis for international negotiations; supporting basic and applied research in environment, ecology and related fields; and facilitating database management on research projects undertaken under the scheme on relevant thematic areas of the Ministry.

The research projects will enable the Ministry to find practical solutions to issues concerning environmental protection and management and to generate information and knowledge from the outcomes of R&D projects for developing policies, strategies, and action plans. It will also help the Ministry in better management and conservation of natural resources for achieving the overarching objectives of sustainable development.

The important thematic areas of the Scheme include Biodiversity Conservation, including issues of Human-wildlife interface; Ecosystem Conservation & Management; Socio- economic issues of Environment and Sustainable Development; Conservation and Management of Landscapes and Ecologically sensitive areas, including issues of sustainable livelihoods; Sustainable Management of Natural Resources; Climate Change: vulnerability & risk assessment, process, mitigation and adaptation; Pollution Prevention; and Waste minimization and management for environmental conservation and protection.

Detailed Document: http://moef.gov.in/wp-content/uploads/2017/08/Guidelines-for-RampD-Scheme.pdf

2. National Environment Policy 2006

The National Environment Policy is intended to be a guide to action in regulatory reforms, programmes and projects for environmental conservation as also to review and enactment of legislation by agencies of the Central, State, and Local Governments. The policy also seeks to stimulate partnerships of different stakeholders, i.e., public agencies, local communities, academic and scientific institutions, the investment community, and international development partners, in harnessing their respective resources and strengths for environmental management.

The dominant theme of this policy is that while conservation of environmental resources is necessary to secure livelihoods and well-being of all, the most secure basis for conservation is to ensure that people dependent on particular a resource obtain better livelihoods from its conservation rather than from degradation.

Detailed Document: https://ibkp.dbtindia.gov.in/DBT_Content_Test/CMS/Guidelines/20190411103521431_National%20Environment%20Policy,%202006.pdf

3. National Action Plan on Climate Change (NAPCC)

The National Action Plan on Climate Change, formulated by the Government of India, hinges on the development and use of new technologies. The focus is on promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation. There are Eight National Missions which form the core of the National Action Plan, representing multi-pronged, long-term and integrated strategies for achieving the key goals in the context of climate change.

Detailed Document: https://archivepmo.nic.in/drmanmohansingh/climate_change_english.pdf

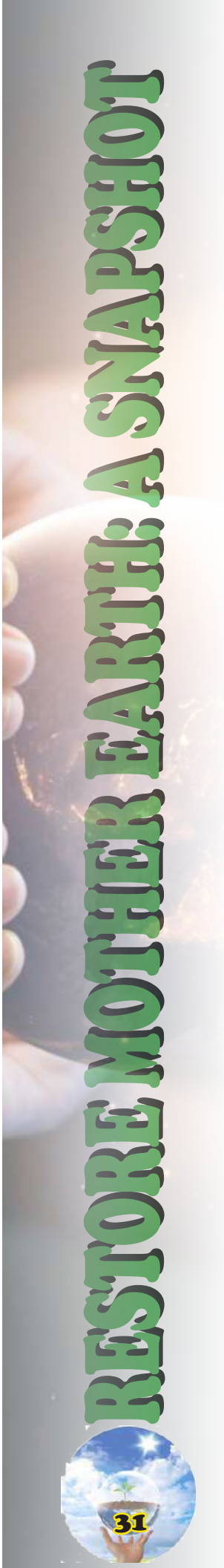
4. National Mission for Sustaining the Himalayan Eco-System (NMSHE)

Recognizing the importance of scientific and technological inputs required for sustaining the fragile Himalayan Ecosystem, the Ministry of Science and Technology has been charged with the nodal responsibility of coordinating The National Mission for Sustaining the Himalayan Ecosystem (NMSHE). However, the mission requires valuable cooperation of the country's Himalayan states, Niti Aayog and the Ministry of Environment and Forests to achieve its goals.

The National Action Plan on Climate Change has enunciated the launch of the National Mission for Sustaining the Himalayan Ecosystem. The Mission aims to deliver better understanding of the coupling between the Himalayan ecosystem and the climatic factors and provide inputs for sustainable development in the Himalayan region while also addressing the protection of a fragile ecosystem. It also attempts to address some important issues concerning the Himalayan glaciers; biodiversity conservation and protection; wildlife conservation and protection; traditional knowledge societies and their livelihoods; and planning for sustaining the Himalayan ecosystem.

The primary objective of the Mission is to develop, in a time-bound manner, a sustainable national capacity to continuously assess the health status of the Himalayan ecosystem, enable policy bodies in their policy formulation functions, and assist states in the Indian Himalayan Region with the implementation of actions selected for sustainable development.

Detailed Document: https://dst.gov.in/sites/default/files/NMSHE_Mission_document.pdf



5. National Mission on Strategic Knowledge for Climate Change

The National Action Plan on Climate Change outlines India's domestic plan for sustainable development with specific proposals under each mission representing what India believes needs to be done in terms of ecologically sustainable development and serving the objectives of adaptation and mitigation. As one of the eight National Missions which form the core of the National Action Plan, the National Mission on Strategic Knowledge for Climate Change (NMSKCC) seeks to build a vibrant and dynamic knowledge system that would inform and support national action for responding effectively to the objective of ecologically sustainable development. The NMSKCC should ideally serve as a support mission for generating and providing strategic knowledge to all other seven national missions under the National Action Plan on Climate Change with inbuilt capacities for continuous and mid-course changes in trajectories to take into account international developments in climate change related issues.

Many Ministries and Departments of the Government of India have been supporting research related to climate change and response options through intra-and extra-mural research and knowledge support systems. These include the Ministry of Science & Technology [Department of Science & Technology (DST), Department of Biotechnology (DBT), Council of Scientific & Industrial Research (CSIR)], Ministry of Earth Sciences (MoES), Ministry of Environment & Forests (MoEF), Ministry of Agriculture [Department of Agriculture and Cooperation (DAC), Indian Council of Agricultural Research (ICAR)], Department of Space (DOS), Ministry of Water Resources (MoWR), and Department of Atomic Energy (DAE), among others. These wide-ranging R&D efforts need to be further strengthened. The National Mission on Strategic Knowledge for Climate Change would build on this existing base to launch new initiatives as appropriate in a mission-mode manner.

Detailed Document: https://dst.gov.in/sites/default/files/NMSKCC_mission%20document%201.pdf

6. National Mission on Himalayan Studies (NMHS)

Recognizing that the Himalayas are important for the ecological security of the country, the Government of India attaches highest priority to protect the unique but highly fragile Himalayan ecosystem. The National Mission on Himalayan Studies (NMHS), a Central sector grant-in-aid scheme, targets to provide a much-needed focus, through holistic understanding of the system's components and their linkages, in addressing the key issues relating to conservation and sustainable management of natural resources in the Indian Himalayan Region (IHR). The scheme will be implemented by the Ministry of Environment, Forest & Climate Change, and it will have its nodal and serving hub with G.B. Pant Institute of Himalayan Environment & Development (GBPIHED) located at Almora in Uttarakhand.

The NMHS envisages to work towards a following set of linked and complementary goals:

- Foster conservation and sustainable management of natural resources;
- Enhance supplementary and/or alternative livelihoods and overall economic well-being of the region;
- Control and prevent pollution in the region;
- Foster increased/augmented human and institutional capacities and the knowledge and policy environment in the region; and

- Strengthen, greening, and fostering development of climate-resilient core infrastructure and basic services assets

The NMHS has identified a list of 25 indicative thematic areas under six broad thematic thrusts: Sustainable management of land and water resources; Environmental assessment and management; Conservation and sustainable use of biodiversity; Sustainable infrastructure and energy security; Supplementary livelihood options; and Awareness and capacity building.

The core philosophy is to enhance the focus and funds for supporting demand-driven research and technological innovations along with institutional strengthening and capacity building. The overall attempt is to work towards coordinated policies and duly informed decisions based on empirical evidence and best practices, thereby providing an enabling environment for innovations and multi-stakeholders' engagement in protection of the Himalayan ecosystems and socio-economic development of the local communities.

Detailed Document: http://nmhs.org.in/pdf/publication/Mission_Documents/MIssion_Document.pdf

7. Policy Brief on Sustainability of Tourism in IHR under Climate Change – Analyses of Policy Options

The prospects of tourism in the Indian Himalayan Region may considerably improve under climate change due to increased inflow of tourists to seek relief from scorching heat in Indian plains, elongated durations of tourist's seasons, new opportunities in high altitude- and remote location- based nature/ culture/ adventure/ educational tourism, and enhanced scope in winter tourism. The increased probability of extreme events, Climate Change (CC) triggered hazards/ disasters, and continued influence of CC in years to come, however, would continue to haunt the tourism's growth, development, and sustainability in IHR.

The sustainable management of tourism under CC, therefore, would require a multi-pronged approach comprising considerations of climate-safe tourism/ developmental planning, minimization of environmental trade-offs, carrying capacity management, inflow regulation through economic instruments and number restrictions, management of tourism operations by centralized booking/ benefit sharing/ effective community organisations, and diffusion of pressure through development of subsidiary pockets, cult and clientele for alternative tourism, system of impact monitoring, and the education, awareness of the guest and host community, etc. The management of urban/ mass tourism centres, which will also serve as a transit for tourism to remote locations under the CC scenarios and tourism in vulnerable eco-sensitive zones in remote pockets, would require special attention.

Detailed Document: http://nmhs.org.in/pdf/publication/Mission_Documents/MIssion_Document.pdf

8. Policy Briefs- Understanding Mountain Peoples

The policy briefs 'Understanding Mountain Peoples' are originally the output of a research project on the approaches and practices needed to combat climate change in the Indian Himalayan Region. The research, which aimed at formulating renewal and reforms for the environment, was funded by National Mission on Himalayan Studies (NMHS) under MoEF&CC and led by the Integrated Mountain Initiative and TERI.

These policy briefs are a bouquet of various smaller research projects on 'Integrated Farming Systems: A case of paddy-cum-fish culture in Arunachal Pradesh'; 'The revival of traditional system (Chutsir) on water allocation: A case from Ladakh'; "Samaj stewardship in managing springs in the Darjeeling and Kalimpong Himalaya'; 'Climate proofing of spring sheds in Meghalaya'; 'Drip irrigation practice in Mizoram for combating the effect of climate change on farmers in Mizoram'; 'Agro-biodiversity for Food, Nutrition and Ecological Security: A Case Study on Jhum Agriculture, Nagaland'; 'DHARA VIKAS – Reviving the springs of Sikkim', and many others.

Detailed Document: http://nmhs.org.in/pdf/publication/Policy_briefs/IMI_TERI_Policy_Briefs.pdf

9. National Mission for Green India (GIM)

The National Mission for Green India (GIM), one of the eight Missions outlined under the NAPCC, aims at protecting, restoring and enhancing India's diminishing forest cover and responding to climate change by a combination of adaptation and mitigation measures. It envisages a holistic view of greening and focuses on multiple ecosystem services, especially biodiversity, water, biomass, preserving mangroves, wetlands, critical habitats, etc. along with carbon sequestration as a co-benefit. This mission has adopted an integrated cross-sectoral approach as it will be implemented on both public as well as private lands with a key role of the local communities in planning, decision-making, implementation and monitoring.

The goal of the Mission is to improve or enhance ecosystem services like carbon sequestration and storage, hydrological services and biodiversity along with provisioning services like fuel, fodder, and timber and non-timber forest products (NTFPs). The goal is also to increase forest-based livelihood incomes.

The National Mission for Green India also hinges upon convergence with related Missions of the National Action Plan on Climate Change, other complementary National Mission Programmes and Schemes for better coordination in developing forests and their fringe areas in a holistic and sustainable manner.

Detailed Document: http://moef.gov.in/en/division/forest-divisions-2/green-india-mission-gim/about-the-mission/

10. Rebuilding Nature as a response to COVID-19 for expediting economic recovery process

In view of the emergence of the global health crisis in 2020 and its economic fallout, the UN Environment Programme (UNEP) and its partners discussed the need to initiate a discourse on mainstreaming nature into the economic recovery process in India. These discussions led to the initiation of a webinar series under the overarching theme of rebuilding nature as a response to the COVID-19 pandemic. The series was titled 'Investing in Nature to Build Back Better', and it aimed to generate and foster discourse on how we can lay the groundwork for scaling up transformation as part of a 'green new normal'. It brought together decision-makers, experts, and practitioners to discuss the significance of biodiversity conservation and ecosystem restoration, and find ways to mobilize investments into nature as we build back better. The webinar series concluded in March 2021, bringing valuable insights on nature rebuilding

to the fore. Collectively, these webinars help identify ways to recognize, demonstrate and capture reflections on the benefits of investing in India's unique biodiversity and natural resources. It provides a powerful message that building back better is needed now more than ever.

Detailed Document: http://www.indiaenvironmentportal.org.in/files/file/Investing%20in%20Nature%20to%20Build%20Back%20Better.pdf

11. Mending the broken relationship with Nature post-COVID-19

This policy brief highlights how human health is directly linked to the state of biodiversity and climate change in the Asia-Pacific region, specifically India. Improving human health and mitigating against future health disasters require simultaneously addressing these causative factors in an integrated fashion.

Detailed Document: http://www.indiaenvironmentportal.org.in/files/file/Nexus%20Policy%20Brief.pdf

12. Policy Guidance for Restoring Biodiversity and the Natural Capital

Nature underpins all economic activities and human well-being. It is the world's most important asset. Yet humanity is destroying biodiversity at an unprecedented rate, posing significant but often overlooked risks to the economy, the financial sector and the well-being of current and future generations. This report provides the latest findings and policy guidance for G7 and other countries in four key areas: measuring and mainstreaming biodiversity; aligning budgetary and fiscal policy with biodiversity; embedding biodiversity in the financial sector; and improving biodiversity outcomes linked to international trade. The report shows how Finance, Economic and Environment Ministries can drive the transformative changes required to halt and reverse the loss of biodiversity.

Detailed Document: http://www.indiaenvironmentportal.org.in/files/file/biodiversity%20natural%20capital%20and%20the%20economy.pdf

International Environment Agreement

1. UN Conference on Human Environment, Stockholm

(Effects of Environmental Degradation on Quality of Human Life)

The world's first United Nations Conference on the Environment was held in 1972 at Stockholm where the environment was identified as one of the major issues of concern. The participants adopted a series of principles for sound management of the environment, including the Stockholm Declaration and Action Plan for the Human Environment, and several resolutions. The Stockholm Declaration, which contained 26 principles, placed environmental issues at the forefront of international concerns and marked the start of a dialogue between industrialized and developing countries on the link between economic growth, the pollution of air, water, and oceans and the well-being of people around the world.

Detailed Document: https://undocs.org/en/A/CONF.48/14/Rev.1

2. Vienna Convention

By 1985, the world developed the scientific understanding of ozone depletion and its impacts on human health and the environment. Thus, the Vienna Convention for the Protection of the Ozone Layer was signed in response. It was the first convention of any kind to be signed by every country involved, taking effect in 1988 and securing universal ratification in 2009. This reflects the enormity of ozone depletion at the time and the willingness of the countries to work together to solve it. The Convention aimed to promote cooperation among nations by exchanging information on the effects of human activities on the ozone layer. The motto of Vienna Convention does not stop afterwards; it's still making progress. The countries involved meet once every three years to make decisions on important issues, including research and systematic observations as well as financial and administrative matters.

Detailed Document: https://ozone.unep.org/sites/default/files/2020-01/VC_Handbook_2019.pdf

3. Montreal Protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer is a global agreement to protect the earth's ozone layer by phasing out the chemicals that deplete it. This phase-out plan includes both the production and consumption of ozone-depleting substances. The landmark agreement was signed in 1987 and entered into force in 1989.

The parties to the Protocol meet once a year to make decisions aimed at ensuring the successful implementation of the agreement. These include adjusting or amending the Protocol, which has been done six times since its inception. The most recent amendment, the Kigali Amendment, called for the phase-down of hydrofluorocarbons (HFCs) in 2016. These HFCs were used as replacements for a batch of ozone-depleting substances eliminated by the original Montreal Protocol. Although they do not deplete the ozone layer, they are known to be powerful greenhouse gases and, thus, contributors to climate change.

The Montreal Protocol provided a set of practical, actionable tasks that were universally agreed upon. The Protocol has successfully met its objectives thus far and continues to safeguard the ozone layer today.

Detailed Document: https://ozone.unep.org/sites/default/files/Handbooks/MP-Handbook-2020-English.pdf

4. Basel Convention

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal was adopted on 22 March 1989 by the Conference of Plenipotentiaries in Basel, Switzerland, in response to deposits of toxic wastes imported from abroad to various developing countries. The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes.

Detailed Document: https://wedocs.unep.org/bitstream/handle/20.500.11822/8385/-Basel%20Convention%20on%20the%20Control%20of%20Transboundary%20Movements%20of%20Hazardous%20Wastes%20-20113644.pdf?sequence=2&amp%3BisAllowed=

5. The Earth Summit

Popularly known as the 'Earth Summit', the United Nations Conference on Environment and Development (UNCED) held on 3-14 June 1992 in Rio de Janeiro, Brazil, marked the twentieth anniversary of the United Nations Conference on the Human Environment held in Stockholm, Sweden, in 1972. Virtually every country in the world was represented (178) and more than 100 heads of state attended. The participating world leaders signed five major instruments: The Rio Declaration (a statement of principles); Agenda 21 (a framework for activity into the 21st century addressing the combined issues of environment protection and fair and equitable development for all, and includes the creation of a new Commission for Sustainable Development); a Framework Convention on Climate Change; a Framework Convention on Biological Diversity; and a Statement of Principles on Forests.

- **The Rio Declaration:** https://undocs.org/en/A/CONF.151/26/Rev.1(vol.I)
- **Agenda-21:** https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf
- **United Nations Framework Convention on Climate Change:** https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf
- **UN Convention on Biological Diversity:** https://www.cbd.int/doc/legal/cbd-en.pdf

6. Kyoto Protocol

The Kyoto Protocol is an international agreement to manage and reduce carbon dioxide emissions and other greenhouse gases. The Protocol was adopted at a conference in Kyoto, Japan, in 1997 and became an international law on February 16, 2005. As many as 192 nations committed to reduce the emission of greenhouse gases by an average of 5.2 per cent by 2012, which would represent about 29 per cent of the world's total emissions.

The countries that ratified the Kyoto Protocol were assigned maximum carbon emission levels for specific periods and participated in carbon credit trading. If a country emitted more than its assigned limit, then it would receive a lower emissions limit in the following period.

Detailed Document: https://unfccc.int/sites/default/files/resource/docs/cop3/l07a01.pdf
https://unfccc.int/sites/default/files/08_unfccc_kp_ref_manual.pdf

7. UN World Summit on Sustainable Development, Johannesburg

The Summit brought together tens of thousands of participants, such as Heads of State and Government, national delegates and leaders from non-governmental organizations (NGOs), businesses and other major groups, to focus the world's attention and direct action toward meeting difficult challenges, including improving people's lives and conserving our natural resources.

The objective of the World Summit on Sustainable Development (WSSD) was to examine the implementation of resolutions made at the conference in Rio, with a particular focus on Agenda 21. Problems such as social justice, dialogue between cultures, health and development were given greater weight than at the previous summits in Stockholm (1972) and Rio de Janeiro (1992). Furthermore, a clearer link was drawn between poverty and the state of the environment.

Detailed Document: https://www.are.admin.ch/are/en/home/sustainable-development/international-cooperation/2030agenda/un-_-milestones-in-sustainable-development/2002--un-world-summit-on-sustainable-development--johannesburg.html

8. Copenhagen Climate Change Conference

The United Nations Climate Change Conference in Copenhagen, Denmark took place from 7-19 December 2009. It included the fifteenth Conference of the Parties (COP 15) to the United Nations Framework Convention on Climate Change (UNFCCC) and the fifth Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (COP/MOP 5).

The Copenhagen Climate Change Conference raised climate change policy to the highest political level. Close to 115 world leaders attended the high-level conclave, making it one of the largest gatherings of world leaders ever outside UN headquarters in New York. The Copenhagen Accord contained several key elements on which there was strong convergence of the views of governments. This included the long-term goal of limiting the maximum global average temperature increase to not more than 2 degree Celsius above pre-industrial levels, subject to a review in 2015. There was, however, no agreement on how to do this in practical terms. It also included a reference to consider limiting the temperature increase to below 1.5 degrees—a key demand made by vulnerable developing countries.

Detailed Document: https://unfccc.int/process-and-meetings/conferences/past-conferences/copenhagen-climate- change-conference-december-2009/copenhagen-climate-change-conference-december-2009

9. United Nations Climate Change Conference, Doha

At the 2012 UN Climate Change Conference in Doha, Qatar (COP18/ CMP8), governments consolidated the gains of the previous three years of international climate change negotiations and opened a gateway to necessary greater ambition and action on all levels. Countries successfully launched a new commitment period under the Kyoto Protocol, agreed on a firm timetable to adopt a universal climate agreement by 2015 and concurred on a path to raise necessary ambition to respond to climate change. They also endorsed the completion of new institutions and agreed on ways and means to deliver scaled-up climate finance and technology to developing countries.

Detailed Document: https://unfccc.int/process-and-meetings/conferences/past-conferences/doha-climate- change-conference-november-2012/doha-climate-change-conference-november-2012

10. The Paris Agreement

The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris on 12 December 2015 and entered into force on 4 November 2016. Its goal is to limit global warming to 1.5 degree Celsius compared to pre-industrial levels. The Paris Agreement is a landmark in the multilateral climate change process because, for the first time, a binding agreement brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects.

Detailed Document: https://unfccc.int/sites/default/files/english_paris_agreement.pdf

ORGANISATIONS

Section Guidelines

1. Indian Forest Service (IFS), Delhi
2. Central Zoo Authority of India (CZAI), Delhi
3. National Biodiversity Authority (NBA), Tamil Nadu
4. National Tiger Conservation Authority (NCTA), Delhi
5. Animal Welfare Board of India (AWBI), Tamil Nadu
6. Botanical Survey of India (BSI), Kolkata
7. Central Pollution Control Board (CPCB), Delhi
8. Environmental Information System (ENVIS), Delhi
9. Odisha State Pollution Control Board (OSPCB), Bhubaneswar
10. Delhi Pollution Control Committee (DPCC), Delhi
11. Directorate of Forest Education (DFE), Uttarakhand
12. Forest Survey of India (FSI), Uttarakhand
13. Indira Gandhi National Forest Academy (IGNFA), Uttarakhand
14. National Afforestation and Eco-Development Board (NAEB), Uttarakhand
15. National Museum of Natural History (NMNH), Delhi
16. National Zoological Park (NZP), Delhi
17. Zoological Survey of India (ZSI), Kolkata
18. Centre for Environment Education (CEE), Gujarat

19. C. P. R. Environmental Education Centre (CPREEC), Tamil Nadu
20. Centre of Excellence in Environmental Economics (CEEE), Kerala Agricultural University
21. Centre for Ecological Sciences (CES), Bengaluru
22. Centre for Environmental Management of Degraded Ecosystem (CEMDE), Delhi
23. Sálim Ali Centre for Ornithology and Natural History (SACON), Tamil Nadu
24. Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), Kerala
25. G B Pant Institute of Himalayan Environment, Almora
26. Indian Institute of Forest Management (IIFM), Bhopal
27. Indian Plywood Industries Research and Training Institute (IPIRTI), Bengaluru
28. Indian Council of Forestry Research and Education (ICFRE), Dehradun
29. Wildlife Institute of India (WII), Dehradun
30. Indian Renewable Energy Development Agency (IREDA), New Delhi
31. CSIR-National Institute of Environmental Engineering Research Institute (NEERI), Nagpur
32. National Institute of Oceanography (CSIR-NIO), Goa
33. National Institute of Solar Energy (NISE), Gurugram
34. Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE), Kapurthala
35. National Institute of Wind Energy (NIWE), Chennai
36. Wadia Institute of Himalayan Geology (WIHG), Dehradun
37. National Institute of Ocean Technology (NIOT), Chennai
38. ESSO - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad
39. National Centre for Antarctic and Ocean Research (NCAOR), Goa
40. National Centre for Earth Science Studies (NCESS), Thiruvananthapuram
41. Indian Institute of Tropical Meteorology (IITM), Pune

1. Indian Forest Service (IFS), Delhi

The Indian Forest Service (IFS), one of the three All India Services, was constituted by the Government of India. The main mandate of the service is to implement the National Forest Policy which envisages scientific management of forests and to exploit them on a sustained basis for primary timber products, among other things.

Ministry/Department: Ministry of Environment, Forest and Climate Change

(MOEF&CC), Government of India
Contact Details:
Sanjay Kumar
Director General
Indian Forest Service (IFS)
Ph. 91-11 24695241
Email: ifs@nic.in
Website link: http://ifs.nic.in/

2. Central Zoo Authority of India (CZAI), Delhi

The Central Zoo Authority (CZA) was established as a statutory body under the Ministry of Environment & Forests by the Government of India in 1992. The main objective of this Authority is to complement and strengthen the national effort in conservation of the rich biodiversity of the country, particularly the fauna. The other objectives of this Authority include enforcing minimum standards and norms for upkeep and healthcare of animals in the Indian zoos and to control mushrooming of unplanned and ill-conceived zoos. For the overall management of the animals housed in the Indian zoos, standards and norms for appropriate housing, upkeep, health care, diet, etc. have been laid down under the Recognition of Zoo Rules, 1992, which was further amended in 2019 and 2013,

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details:
Dr P S N Rao
Director
Central Zoo Authority of India (CZAI), Delhi
Ph. 91-011-24367851/52
Email: cza@nic.in
Website Link: http://cza.nic.in/

3. National Biodiversity Authority (NBA), Tamil Nadu

The National Biodiversity Authority (NBA) was established in 2003 by the Central Government. It is a statutory body that performs facilitative, regulatory and advisory functions for the Government of India on the issues of conservation, sustainable use of biological resources and fair and equitable sharing of benefits of use.

Ministry/ Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details:
Dr V. B. Mathur
Chairman
National Biodiversity Authority (NBA), Tamil Nadu
Ph. 91-44-22541805
Email: chairman@nba.nic.in; secretary@nba.nic.in
Website link: http://nbaindia.org/

4. National Tiger Conservation Authority (NCTA), Delhi

The National Tiger Conservation Authority (NCTA) is a statutory body under the Ministry of Environment, Forests and Climate Change (MOEF&CC) constituted for strengthening tiger conservation. The NCTA has been fulfilling its mandate for strengthening tiger conservation in the country by retaining an oversight through advisories/normative guidelines, based on appraisal of tiger status, ongoing conservation initiatives and recommendations of specially constituted committees.

Ministry/ Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details:
Dr S. P. Yadav
National Tiger Conservation Authority (NCTA), Delhi
Ph. 91-11-24367837
Email: ms-ntca@nic.in
Website link: https://ntca.gov.in/

5. Animal Welfare Board of India (AWBI), Tamil Nadu

The Animal Welfare Board (AWBI) of India is a statutory advisory body on animal welfare laws and promotes animal welfare in the country. It ensures that animal welfare laws in the country are diligently followed; provides grants to animal welfare organisations, and advises the Government of India on animal welfare issues.

Ministry/ Department: Ministry of Fisheries, Animal Husbandry and Dairying, Government of India
Contact Details:
Dr Sujit Kumar Dutta
Secretary
Animal Welfare Board of India (AWBI), Tamil Nadu
Ph.: 9650609880
Email: animalwelfareboard@gmail.com; assistantsecretaryawbi2018@gmail.com
Website Link: http://www.awbi.in/

6. Botanical Survey of India (BSI), Kolkata

The Botanical Survey of India (BSI) was established in 1890 with the objectives of exploring the plant resources of the country and identifying plant species with economic benefits. In 1954, the Government reorganised the BSI with the objectives of (1) undertaking intensive floristic surveys and collecting accurate and detailed information on the occurrence, distribution, ecology and economic utility of plants in the country; (2) collecting, identifying and distributing materials that may be of use to educational and research institutions; and (3) acting as the custodian of authentic collections in well-planned herbaria and documenting plant resources in the form of local, district, state and national flora.

Ministry/ Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India

Contact Details:
Dr A. A. Mao
Director
Botanical Survey of India (BSI), Kolkata
Ph.033- 23344963
Email: hq@bsi.gov.in; tech@bsi.gov.in
Website link: https://bsi.gov.in/

7. Central Pollution Control Board (CPCB), Delhi

The Central Pollution Control Board (CPCB) is statutory organisation that was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. It serves as a field formation and also provides technical services to the Ministry of Environment and Forests on the provisions of the Environment (Protection). The principal functions of the CPCB are (i) to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and (ii) to improve the quality of air and to prevent, control or abate air pollution in the country.

Ministry/ Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details: Dr Prashant Gargava
Member Secretary
Central Pollution Control Board (CPCB), Delhi
Ph. 91-11-22303655
Email: mscb.cpcb@nic.in
Website link: https://cpcb.nic.in/index.php

8. Environmental Information System (ENVIS), Delhi

The ENVIS serves as a single-stop web-enabled repository of comprehensive environmental information with collection, collation, storage, retrieval and dissemination of the same through a nationwide network of ENVIS Hubs (hosted by the Environment/ Forest Department of State Governments/ UT Administrations) and ENVIS Resource Partners (RPs)

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details:
Dr Unmana Sarangi
Joint Director
Environmental Information System (ENVIS), Delhi
Ph.91-11-24695367
Email: unmana.sarangi@nic.in
Website Link: http://envis.nic.in/

9. Odisha State Pollution Control Board (OSPCB), Bhubaneswar

The Odisha State Pollution Control Board (SPCB) has been established as a regulatory authority for implementing various pollution control laws. The Board is committed to providing a

pollution-free environment to the people of the state. It has undertaken various studies of underground water, soil and air to take remedial steps to control pollution.

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details:
Dr K. Murugesan
Member Secretary
Odisha State Pollution Control Board (OSPCB), Bhubaneswar
Ph. 0674- 2561909
Email: paribesh1@dataone
Website link: http://ospcboard.org/

10. Delhi Pollution Control Committee (DPCC), Delhi

The Delhi Pollution Control Committee (DPCC) has been established as a regulatory authority for implementing various pollution control laws. The committee is committed to providing a pollution-free environment to the people of the state. It has undertaken various studies of underground water, soil and air to take remedial steps to control pollution.

Ministry/ Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details: Dr K.S Jayachandran
Member Secretary
Delhi Pollution Control Committee (DPCC), Delhi
Ph.: 9717593501
Email: ssenv@delhi.gov.in
Website Link: https://www.dpcc.delhigovt.nic.in/#gsc.tab=0

11. Directorate of Forest Education (DFE), Uttarakhand

The Directorate of Forest Education (DFE), Dehradun is a premier organisation under the aegis of Ministry of Environment, Forests and Climate Change, Government of India, which imparts training to State Forest Service (SFS) Officers and Forest Range Officers (FRO) in the country. The Directorate was part of the Forest Research Institute and Colleges, Dehradun and remained responsible for professional and technical level training/education in the country.

Ministry/ Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details:
R.P. Singh
Director
Directorate of Forest Education (DFE), Uttarakhand
Ph.: 0135 – 2757326
Email: dfe-dehradun@gov.in; casfos.dd-mef@gov.in
Website Link: http://www.dfe.gov.in/

12. Forest Survey of India (FSI), Uttarakhand

The Forest Survey of India (FSI), a premier national organisation under the Union Ministry of Environment and Forests, is responsible for a regular assessment and monitoring of the forest resources of the country. In addition, it is also engaged in providing the services of training, research and extension.

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details:
Shri Pankaj Agrawal
Director General
Forest Survey of India (FSI), Uttarakhand
Ph. 91- 0135 - 2756139
Email: dgfsi@fsi.nic.in
Website Link: https://www.fsi.nic.in/

13. Indira Gandhi National Forest Academy (IGNFA), Uttarakhand

The Indian Forest College, which was set up in 1938 to impart professional forestry training to newly recruited Forest Officers, was renamed as the Indira Gandhi National Forest Academy in 1987. It was given the added status of a staff college to train a cadre of competent forest managers at various levels, including in-service training, to manage India's forest resources. The Academy conducts various training programmes to strengthen professional efficiency.

Ministry/ Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details:
Shri Bharat Jyoti
Director
Indira Gandhi National Forest Academy (IGNFA), Uttarakhand
Ph.: 91-135-2757316
Email: director@ignfa.gov.in
Website Link: http://www.ignfa.gov.in/

14. National Afforestation and Eco-Development Board (NAEB), Uttarakhand

The National Afforestation and Eco-Development Board (NAEB) is responsible for promoting afforestation, tree planting, ecological restoration and eco-development activities in the country, with special attention to the degraded forest areas and lands adjoining the forest areas, national parks, sanctuaries and other protected areas. It also pays attention to the ecologically fragile areas like the Western Himalayas, Aravallis, Western Ghats, etc.

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India

Contact Details:
Shri Pankaj Asthana
Inspector General of Forests
National Afforestation and Eco-Development Board (NAEB), Uttarakhand
Ph.: 24367404
Email: pankaj.asthana@nic.in
Website Link: http://www.naeb.nic.in/

15. National Museum of Natural History (NMNH), Delhi

The NMNH organises a large number of educational programmes throughout the year. These may be classified as interpretation, extension, in-reach, and outreach programmes. The programmes consist of museum studies, discussion sessions, outdoor nature explorations, observation and analysis of pollution problems in the urban environment, individual project assignments and exposure to the ecosystem in a National Park or wildlife sanctuary in India.

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India

Contact Details:
Dr B. Venugopal
Director
National Museum of Natural History (NMNH), Delhi
Ph.: 91-11-23314849
Email: dirnmnh@gmail.com
Website Link: http://www.nmnh.nic.in/

16. National Zoological Park (NZP), Delhi

The National Zoological Park (NZP) has been established to provide a more enriched environment for the animals, quality of animal exhibits, conservation education and sustainable management practices. It is also working towards generating awareness and compassion in the society towards wildlife and garnering their support for the national conservation efforts.

Ministry/Department: Central Zoo Authority (CZA), Government of India

Contact Details:
Sh. Ramesh Kumar Pandey
Director
National Zoological Park (NZP), Delhi
Ph.: 011-24358500
Email: info-nzp@gov.in
Website Link: https://nzpnewdelhi.gov.in/?ln=en

17. Zoological Survey of India (ZSI), Kolkata

The Zoological Survey of India (ZSI) was established to promote survey, exploration and research leading to the advancement of various aspects of exceptionally rich life of the erstwhile British Indian Empire. Scientists in ZSI are engaged in exploring, naming, describing, classifying and documenting animals from all over India.

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India

Contact Details:
Dr Kailash Chandra
Director
Zoological Survey of India (ZSI), Kolkata
Ph. : 91-33-24008595
Email: zsi.kolkata@gmail.com
Website Link: https://zsi.gov.in/App/index.aspx

18. Centre for Environment Education (CEE), Gujarat

CEE develops innovative programmes and educational material and also builds capacity in the field of Education for Sustainable Development (ESD). It is committed to ensuring that Environmental Education (EE) leads to action for sustainable development. It undertakes field projects that demonstrate and validate the role education can play in sustainable development. CEE works with local, state, national and international agencies, organisations and governments in India and in various other countries to help create a sustainable future. In addition, it works closely with Forest Departments and other relevant organisations in creating interpretation programmes and facilities.

Ministry/ Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India

Contact Details:
Ms Indu Capoor
Founder Director
Centre for Environment Education (CEE), Gujarat
Ph.: 91-79-26844700
Email: cee@ceeindia.org
Website Link: https://www.ceeindia.org/

19. C. P. R. Environmental Education Centre (CPREEC), Tamil Nadu

C. P. R. Environmental Education Centre (CPREEC) is a Centre of Excellence in Environmental Education established by the Ministry of Environment, Forests and Climate Change (MoEF&CC), Government of India, and CPR Foundation, Chennai, in 1989. Its mandate is to raise awareness and disseminate information about the environment and its various problems. CPREEC develops innovative programmes and builds capacity in the field of education and communication for sustainable development. It endorses attitudes, strategies and technologies that are environmentally sustainable.

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India

Contact Details:
Nanditha Krishna
Director
C. P. R. Environmental Education Centre (CPREEC), Tamil Nadu
Ph.: 91- 44 - 48529990
Email: cpreec@gmail.com
Website Link: https://cpreec.org/

20. Centre of Excellence in Environmental Economics (CEEE), Kerala Agricultural University

The vision of the CEEE is to build up a cadre of natural resource/environmental economists, scientists, policy makers, planners and administrators to discuss, assess and research the issues confronting environmental management and development.

The Centre acts as the analytical and advisory body for the management of environmental issues considering the wider dimensions of economic growth with social equity, justice and sustainability. It is envisaged to play a catalytic role in the sustainable economic development of the state of Kerala.

Ministry/ Department: Directorate of Environment and Climate Change, Government of Kerala, Kerala Agricultural University
Contact Details:
Dr P. Indiradevi
Director
Centre of Excellence in Environmental Economics (CEEE), Kerala
Ph: 91-487-2438327
Email: adhort@kau.in
Website Link: http://ceee.kau.in/

21. Centre for Ecological Sciences (CES), Bengaluru

The Centre for Ecological Sciences offers exciting opportunities for research in a variety of areas in ecology. It has instilled a tradition of rigorous enquiry in diverse areas of ecology, evolution and behaviour. Their projects are often integrative and they use multiple approaches, from theoretical and laboratory studies to field-based research, to explore their research questions. CES continues to evolve, expand and diversify its activities in teaching, research, outreach and conservation, while maintaining its standards of academic excellence.

Ministry/ Department: Ministry of Environment and Forests and Climate Change (MOEF&CC) & Indian Institute of Science (IISc), Bengaluru
Contact Details:
Sh. Janardhanan Pillai
Technical Officer
Centre for Ecological Sciences (CES), Bengaluru
Ph.: 91-80-2360-0985
Email: office.ces@iisc.ac.in; chair.ces@iisc.ac.in
Website Link: http://ces.iisc.ac.in/new/

22. Centre for Environmental Management of Degraded Ecosystem (CEMDE), Delhi

The Centre for Environmental Management of Degraded Ecosystems (CEMDE) was established by the Board of the Interdisciplinary Programme of the University of Delhi to understand ecological drivers and evolutionary processes influencing anthropogenic redistribution of biota with emphasis on exotic invasions. It also studies how plant chemicals form

the basis of understanding the competitive dominance of weeds at various levels of ecological organisation and how ecological processes, climatic and abiotic and biotic soil factors influence it. Further, it encourages Action Research for finding solutions to contemporary environmental and ecological challenges at the local, subnational, and national levels.

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India

Contact Details:

Prof. Inderjit Singh
Director
Centre for Environmental Management of Degraded Ecosystem (CEMDE), Delhi
Ph.: 011-27667689
Email: Inderjit@cemde.du.ac.in
Website Link: http://oldweb.du.ac.in/index.php?page=cemde

23. Sálim Ali Centre for Ornithology and Natural History (SACON), Tamil Nadu

The Sálim Ali Centre for Ornithology and Natural History (SACON) has been envisaged as encompassing the entire natural history with ornithology at the centre stage. It designs and conducts research in ornithology covering all aspects of biodiversity and natural history. Further, it creates data banks, confers honorary awards and disseminates knowledge relating to ornithology and natural history for the benefit of the community.

Minister/ Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India

Contact Details:

Dr S. Muralidharan
Director
Sálim Ali Centre for Ornithology and Natural History (SACON), Tamil Nadu
Ph.: 0422-2203100, 109
Email: salimali@sacon.in; salimalicentre@gmail.com
Website Link: https://www.sacon.in/

24. Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), Kerala

The Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI) functions for inventory, conservation and sustainable utilization of our plant wealth through appropriate research and development (R&D) efforts for the welfare of the state and the country at large. Towards achieving this, the Institute has framed time-bound programmes and projects with the financial support from various national and international funding agencies. It promotes and establishes modern scientific research and development studies relating to plants of importance to India and to Kerala in particular. It has also established laboratories for botanical, horticultural and chemical research, with the aim of improvement and utilization of plants of medicinal and ornamental value.

Ministry/Department: Kerala State Council for Science, Technology and Environment (KSCSTE)

Contact Details:
Dr R. Prakashkumar
Director
Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), Kerala
Ph.: 91-9495408856
Email: director@jntbgri.res.in; prasanna@jntbgri.res.in
Website Link: https://jntbgri.res.in/

25. G B Pant Institute of Himalayan Environment, Almora

The G.B. Pant National Institute of Himalayan Environment (formerly known as G.B. Pant Institute of Himalayan Environment & Development) was established in 1988-89, during the birth centenary year of Bharat Ratna Pt. Govind Ballabh Pant, as an autonomous institute of the Ministry of Environment, Forest & Climate Change (MoEF&CC), Govt. of India, which has been identified as a focal agency to advance scientific knowledge, evolve integrated management strategies, demonstrate their efficacy for conservation of natural resources, and ensure environmentally sound development in the entire Indian Himalayan Region (IHR).

The Institute attempts to maintain a balance of intricate linkages between socio-cultural, ecological, economic and physical systems that could lead to sustainability in the IHR. To achieve this, it follows a multidisciplinary and holistic approach in all its Research and Development (R&D) programmes with emphasis on interlinking natural and social sciences. In this effort, particular attention is given to the preservation of fragile mountain ecosystems, indigenous knowledge systems and sustainable use of natural resources. A conscious effort is made to ensure participation of local inhabitants for long-term acceptance and success of various programmes. Training, environmental education and awareness for different stakeholders are essential components of all the R&D programmes of the Institute.

Ministry/Department: Ministry of Environment, Forest & Climate Change (MoEF&CC), Government of India

Contact Details:
Er. Kireet Kumar
Director In-charge
G.B. Pant National Institute of Himalayan Environment, Almora, Uttarakhand
Ph. (0592) 241041(O)
Email: kireet@gbpihed.nic.in
Website Link: http://gbpihed.gov.in/index.php

26. Indian Institute of Forest Management (IIFM), Bhopal

The Indian Institute of Forest Management is a sectoral management institute, which constantly endeavours to evolve knowledge useful for the managers in the area of Forest, Environment and Natural Resources Management and allied sectors. It disseminates such knowledge in ways that promote its application by individuals and organisations.

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India

Contact Details:
Dr Pankaj Srivastava
Director
Indian Institute of Forest Management, Bhopal, Madhya Pradesh
Phone (Director): +91-755-2775998
Email: director@iifm.ac.in
Website Link: http://iifm.ac.in/

27. Indian Plywood Industries Research and Training Institute (IPIRTI), Bengaluru

The Indian Plywood Manufacturers' Research Association (IPMRA) was formed in 1962 as a cooperative research laboratory under the umbrella of Council of Scientific and Industrial Research (CSIR) for undertaking applied research on plywood, an important wood-based panel material.

The Institute was re-designated as the Indian Plywood Industries Research Institute in 1970 and its administrative control was transferred to the Ministry of Industry in 1978. Realising the need for trained manpower for wood-based panel industries, training facilities in mechanical wood industries technology were established during 1988 with the assistance of Food and Agriculture Organization (FAO), United Nations Development Programme (UNDP), and Government of India (GOI).

Recognising the greater role of the Institute in conservation of natural resources, its administrative control was transferred to the MoEF in 1990. As a reflection to its premier position as a centre of excellence in training for mechanical wood industries technology, the name of the Institute was changed to the Indian Plywood Industries Research and Training Institute in 1992.

Ministry/Department: Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India
Contact Details:
Dr Shakti Singh Chauhan
Director
Indian Plywood Industries Research & Training Institute, Yeswanthpur, Bengaluru - 560022
Phone (Director): 91-80-28394341
E-mail: director@ipirti.gov.in
Website Link: http://www.ipirti.gov.in/index.html

28. Indian Council of Forestry Research and Education (ICFRE), Dehradun

In 1986 the Indian Council of Forestry Research and Education or ICFRE was formed as an umbrella organisation for taking care of forestry research, education and extension needs of the country. On 1st June 1991, ICFRE was declared an autonomous Council under the then Ministry of Environment and Forests and registered as a Society under the Societies Registration Act, 1860.

Presently, ICFRE, with its headquarters at Dehradun, is an apex body in the national forestry research system that promotes and undertakes need-based forestry research

extension. The Council has a pan-India presence with its nine Regional Research Institutes and five centres in different bio-geographical regions of the country. Each institute has a history of its own, and under the umbrella of ICFRE, is directing and managing research, extension and education in the forestry sector in the states under its jurisdiction. The regional research institutes are located at Jodhpur, Dehradun, Shimla, Hyderabad, Coimbatore, Ranchi, Bengaluru, Jorhat and Jabalpur, and the centres are at Agartala, Aizawl, Allahabad, Chhindwara and Visakhapatnam.

Ministry/Department: Ministry of Environment, Forest & Climate Change (MoEF&CC), Government of India
Contact Details:
Sh. A. S. Rawat
Director General
Indian Council of Forestry Research & Education, Dehradun
Ph.: 0135-2759382
Email: dg@icfre.org
Website Link: https://icfre.gov.in/

29. Wildlife Institute of India (WII), Dehradun

Established in 1982, Wildlife Institute of India (WII) is an internationally acclaimed institution, which offers training programmes, academic courses and advisory in wildlife research and management. The Institute is actively engaged in research across the country on biodiversity-related issues.

Ministry/Department: Ministry of Environment, Forest & Climate Change (MoEF&CC), Government of India
Contact Details:
Dr Dhananjai Mohan
Director
Wildlife Institute of India, Dehradun, Uttarakhand
Ph: +91 135-2640910(D)
Email: dwii@wii.gov.in
Website Link: https://www.wii.gov.in/

30. Indian Renewable Energy Development Agency (IREDA), New Delhi

The Indian Renewable Energy Development Agency is a non-banking financial institution under the administrative control of Ministry of New and Renewable Energy (MNRE) for providing term loans for renewable energy and energy efficiency projects.

Ministry/Department: Ministry of New and Renewable Energy (MNRE), Govt. of India
Contact Details:
Shri Pradip Kumar Das
Chairman and Managing Director
Indian Renewable Energy Development Agency (IREDA), New Delhi - 110066
Phone: 91-1124682206-19
Email id: cmd@ireda.in
Website Link: https://www.ireda.in/

31. CSIR-National Institute of Environmental Engineering Research Institute (NEERI), Nagpur

The CSIR-National Environmental Engineering Research Institute (CSIR-NEERI) is a research institute created and funded by the Government of India. It was established at Nagpur in 1958 with focus on water supply, sewage disposal, communicable diseases, and, to some extent, on industrial pollution and occupational diseases commonly found in post-independent India.

NEERI, a pioneer laboratory in the field of environmental science and engineering, is a constituent laboratory of Council of Scientific and Industrial Research (CSIR). It has five zonal laboratories located in Chennai, Delhi, Hyderabad, Kolkata and Mumbai. NEERI comes under the Ministry of Science and Technology (India) of the Central Government, and is an important partner organisation in India's National Implementation Plan (NIP) on tackling Persistent Organic Pollutants (POPs). It is devoted to research and innovations in environmental science and engineering besides solving a range of problems posed by industry, government and public.

Ministry/Department: Council of Scientific and Industrial Research (CSIR), Government of India
Contact Details:
Dr S Chandrasekhar
Director
National Environmental Engineering Research Institute, Nagpur
Phone (Director Office): +91-712-2249999/66
Website Link: https://www.neeri.res.in/#googtrans(en|en)

32. National Institute of Oceanography (CSIR-NIO), Goa

The National Institute of Oceanography (NIO), with its headquarters at Dona Paula in Goa, and regional centres at Kochi, Mumbai and Visakhapatnam, is one of the 37 constituent laboratories of the Council of Scientific & Industrial Research (CSIR), New Delhi.

CSIR-NIO was established on 1 January 1966 following the International Indian Ocean Expedition (IIOE) in the 1960s. The institute has since grown into a multidisciplinary oceanographic research institute of international repute. The principal focus of research has been on observing and understanding special oceanographic characteristics of the Indian Ocean.

Ministry/Department: Council of Scientific and Industrial Research (CSIR), Government of India
Contact Details:
Prof. Sunil Kumar Singh
Director
CSIR-National Institute of Oceanography, Dona Paula, Goa - 403004
Phone (Director Office): +91 8322450500
Email: tmarihal@nio.org
Website Link: https://www.neeri.res.in/#googtrans(en|en)

33. National Institute of Solar Energy (NISE), Gurugram

National Institute of Solar Energy (NISE), an autonomous specialized institute under the Ministry of New and Renewable Energy (MNRE), Govt. of India, is mandated for research and development (R&D), solar component testing and certification, capacity building, and

development of solar products and applications. The technical support of NISE complements the requirements of MNRE to become a self-reliable renewable power producing nation and accept the series of challenges that intervened amidst the implementation of the National Solar Mission (NSM). NISE envisions accelerating the proliferation of the renewable energy sector by intently working together with the Government of India.

Following are the main objectives of NISE:

(i) To function as the National Research Organisation for undertaking and/ or sponsoring Research and Development projects on various aspects of solar energy technologies;

(ii) To act as an apex organisation for testing, certification, development of specification, and standards; and

(iii) To create skilled manpower and offer consultancy services on solar energy technologies.

Ministry/Department: Ministry of New and Renewable Energy (MNRE), Government of India

Contact Details:

Dr Jai Prakash
Director
National Institute of Solar Energy (NISE)
Phone Director Office: +91-124-285-3095
Email: jaiprakash.singh@nise.res.in
Website Link: https://nise.res.in/

34. Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE), Kapurthala

Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIBE), an autonomous specialized institute under the Ministry of New and Renewable Energy (MNRE), Government of India, is a fledgling R&D centre with its mandate to focus on bioenergy and develop innovative technologies in the area of renewables and biofuels. The vision of the Institute is to carry out state-of-the-art R&D covering the entire spectrum of bioenergy leading to commercialization and their integration with other renewable energy technologies.

Ministry/Department: Ministry of New and Renewable Energy (MNRE), Government of India

Contact Details:

Abhishek Gupta
Deputy Director
Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE), Kapurthala
Phone (Director Office): 01822-507404
Email id: abhishek.gupta27@gov.in
Website Link: http://www.nibe.res.in/index.php

35. National Institute of Wind Energy (NIWE), Chennai

The National Institute of Wind Energy (NIWE), an autonomous specialized institute under the Ministry of New and Renewable Energy (MNRE), Government of India, aims at developing

wind energy and helping India achieve self-reliance in the power sector supplementing the core conventional resources. MNRE has been planning and developing the basic infrastructure, institutions, and resources for carrying out research and development (R&D), large-scale demonstration and diffusion of the non-conventional energy sources.

Ministry/Department: Ministry of New and Renewable Energy (MNRE), Government of India
Contact Details:
Dr K Balaraman
Director General
National Institute of Wind Energy (NIWE), Chennai
Phone (Director Office): 044-22463981
Email: dg.niwe@gov.in
Website Link: https://niwe.res.in/index.php

36. Wadia Institute of Himalayan Geology (WIHG), Dehradun

The Wadia Institute of Himalayan Geology, Dehradun is an autonomous research institute of the Department of Science & Technology, Govt. of India. Initially named as the Institute of Himalayan Geology, it was renamed as the Wadia Institute of Himalayan Geology in memory of its founder, the late Prof. D. N. Wadia (Fellow of the Royal Society and National Professor), in appreciation of his contributions to the geology of the Himalayas. During the last quarter century the Institute has grown into a centre of excellence in Himalayan Geology and is recognised as a National Laboratory of international repute with well-equipped laboratories and other infrastructural facilities for undertaking advanced level of research in the country. The institute carries out research towards the development of new concepts and models concerning geodynamic evolution of the Himalayas through an integrated interdisciplinary approach and also co-ordinates research activities amongst different institutions and universities in the country working in the field of Himalayan Geology and related areas.

Ministry/Department: Department of Science & Technology (DST), Govt. of India
Contact Details:
Dr. Kalachand Sain
Director
Wadia Institute of Himalayan Geology (WIHG), 33 GMS Road, Dehradun - 248171
Phone: 91-0135- 2525 100
Email: director@wihg.res.in
Website Link: https://www.wihg.res.in/

37. National Institute of Ocean Technology (NIOT), Chennai

The National Institute of Ocean Technology (NIOT) was established in November 1993 as an autonomous society under the Ministry of Earth Sciences, Government of India. The principal aim of the institute is to develop reliable indigenous technology to solve the various engineering problems associated with harvesting of non-living and living resources in the Indian Exclusive Economic Zone (EEZ), which is about two-thirds of the land area of India.

Ministry/Department: Ministry of Earth Sciences (MoES), Govt. of India

Contact Details:
Dr G A Ramadass
Director
National Institute of Ocean Technology (NIOT), Chennai - 600100, Tamil Nadu
Phone: 91-044-66783300
Email: postmaster@niot.res.in
Website Link: https://www.niot.res.in/niot1/index.php

38. ESSO - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad

ESSO-INCOIS was established as an autonomous body in 1999 under the Ministry of Earth Sciences (MoES) and is a unit of the Earth System Science Organisation (ESSO). ESSO-INCOIS is mandated to provide the best possible ocean information and advisory services to society, industry, government agencies and the scientific community through sustained ocean observations and constant improvements through systematic and focused research.

INCOIS, being the central repository for marine data in the country, receives large real-time oceanographic data from a variety of in-situ and remote sensing observing systems. The Ocean Information Bank provides information on physical, chemical, biological and geological parameters of ocean and coasts on spatial and temporal domains that are vital for both research and operational oceanography.

INCOIS has been designated as the National Oceanographic Data Centre by the International Oceanographic Data Exchange Programme (IODE) of International Oceanographic Commission (IOC). Further, INCOIS serves as the National Argo Data Centre, Regional Argo Data Centre, and also the regional data centre and clearing house for the Indian Ocean region for the IOGOOS Programme.

ESSO-INCOIS has a prominent international presence, being a permanent member of the Indian delegation to IOC of UNESCO and a founding member of the Indian Ocean Global Ocean Observing System (IOGOOS) and the Partnership for Observing the Oceans (POGO) which is actively engaged in capacity building and international exchange of students and researchers. ESSO-INCOIS houses the IOGOOS secretariat and the Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) International Programme Office.

Ministry/Department: Ministry of Earth Sciences (MoES), Govt. of India
Contact Details:
Dr T. Srinivasa Kumar
Director
Indian National Centre for Ocean Information Services (INCOIS), Ocean Valley, Hyderabad
Phone: 91-40-23886000
Email: webmaster@incois.gov.in
Website Link: https://incois.gov.in/portal/index.jsp

39. National Centre for Antarctic and Ocean Research (NCAOR), Goa

The National Centre for Antarctic and Ocean Research (NCAOR) was established as an autonomous Research and Development (R&D) institution of the Ministry of Earth Sciences (formerly Department of Ocean Development), Government of India ,on 25th May 1998.

NCAOR is the nodal agency for planning, promotion, coordination and execution of the entire gamut of polar and southern ocean scientific research in the country as well as for the associated logistics activities. The institution is designated for the co-ordination and implementation of the Indian Antarctic Programme, including the maintenance of India's permanent station in Antarctica.

At NCAOR, the scientific mandate is multidisciplinary. Operating in a complex matrix, it has, as its focal theme, research in those areas of polar science currently not being undertaken by any other institution in India. In a rapid stride, not only have the basic infrastructure and computing facilities been established but also real scientific recognition earned. The Universities of Goa and Mangalore have recognised NCAOR as a research centre for the pursuit of doctoral research.

Ministry/Department: Ministry of Earth Sciences (MoES), Govt. of India
Contact Details:
Dr M. Ravichandran
Director
National Centre for Polar and Ocean Research (NCPOR), Vasco-da-Gama, Goa-403 804
Phone: 91-832-2520876 /2525511
Email: director@ncaor.gov.in, info@ncaor.gov.in
Website Link: https://ncpor.res.in/

40. National Centre for Earth Science Studies (NCESS), Thiruvananthapuram

The National Centre for Earth Science Studies (NCESS) is a premier institute in India that has strong linkages to research and studies related to the Earth System. The major two areas are Earth System Dynamics and Earth Science Applications.

Ministry/Department: Ministry of Earth Sciences (MoES), Govt. of India
Contact Details:
Prof. Jyotiranjan S Ray
Director
National Centre for Earth Science Studies (NCESS), Akkulam, Thiruvananthapuram
Phone: 91-471-2511501
Email: director@ncess.gov.in, jyotiranjan.ray@ncess.gov.in
Website Link: https://www.ncess.gov.in/

41. Indian Institute of Tropical Meteorology (IITM), Pune

The Indian Institute of Tropical Meteorology (IITM) is a premiere research institute to generate scientific knowledge in the field of meteorology and atmospheric sciences that has potential application in various areas such as agriculture, economics, health, water resources, transportation, communications, etc. It functions as a national centre for basic and applied research in monsoon meteorology. The Institute has pride of place in the career of many eminent scientists, globally known for their contributions in Meteorology and Atmospheric Sciences. Prominent amongst them are late Prof. P.R. Pisharoty, late Prof. R. Ananthakrishnan, Prof. G.C. Asnani, Dr R.P. Sarkar, Shri D.R. Sikka, Prof. R.N. Keshavamurthy, Dr R.R. Kelkar, Prof. Jagdish Shukla and Prof. Sulochana Gadgil.

Ministry/Department: Ministry of Earth Sciences (MoES), Govt. of India
Contact Details:
Prof. Ravi Shankar Nanjundiah
Director
Indian Institute of Tropical Meteorology (IITM), Pune 411 008
Phone: 91-20-2590-4200
Email: ravisn@tropmet.res.in
Website Link: https://www.tropmet.res.in/

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FEATURE ARTICLES

Section Guidelines

Air pollution and atmospheric chemistry in different environments of India

Sanitary Waste Related Challenges and its Management

Ecosystem Restoration of Ganga River Basin

Addressing Societal Challenges to Reduce Deforestation in Himalayas using Climate Sensitive Restoration Planning

Study reveals the ill effects of unscientific waste disposal on environmental parameters

Major Ocean Initiatives

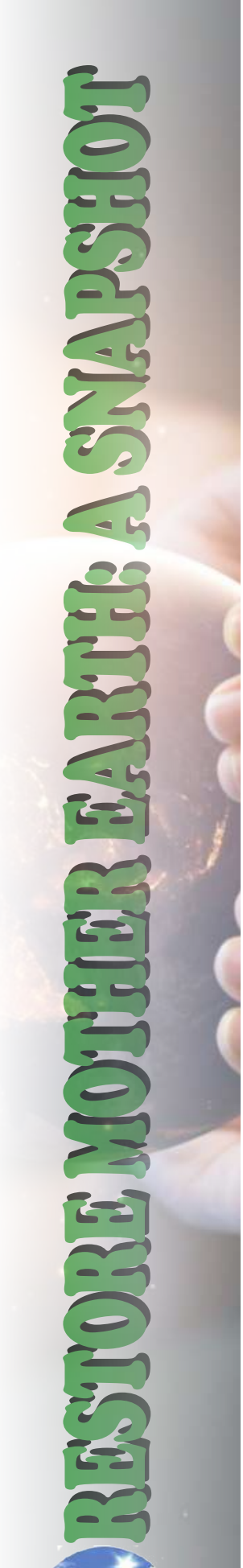
Modern technology and Indian traditional knowledge combine to bring safe & healthy drinking water

Biodegradable yoga mat developed by 6 young girls from Assam may save lakes from water hyacinth menace

Integrated Solar Dryer and Pyrolysis pilot plant will help smart cities transform urban organic waste into biochar & energy

New electronic nose with biodegradable polymer and monomer can detect hydrogen sulphide from sewers

New material found can efficiently convert waste heat to electricity to power small home equipment & vehicles



Study shows significant reduction of heavy metal pollution during COVID-19 pandemic

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Scientists develop gold microstructure substrate with tunable wettability useful in water transportation & self-cleaning

New technology can make power generation from waste steam more efficient

Demystified transformation of glass to crystal that helps in dispose of liquid nuclear waste

Aerosols in Indo-Gangetic Plain enhanced high rainfall near the Himalayan foothills

Exploring Himalayan geological dynamics, natural hazards, climate variability, and natural resources

Desalination membranes using graphene oxide liquid crystals may soon help bring down costs of clean water access

Geological structure that triggers large concentration of micro and moderate earthquake near Kumaon Himalaya

Air pollution and atmospheric chemistry in different environments of India

Kirpa Ram

Institute of Environment and Sustainable Development

Banaras Hindu University, Varanasi

Email: kirpa81@gmail.com, ram.iesd@bhu.ac.in

Air pollution, both of particulate and gaseous nature, has emerged as a serious environmental problem and concern of the century with severe health consequences as well as societal, economic and climate impacts. Air pollution has impacted Asian countries the most as they are facing challenges in the technological advancement and, at the same time, a rapid increase in population has led to a burgeoning demand for food and energy. The urbanisation and industrial development have raised the demand of more energy from fossil fuels which, in turn, has led to an increase in emission of atmospheric gaseous pollutants such as NO_x, SO_2 and CO as well as particulate matter concentrations in the atmosphere.

Atmospheric aerosols, particularly carbonaceous aerosols, over South and South East Asia have been a subject of extensive research over the past two decades because of their potential impact on the regional air quality, climate and hydrological cycle[1-4]. Atmospheric aerosol is, so far, very well known to have vast impacts on atmospheric chemistry, biogeochemistry, radiative forcing and cloud formation. However, the extent of their impacts is highly dependent on their spatio-temporal variability and composition.

This article provides an overview of datasets on chemical characterization (primary as well as secondary aerosols) and their impact on aerosol and rainwater chemistry as well as optical properties over India, and particulate over the Indo-Gangetic plain and adjoining areas.

Carbonaceous aerosols: Chemical characterization, source apportionment and optical properties over India

Carbonaceous aerosols, consisting of organic carbon (OC) and elemental carbon (EC, also referred as black carbon; BC), are the major components of atmospheric particulate matter (PM) and constitute ~30–70% of the fine aerosol mass over urban atmospheres of India[5-8]. Carbonaceous aerosols, originating from a variety of anthropogenic emission sources (vehicular exhaust, biomass burning and fossil fuel emissions) are gaining considerable importance because of their potential impact on regional air quality, atmospheric chemistry and climate[2,9-12]. The measurements of aerosol chemical composition are crucial for improving the model parameterizations for air quality, visibility pattern, and to assess sources of these health-afflicting aerosols. There have been several researches on physico-chemical and optical properties of aerosols over India to understand the complex interaction between aerosols-chemistry-optical properties and climate. For example, the Indian Space Research Organisation-Geosphere

Biosphere Programme (ISRO-GBP) conducted two major land campaigns over different parts of India. The first land campaign (LC-I) was conducted over the peninsular western India during February–March 2004[13]. The second land campaign (LC-I) was dedicated to study aerosol composition and optical properties during 1st to 31st December 2004, which included seven different sampling locations representing urban (Hisar, Delhi, Agra, Allahabad and Kharagpur), rural (Jaduguda) and a high altitude site (Manora Peak) of northern India. These studies have provided a decent amount of data on chemical, optical and physical properties though were limited to smaller samplings[14-25]. Apart from such land campaign studies, several Indian researchers have independently provided data sets pertaining to either chemical[5,6,26-31] or optical properties32-38 of aerosols over different parts of India. However, a complete characterization and data of physico-chemical and optical properties of aerosols are still lacking for entire India.

Secondary aerosols formation and its impact on Fog-haze formation

The fog/haze formation over the entire stretch of Indo-Gangetic Plan (IGP) and the Bay of Bengal (BoB) is a classic example of the manifestation and complex interplay between emission, atmospheric chemistry and meteorology, especially during wintertime. However, whether it is a result of manifestation of atmospheric chemistry, mainly secondary aerosol formation, leading to foggy/hazy condition or vice-versa, is not very well known. This is mainly due to the wide range of temporal scale variability (a few seconds to few hours or day) of secondary organic aerosol (SOA) formation and other relevant atmospheric chemical/physical processes. However, detailed and long-term studies of the phenomenon over India are lacking and, thus, are highly recommended not only for better source apportionment but also to reduce the gap between measurements and modelling studies of SOAs.

A significant fraction of organic aerosol (OA) can also be derived from secondary formation in the atmosphere (referred to as secondary organic aerosol; SOA). Most of the SOAs are soluble in water (referred to as water-soluble OC, WSOC) and thus, WSOC/OC ratios have been often used for understanding SOA formation[28]. The formation mechanism, the aging of organic aerosols and their hygroscopicity during the transport depends on the amount of volatile organic compounds (VOCs) and oxidizing species (O_3, OH, NO_x radicals) at a given location[39,40]. Thus, measurements of VOCs and oxidizing species, low molecular weight carboxylic acids (C2–C6) can provide an insight for the evolution of organic aerosols over Indian regions[41,42].

The measurements of aerosol chemical composition by an aerosol mass spectrometer (AMS) can provide the information on the degree of oxygenation and secondary organic aerosol (SOA) formation. In absence of AMS data, we rely on the filter-based measurements of chemical composition and WSOC in bulk- and/or size-segregated fractions[27-29]. Therefore, future investigations on the emission inventories of POA and SOA, and the measurements of poly-aromatic hydrocarbon (PAHs) would be required to constrain the organic aerosol budget from the South Asian region.

Atmospheric Humic-Like substances (HULIS) and Brown Carbon (BrC)

Atmospheric humic-like substances (HULIS) are a class of macromolecular organic compounds prevalent in diverse environmental media (e.g., aerosol, rainwater, cloud water), which have been recognized as the main component of BrC[43-45]. The atmospheric HULIS can be easily

isolated from the aerosols and considered as the surrogate of water-soluble BrC[46]. During the past few years, researches regarding the atmospheric HULIS have been carried out globally, e.g., in the Amazon basin where large-scale forests are distributed[47] in the urban and rural environment with intensive anthropogenic activities[48,49], and even in the marine aerosols and Arctic snowpack[50,51]. Atmospheric HULIS can be emitted directly during the process of biomass burning[47,52]. Biopolymer like cellulose and lignin could thermally breakdown to (semi-) volatile, low molecular weight substances, which could further condense to the higher molecular weight HULIS through the gas-phase reactions[45]. In addition, soil may also contribute to the atmospheric HULIS under certain geographic and meteorological conditions[53].

Besides the primary sources, atmospheric HULIS could also be produced by complex secondary reactions (e.g., heterogeneous and photosensitized reactions) from the anthropogenic or biogenic volatile organic compounds (VOCs)[43,54]. Recent studies have shown that certain types of organic aerosols such as brown carbon (BrC), apart from well-known black carbon (BC), also exert considerable light absorption capability for the solar radiation, particularly at shorter wavelengths. The radiative impact of BrC increases and radiative forcing can be equal to 24% of BC when BrC is deposited on snow and sea ice. However, radiative forcing of BrC strongly depends on its optical properties, which is still poorly understood due to its complicated composition, sources and various formation processes. There are only a few studies on chemical characterization, optical properties and radiative impact of BrC over India[55,56]. The optical properties of BrC are believed to vary in different regions[43], leading to a large gap between the global and regional modeling results. Therefore, it highlights the necessity to conduct more fundamental researches in different geographic areas to study its chemical and optical properties of brown carbon. In addition, the presence of BrC may also have significant impact on the atmospheric chemical processes, because ultraviolet radiation promotes many photochemical reactions in the atmosphere. However, the quantification of BrC/WSOC ratio is still lacking over India and needs to be investigated on a spatio-temporal scale.

Following are the objectives of the proposed research work:

1. Rainwater chemistry over IGP and Himalayas

Wet precipitation is an important and efficient mechanism for the removal of particulate (i.e., aerosols) and gaseous pollutants from the atmosphere. In addition, the chemical composition of rainwater can reveal the sources and interaction processes whereas its deposition on earth's surface can affect the ecosystem, monuments and sub-surface water chemistry. The pH of precipitation revealed its alkaline nature over the Himalayas[57] as well in the IGP and the east coast[58] due the mixture of anthropogenic as well as the natural chemical constituents. Among the ions, HCO_3^- (35%) makes the highest contribution indicating that the rainwater chemistry during summer monsoon over the region was influenced mainly by terrigenous components and transported dust. One of the surprising but an important observation revealed the significant contribution from NH_4^+ in precipitation samples of Varanasi. Although a detailed measurement of NH_3 is still lacking over the IGP, application of fertilizers and animal and human excretions in the immediate vicinity are the potential reasons for high ammonium concentration. The presence of high concentrations of acid neutralizing species, such as Ca_2^+ and NH_4^+, are the likely reason for the absence of acid rain, despite high emissions of NO_x and SO_2 over Indian region. The Principle Component Analysis (PCA) suggests that the SO_4^{2-} and NO_3^- are present in the Himalayan region in rainwater as a salt form and transported from continental polluted side produced from both man-made and natural sources.

2. Air pollution and health

Recent studies have suggested that PM2.5 Oxidative Potential are highly variable within the city[59] as well in different cities[60]. The studies revealed the contributions of city-specific PM2.5 to differential in-vitro Oxidative Stress and Toxicity between Beijing and Guangzhou of China. A recent study concluded that mixture of toxic pollutants such as polyaromatic hydrocarbons (PAHs) and metals in complex environment jointly can produce cumulative effects. However, PAHs contributed approximately twice the share of the PM2.5 mixture effects as metals with Fe, Cu, and Mn as the dominant metals. Therefore, this study would be helpful in assessing the impact of pollutants on human health in the Indo-Gangetic Plain.

Even the air pollution exposure between racial and ethnic communities is found to be very different[61]. The induced toxicity may vary with aerosol size, mixing state and attachment of toxic metals on the surfaces of the particles. Because the toxic metal is externally attached to the surface, it may be readily available and can thus easily move into the body. A recent study also concluded that air pollution was responsible for more deaths than smoking in Europe[62]. Toxicity depends on the aerosol composition and exposure to different species (e.g., BC vs metals in atmospheric dust) can have health effect. PM2.5 aerosols were found to be enriched in Fe and K along with natural crustal elements (e.g., Al, Si, O, Mg, and S) at an urban site in Varanasi[63]. Moreover, the presence of heavy metals (e.g., Pb, Zn) and As in PM2.5, along with other toxic pollutants such as black carbon and PAHs, were noted in PM2.5 over the region. Therefore, the mixture of toxic pollutants, such as PAHs and heavy metals in complex environments, is likely to increase the toxic potential of PM2.5, thus imposing serious effects on human health.

3. Air pollution mitigation and the way forward

The COVID-19 pandemic and the resultant lockdowns imposed during 2020 and 2021 have provided an opportunity to assess the impact of anthropogenic aerosols on the air quality over India. In our recent research, we have found a significant decrease in concentrations of all pollutants, except O3, during lockdown periods (LP)s compared to those in pre-LPs in 2020. The Air Quality Index (AQI) values reduced by ~48 per cent, 42 per cent, 43 per cent, 32 per cent, 24 per cent and 21 per cent over Delhi, Kolkata, Bengaluru, Hyderabad, Mumbai and Chennai, respectively. Notably, the reduction in air pollution is more pronounced over land-locked cities (Delhi, Kolkata, Bengaluru and Hyderabad) compared to the coastal mega cities (Mumbai and Chennai). However, the benefits are temporary as reviving the economy after lockdown may again result in a deteriorated air quality. Although, a significant reduction in concentrations of CO, NO_2, NO_x and SO_2 is observed, an increase in O_3 concentration is observed over most of the study sites during the lockdown 2020. This increase may be attributed to a decrease in the NOx level along with PM concentrations during the lockdown. This suggests that attention should be extended towards adopting efficient mitigation measures to control the emissions of precursors to reactive secondary pollutants while controlling emissions of PM in India. We suggest that a significant improvement in air quality could be expected if strict execution of air quality control measures is implemented in India. A substantial reduction of aerosol concentration during lockdown might paradoxically reduce the percentage of mortalities due to PM exposure in India.

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References

1 Menon, S., Hansen, J., Nazarenko, L. & Luo, Y. Climate effects of black carbon aerosols in China and India. *Science* **297**, 2250-2253 (2002).

2 Ramanathan, V. & Carmichael, G. Global and regional climate changes due to black carbon. *Nature Geosci.,* 221-227 (2008).

3 Ramanathan, V. *et al.* Atmospheric brown clouds: Hemispherical and regional variations in long-range transport, absorption, and radiative forcing. *J. Geophys. Res.* **112, D22S21,** doi:10.1029/2006JD008124 (2007).

4 Bollasina, M. A., Ming, Y. & Ramaswamy, V. Anthropogenic Aerosols and the Weakening of the South Asian Summer Monsoon. *Science* **334,** 502-505, doi:10.1126/science.1204994 (2011).

5 Rajput, P., Sarin, M. & Kundu, S. S. Atmospheric particulate matter (PM2.5), EC, OC, WSOC and PAHs from NE–Himalaya: abundances and chemical characteristics. *Atmospheric Pollution Research* **4,** 214-221 (2013).

6 Ram, K. & Sarin, M. M. Carbonaceous Aerosols over Northern India: Sources and Spatio-temporal variability. *Proceedings of the Indian National Science Academy* **78,** 523-533 (2012).

7 Ram, K. & Sarin, M. M. Atmospheric carbonaceous aerosols from Indo-Gangetic Plain and Central Himalaya: Impact of anthropogenic sources. *Journal of Environmental Management* **148,** 153-163, doi:http://dx.doi.org/10.1016/j.jenvman.2014.08.015 (2015).

8 Rengarajan, R., Sarin, M. M. & Sudheer, A. K. Carbonaceous and inorganic species in atmospheric aerosols during wintertime over urban and high-altitude sites in North India. *J. Geophys. Res.* **112, D21307,** doi:10.1029/2006JD008150 (2007).

9 Ramachandran, S., Rengarajan, R. & Sarin, M. M. Atmospheric carbonaceous aerosols: issues, radiative forcing and climate impacts. *Curr. Sci.* **97,** 18-20 (2009).

10 Ramana, M. V. *et al.* Warming influenced by the ratio of black carbon to sulphate and the black-carbon source. *Nature Geoscience,* 542-545, doi:DOI 10.1038/ngeo918 (2010).

11 Ramanathan, V. et al. Atmospheric brown clouds: Impacts on south Asian climate and hydrological cycle. *Proc. Natl. Acad. Sci. U. S. A.* **102,** 5326– 5333 (2005).

12 Ramanathan, V., Crutzen, P. J., Kiehl, J. T. & Rosenfeld, D. Atmosphere: Aerosols, climate, and the hydrological cycle. *Science* **294,** 2119-2124 (2001).

13 Moorthy, K. K. *et al.* Wintertime spatial characteristics of boundary layer aerosols over peninsular India. *J. Geophys. Res.* **110,** D08207, doi:10.1029/2004JD005520 (2005).

14 Ram, K. & Sarin, M. M. Absorption coefficient and site-specific mass absorption efficiency of elemental carbon in aerosols from urban, rural and high-altitude sites in India. *Environmental Science and Technology* **43,** 8233-8239 (2009).

15 Tare, V. et al. Measurements of atmospheric parameters during Indian Space Research Organization Geosphere Biosphere Program Land Campaign II at a typical location in the Ganga Basin: 2. Chemical properties. *Journal of Geophysical Research D: Atmospheres* **111,** doi:10.1029/2006JD007279 (2006).

16 Nair, V. S. *et al.* Wintertime aerosol characteristics over the Indo-Gangetic Plain (IGP): Impacts of local boundary layer processes and long-range transport. J*ournal of Geophysical Research D: Atmospheres* **112,** doi:10.1029/2006JD008099 (2007).

17 Aloysius, M., Mohan, M., Parameswaran, K., George, S. K. & Nair, P. R. Aerosol transport over the Gangetic basin during ISRO-GBP land campaign-II. *Annales Geophysicae* **26,** 431–440 (2008).

18 Ganguly, D., Jayaraman, A., Rajesh, T. A. & Gadhavi, H. Wintertime aerosol properties during foggy and nonfoggy days over urban center Delhi and their implications for shortwave radiative forcing. *Journal of Geophysical Research D: Atmospheres* **111,** doi:10.1029/2005JD007029 (2006).

19 Niranjan, K., Sreekanth, V., Madhavan, B. L. & Moorthy, K. K. Wintertime aerosol characteristics at a north Indian site Kharagpur in the Indo-Gangetic plains located at

the outflow region into Bay of Bengal. *Journal of Geophsical Research* **111, D24209,** doi:10.1029/2006JD007635 (2006).

20 Pant, P. et al. Aerosol characteristics at a high-altitude location in central Himalayas: Optical properties and radiative forcing. *Journal of Geophysical Research D: Atmospheres* **111,** doi:10.1029/2005JD006768 (2006).

21 Rengarajan, R., Sarin, M. M. & Sudheer, A. K. Carbonaceous and inorganic species in atmospheric aerosols during wintertime over urban and high-altitude sites in North India. *Journal of Geophysical Research D: Atmospheres* **112,** doi:10.1029/2006JD008150 (2007).

22 Tripathi, S. N. et al. Measurements of atmospheric parameters during Indian Space Research Organization Geosphere Biosphere Programme Land Campaign II at a typical location in the Ganga basin: 1. Physical and optical properties. *Journal of Geophysical Research D: Atmospheres* doi:10.1029/2006JD007278 (2006).

23 Ram, K. & Sarin, M. M. Spatio-temporal variability in atmospheric abundances of EC, OC and WSOC over northern India. *Journal of Aerosol Science* **41,** 88-98 (2010).

24 Ramachandran, S., Rengarajan, R., Jayaraman, A., Sarin, M. M. & Das, S. K. Aerosol radiative forcing during clear, hazy, and foggy conditions over a continental polluted location in north India. *Journal of Geophysical Research D: Atmospheres* **111,** doi:10.1029/2006JD007142 (2006).

25 Das, S. K., Jayaraman, A. & Misra, A. Fog-induced variations in aerosol optical and physical properties over the Indo-Gangetic Basin and impact to aerosol radiative forcing. *Annales Geophysicae* **26,** 1345–1354 (2008).

26 Rajput, P. & Sarin, M. M. Polar and non-polar organic aerosols from large-scale agricultural-waste burning emissions in Northern India: Implications to organic mass-to-organic carbon ratio. *Chemosphere,* doi:10.1016/j.chemosphere.2013.11.028 (2014).

27 Ram, K. & Sarin, M. M. Spatio-temporal variability in atmospheric abundances of EC, OC and WSOC over northern India. *J. Aerosol Sci.* **41,** 88-98 (2010).

28 Ram, K. & Sarin, M. M. Day-night variability of EC, OC, WSOC and inorganic ions in urban environment of Indo-Gangetic Plain: Implications to secondary aerosol formation. *Atmos. Environ.* **45,** 460-468, doi:doi: 10.1016/j.atmosenv.2010.09.055 (2011).

29 Ram, K., Sarin, M. M. & Tripathi, S. N. A 1 year record of carbonaceous aerosols from an urban location (Kanpur) in the Indo-Gangetic Plain: Characterization, sources and temporal variability. *J. Geophys. Res.* **115,** D24313, doi:10.1029/2010JD014188 (2010).

30 Rastogi, N. & Sarin, M. M. Long-term characterization of ionic species in aerosols from urban and high-altitude sites in western India: Role of mineral dust and anthropogenic sources. *Atmospheric Environment* **39,** 5541-5554 (2005).

31 Rastogi, N. & Sarin, M. M. Chemistry of aerosols over a semi-arid region: Evidence for acid neutralization by mineral dust. Geophys. *Res. Lett.* **33, L23815,** doi:10.1029/2006GL027708 (2006).

32 Tripathi, S. N., Dey, S., Tare, V. & Satheesh, S. K. Aerosol black carbon radiative forcing at an industrial city in northern India. *Geophys. Res. Lett.* **32, L08802,** doi:10.1029/2005GL022515 (2005).

33 Dey, S. & Tripathi, S. N. Retrieval of black carbon and specific absorption over Kanpur city, northern India during 2001–2003 using AERONET data. *Atmos. Environ.* **40,** 445–456 (2006).

34 Dey, S. & Tripathi, S. N. Estimation of aerosol optical properties and radiative effects in the Ganga basin, northern India, during the wintertime. *J. Geophys. Res.* **112, D03203,** doi:10.1029/2006JD007267 (2007).

35 Dey, S. & Tripathi, S. N. Aerosol direct radiative effects over Kanpur in the Indo-Gangetic basin, northern India: Long-term (2001–2005) observations and implications to regional climate. *J. Geophys. Res.* **113, D04212,** doi:10.1029/2007JD009029 (2008).

36 Dey, S., Tripathi, S. N. & Mishra, S. K. Probable mixing state of aerosols in the Indo-Gangetic Basin, northern India. *Geophys. Res. Lett.* **35, L03808,** doi:10.1029/2007GL032622 (2008).

37 Mishra, S. K., Dey, S. & Tripathi, S. N. Implications of particle composition and shape to dust radiative effect: A case study from the Great Indian Desert. *Geophys. Res. Lett.* **35, L23814,** doi:10.1029/2008GL036058 (2008).
38 Mishra, S. K. & Tripathi, S. N. Modeling optical properties of mineral dust over the Indian Desert. *J. Geophys. Res.* **113, D23201,** doi:10.1029/2008JD010048 (2008).
39 Jimenez, J. L. *et al.* Evolution of Organic Aerosols in the Atmosphere. *Science* **325,** 1525-1529, DOI: 1510.1126/science.1180353 (2009).
40 Zhang, Q. *et al.* Ubiquity and dominance of oxygenated species in organic aerosols in anthropogenically-influenced Northern Hemisphere midlatitudes. Geophys. *Res. Lett.* **34,** L13801, doi:10.1029/2007GL029979 (2007).
41 Agarwal, S., Aggarwal, S. G., Okuzawa, K. & Kawamura, K. Size distributions of dicarboxylic acids, ketoacids, -dicarbonyls, sugars, WSOC, OC, EC and inorganic ions in atmospheric particles over Northern Japan: implication for long-range transport of Siberian biomass burning and East Asian polluted aerosols. *Atmos. Chem. Phys. 10,* 5839–5858 (2010).
42 Miyazaki, Y., Aggarwal, S. G., Singh, K., Gupta, P. K. & Kawamura, K. Dicarboxylic acids and water-soluble organic carbon in aerosols in New Delhi, India in winter: Characteristics and formation processes. *J. Geophys. Res.* **114,** D19206, doi:10.1029/2007JD009116 (2009).
43 Laskin, A., Laskin, J. & Nizkorodov, S. A. Chemistry of atmospheric brown carbon. *Chemical Reviews* **115,** 4335-4382, doi:10.1021/cr5006167 (2015).
44 Andreae, M. & Gelencsér, A. Black carbon or brown carbon? The nature of light-absorbing carbonaceous aerosols. *Atmospheric Chemistry and Physics* **6,** 3131-3148 (2006).
45 Zheng, G., He, K., Duan, F., Cheng, Y. & Ma, Y. Measurement of humic-like substances in aerosols: A review. *Environmental Pollution* **181,** 301-314, doi:10.1016/j.envpol.2013.05.055 (2013).
46 Graber, E. R. & Rudich, Y. Atmospheric HULIS: How humic-like are they? A comprehensive and critical review. *Atmospheric Chemistry and Physics* **6,** 729-753 (2006).
47 Hoffer, A. *et al.* Optical properties of humic-like substances (HULIS) in biomass-burning aerosols. *Atmospheric Chemistry and Physics* **6,** 3563-3570 (2006).
48 Baduel, C., Voisin, D. & Jaffrezo, J. L. Seasonal variations of concentrations and optical properties of water soluble HULIS collected in urban environments. *Atmospheric Chemistry and Physics* **10,** 4085-4095, doi:10.5194/acp-10-4085-2010 (2010).
49 Lin, P., Huang, X.-F., He, L.-Y. & Yu, J. Z. Abundance and size distribution of HULIS in ambient aerosols at a rural site in South China. *Journal of Aerosol Science* **41,** 74-87, doi:10.1016/j.jaerosci.2009.09.001 (2010).
50 Krivacsy, Z. et al. Study of water-soluble atmospheric humic matter in urban and marine environments. *Atmospheric Research* **87,** 1-12, doi:10.1016/j.atmosres.2007.04.005 (2008).
51 Voisin, D. *et al.* Carbonaceous species and humic like substances (HULIS) in Arctic snowpack during OASIS field campaign in Barrow. *Journal of Geophysical Research-Atmospheres* **117,** doi:10.1029/2011jd016612 (2012).
52 Lin, P., Engling, G. & Yu, J. Z. Humic-like substances in fresh emissions of rice straw burning and in ambient aerosols in the Pearl River Delta Region, China. *Atmospheric Chemistry and Physics* **10,** 6487-6500, doi:10.5194/acp-10-6487-2010 (2010).
53 Gelencser, A. et al. On the possible origin of humic matter in fine continental aerosol. *Journal of Geophysical Research-Atmospheres* **107,** doi:10.1029/2001jd001299 (2002).
54 Chang, J. L. & Thompson, J. E. Characterization of colored products formed during irradiation of aqueous solutions containing H_2O_2 and phenolic compounds. *Atmospheric Environment* **44,** 541-551 (2010).
55 Shamjad, P. M., Tripathi, S. N., Thamban, N. M. & Vreeland, H. Refractive Index and Absorption Attribution of Highly Absorbing Brown Carbon Aerosols from an Urban Indian City-Kanpur. *Scientific Reports* **6,** 37735, doi:10.1038/srep37735 http://www.nature.com/articles/srep37735#supplementary-information (2016).

56 Satish, R., Shamjad, P. M., Navneeth, T., Tripathi, S. N. & Rastogi, N. Temporal characteristics of Brown Carbon over the central Indo-Gangetic Plain. *Environ. Sci. Tech.,* doi:10.1021/acs.est.7b00734300295v (2017).

57 Bisht, D. S. *et al.* Chemical characterization of rainwater at a high-altitude site "Nainital" in the central Himalayas, India. *Environmental Science and Pollution Research* **24,** 3959-3969, doi:10.1007/s11356-016-8093-z (2017).

58 Tripathy, G. R., Mishra, S., Danish, M. & Ram, K. Elevated Barium concentrations in rain water from east-coast of India: role of regional lithology. *Journal of Atmospheric Chemistry* **76,** 59-72 (2019).

59 Weichenthal, S. *et al.* Within-City Spatial Variations in Multiple Measures of PM2.5 Oxidative Potential in Toronto, Canada. *Environmental Science & Technology* **53,** 2799-2810, doi:10.1021/acs.est.8b05543 (2019).

60 Jin, L. *et al.* Contributions of City-Specific Fine Particulate Matter (PM2.5) to Differential In Vitro Oxidative Stress and Toxicity Implications between Beijing and Guangzhou of China. *Environmental Science & Technology* **53,** 2881-2891, doi:10.1021/acs.est.9b00449 (2019).

61 Tessum, C. W. *et al.* Inequity in consumption of goods and services adds to racial–ethnic disparities in air pollution exposure. *Proceedings of the National Academy of Sciences,* 201818859, doi:10.1073/pnas.1818859116 (2019).

62 Raz, R. *et al.* Autism Spectrum Disorder and Particulate Matter Air Pollution before, during, and after Pregnancy: A Nested Case–Control Analysis within the Nurses' Health Study II Cohort. *Environmental Health Perspectives* **123,** 264-270, doi:10.1289/ehp.1408133 (2015).

63 Mehra, M., Zirzow, F., Ram, K. & Norra, S. Geochemistry of PM2.5 aerosols at an urban site, Varanasi, in the Eastern Indo-Gangetic Plain during pre-monsoon season. *Atmospheric Research* **234,** 104734, doi:https://doi.org/10.1016/j.atmosres.2019.104734 (2020).

Sanitary Waste Related Challenges and its Management

Dr. Nitin Labhsetwar

Sr. Scientist,

CSIR- NEERI, Nagpur

Email: nk_labhsetwar@neeri.res.in

Menstruation is a normal physiological phenomenon that women and adolescent girls experience every month. Hygienic management of menstruation is associated with the dignity and wellbeing of women and is the primary pillar of sanitation, hygiene and reproductive health. It may sound shocking but, unfortunately, it is considered as taboo in many societies even in the 21st century.

Restricting women from visiting religious places and barring other activities like cooking and eating certain foods are usually slapped on them during menstruation, more as perpetuation of outdated social practices but without any scientific validation. Due to social pressure, many girls opt to skip schools until the completion of periods because of lack of menstrual hygiene resources. In fact, there are several schools where separate toilets for girls are non-existent or are in a state of negligence. Such social stigma is a major stumbling block in achieving the lofty objective of gender equality and also affects the overall development of society.

With rapid urbanization, product availability and distribution, access to various options, increased mobility, awareness about menstrual hygiene, and consistent efforts from governments, the use of disposable sanitary napkins is growing rapidly. According to a recent study, 44,254 cm3 per female/year is the annual generation load of disposable sanitary napkins, which is often higher than any other hygiene product. It is estimated that 121 million women and adolescent girls use on average eight sanitary napkins every month in India; annually, this number shoots to 113,000 tons of menstrual waste generated. The generation of such high quantity sanitary pad waste creates stress on the waste management sector and poses a challenge for its safe disposal. Sanitary waste management with conventional tool and techniques may pose an immense threat to the land, water bodies, and human health.

Therefore, it is extremely necessary to promote the usage of sanitary napkins and avoid the risk resulting from the unscientific dumping of used sanitary waste in landfills and elsewhere. Better access to socially and culturally acceptable sanitary waste management facilities improves environmental sustainability and enables women and girls to fully engage in education and the workforce. The usual soiled sanitary pad disposal practice includes mixing with common garbage bins. The waste collector needs to segregate the menstrual

waste from the rest solid waste, which is difficult, time-consuming and challenging. Therefore, at community levels, disposal techniques that are on-site, quick, safe and hygienic need to be prioritised.

Controlled decentralized incineration of soiled sanitary pads is the proven technique and it has marked its presence in many commercially available decentralized incinerators. Controlled incineration helps destroy the pathogens and pad material, and aids in overall sanitary waste management without which sanitary pads either get mixed with municipal solid waste or landfilled. The incinerators are the most favoured options at community levels; however, they are usually recognized for their poor performance, energy-intensive operation, toxic fumes generation from burning of plastics (e.g., furans and dioxins), costly and heavy in maintenance.

Based on the market research, there are limited incinerators that comply with the environmental guidelines. The available sanitary pad incinerators mostly perform subpar when it comes to achieving desired combustion chamber temperature and emission norms. Keeping in mind the voluminous sanitary waste generation, disposal and need of better designs of conventional incinerators, CSIR-NEERI, Sowball Aerothermics, Secunderabad, and International Advanced Research Centre for Powder Metallurgy and New Materials, Hyderabad came up with *GreenDispo,* an improved eco-friendly and energy-efficient electric sanitary pad incinerator.

GreenDispo: An Eco-friendly and Efficient Incinerator

An improved sanitary pad incinerator, "GreenDispo" is designed and developed with innovation in combustion chamber, ensuring instant and hygienic disposal of menstrual wastes in an automatic way, with auto power and thermal cut-off and is suitably insulated for energy conservation and user safety. Unlike many other incinerators operating at around 300-400°C resulting in harmful air emissions, GreenDispo has a primary and a secondary combustion chamber (optionally), which operates at 800 ± 50 °C and 950 ± 50 °C, respectively, with 2 seconds of gases residence time to help reduce carcinogenic air emissions, produced during the burning of plastics/chlorinated products. The unit can efficiently burn pads with high moisture content and super absorbent polymers (SAP). The exhaust concentration of Total Particulate Matter (TPM), CO, SO_2, and NOx was observed to be 48.37 ± 8.7 mg/m^3, 62.46 ± 8.10 mg/m^3, 38.18 ± 1.08 mg/m^3, 1.08 ± 0.44 mg/m^3, respectively, with less than 5% ash per napkin, meeting standards under Waste Management Rules, 2016 (CPCB).

The exclusiveness of GreenDispo in terms of desired combustion temperature and emissions in line with the recommended value has generated excellent market, especially from responsible buyers, governments and other agencies. Development of such an incinerator is an excellent example of what can come out from judicious collaborations not only between two government R&D institutions, but also among the industry. This will promote the indigenous capabilities and potential available, thereby creating employment generation opportunities.

GreenDispo comes in Mini, Midi and Maxi sizes based on capacity of pads and combustion chamber volume.

GreenDispo - Midi

Salient Features

Ensures used sanitary pads disposal in a scientific and hygienic way

Energy-efficient heaters and innovative design of combustion chamber

Incinerates used sanitary pads at a temperature more than 800 °C

Optimized A/F ratio and heating cycles

Efficiently burns unbleached pads with high cellulose and super absorbent polymers (SAP)

Exhaust emissions comply with Bio-medical Waste (BMW) Management Rules, 2016

Eliminates Dioxin and Furan during combustion

Ash collected in separate tray with < 5% ash generated per napkin

Auto power and thermal cut-off and automatic temperature control

Suitably insulated with safe device surface temperatures

Easy to operate and with low maintenance

Beneficiaries

Schools and institutions

Community toilets

Girls' hostels
Industries and Offices
Metro/Railway Stations
Convention Centres
Public Health Centres (PHCs)

Dissemination

Over 1,000 units covering different states/cities.

Users and supporters include the Madhya Pradesh government, Ministry of Human Resource Development (MHRD), All India Council for Technical Education (AICTE) institutions, UNDP, WaterAID and several other reputed agencies.

Ecosystem Restoration of Ganga River Basin

Peeyush Gupta

Real Time Information Specialist, National Mission for Clean Ganga,

Ministry of Jal Shakti, Government of India

Email: peeyush.gupta@nmcg.nic.in

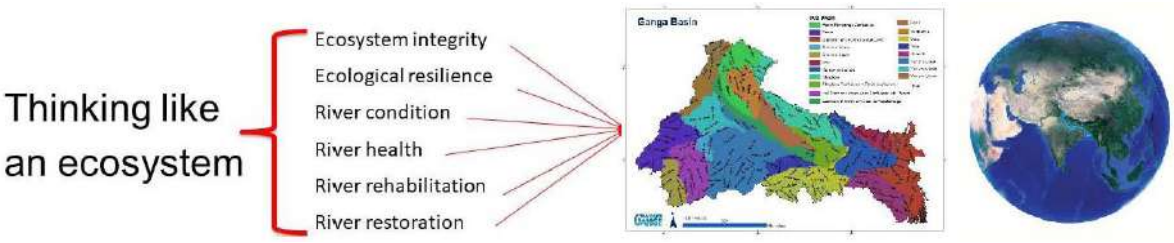
World Environment Day

In 1972, the UN General Assembly designated **5th June** as **World Environment Day.** The first celebration, under the slogan **"Only One Earth"** took place in **1974.** In the following years, WED has developed as a platform to raise awareness on the problems facing our environment such as water pollution, air pollution, plastic pollution, illegal wildlife trade, sustainable consumption, sea-level increase, and food security, among others. Furthermore, WED helps drive change in consumption patterns and in national and international environmental policy. The theme for **World Environment Day 2021** is "Ecosystem Restoration".

Ecosystem Restoration

Ecosystem restoration means assisting in the recovery of ecosystems that have been degraded or destroyed, as well as conserving the ecosystems that are still intact. Healthier ecosystems, with richer biodiversity, yield greater benefits such as more fertile soils, bigger yields of timber and fish, and larger stores of greenhouse gases. Restoration can happen in many ways – for example through actively planting or by removing pressures so that nature can recover on its own. It is not always possible – or desirable – to return an ecosystem to its original state. We still need farmland and infrastructure on land that was once forest, for instance, and ecosystems, like societies, need to adapt to a changing climate. Between now and 2030, the restoration of 350 million hectares of degraded terrestrial and aquatic ecosystems could generate US$9 trillion in ecosystem services. Restoration could also remove 13 to 26 gigatons of greenhouse gases from the atmosphere. The economic benefits of such interventions exceed nine times the cost of investment, whereas inaction is at least three times more costly than ecosystem restoration. All kinds of ecosystems can be restored, including river ecosystem, forests, farmlands, cities, wetlands and oceans.

Significant loss of species biodiversity in the Ganga river network has been observed over the past many decades, with many important aquatic species (fishes, dolphins, ghariyals, turtles, etc.) having dwindled or disappeared from river stretches in recent history. Now, a river ecosystem – with its intrinsic biodiversity – plays a crucial role in the functional health of the river basin and the ecosystem services provided by the river. To grasp the biodiversity changes in National River Ganga and devise suitable means to restore her ecological balance, it is necessary to understand the dynamics of the Ganga river ecosystem and assess the possible anthropogenic and non-anthropogenic factors affecting it. Broadly, an ecosystem is a com-

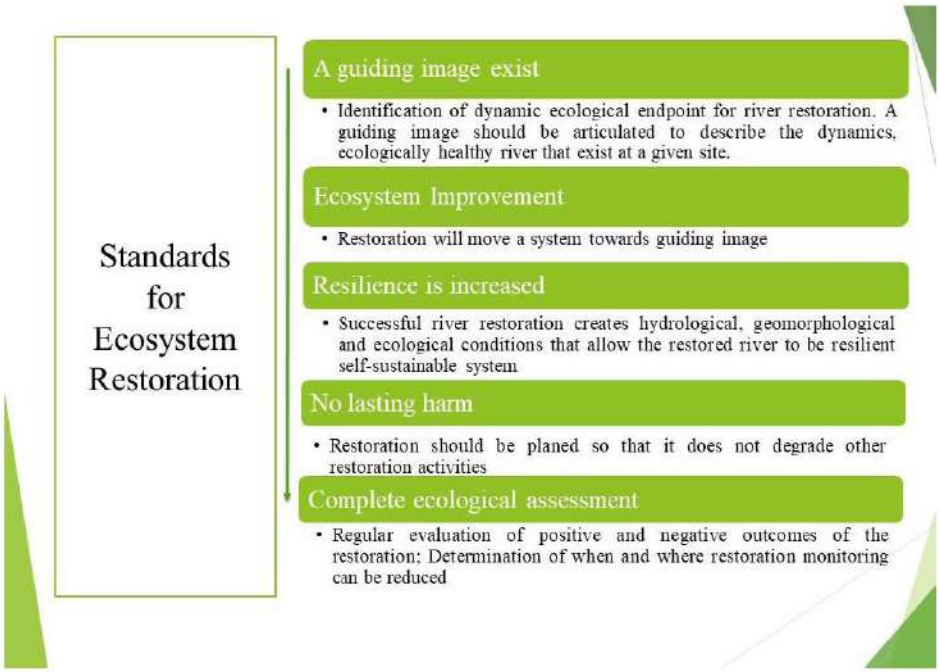


munity of living organisms (plants, animals and microbes) in conjunction and interacting with non-living components of their environment. The biotic and abiotic components are linked together through nutrient cycles and energy flows: energy and carbon enter the ecosystems through photosynthesis, while mineral nutrients are mostly recycled within the ecosystems. Now ecosystems are controlled both by external factors (or "state factors, such as climate underlying geological material, topography and time) and internal factors (such as decomposition, periodic disturbances, species competition and human activities). Since ecosystem processes are driven by the types and number of species in an ecosystem and the relative abundance of organisms within these species, hence species biodiversity plays an important role in ecosystem functioning. In general, ecosystems can be assessed either in terms of the services (or goods and services) they provide to humans, or in terms of "ecosystem structure" (i.e. measureable attributes of a least impacted or reference state of the ecosystem). The Ganga river being a diverse landscape-scale ecosystem. To start with, the river traverses three distinct climatic-geographical zones from the snow-clad and alpine Himalayan reaches to the tropical alluvial plains until she enters the estuarine zone and meets the sea. Ecologically, the diversity of the basin within each climatic zone plays an overarching role on River Ganga. For while a river's ecosystem boundary may be nominally demarcated by the river banks, there are varying degrees of (but often close) biotic and abiotic interactions of the river with her riparian zones, flood plains and drainage basin. The saturated sub-surface zone under the river bed also forms a unique habitat (termed "hyporheic biotope") for a diverse group of fauna, which also provides temporary refuge for aquatic organisms in times of adversity and plays an important role in the processing of river nutrients and interacting with groundwater. National River Ganga and her tributaries are home to a wide variety of aquatic organisms (from microscopic flora and fauna to higher invertebrates and vertebrates) and visited periodically by many other creatures from far and near.

Criteria for measuring success of eco-restoration steps referred to as standards for ecological successful river restoration

Role and Impact of Riparian Vegetation in Ecosystem restoration

Riparian ecosystem is a connecting link between stream environment and terrestrial catchment. Riparian forest is an area of trees accompanied by shrubs and herbs that is adjacent to the water body. It influences the structure of both aquatic and upland terrestrial communities. The components influenced by riparian ecosystem are modifying storage capacity and aquifer recharge, in-channel primary and secondary productivity, organic matter quality and quantity, biodiversity and migratory patterns, and biogeochemical pathways and rates. Riparian flora also helps in trapping pollution, filtering and converting sediments, nutrients and



Standards for Ecosystem Restoration

other chemicals. They absorb periodic flood fluxes and supply food cover and thermal protection to biota. Ecological buffers that are important to riparian ecosystem. Ecological buffers are as predominance of wood plant community, presence of surface water and abundant soil moisture, diversity interspersion of habitat features, & Corridor for dispersal and migration. Riparian ecosystem has many functional characteristics. They are highly productive because of convergence of energy and material, and unique hydrological conditions. Degradation of riparian zones and streams diminishes their capacity to provide critical ecosystem functions, including the cycling and chemical transformation of nutrients, purification of water, attenuation of floods, maintenance of stream flows and stream temperatures, recharging of groundwater, and establishment and maintenance of habitats for fish and wildlife.

Threats to Biodiversity of National River Ganga

The riverine ecosystem has been exploited for meeting human needs. Major threats to the Ganga basin as well as other river basins in the country affecting/disturbing ecological integrity.

1. **Habitat Fragmentation & Changes in the Flow Regime:** The flow patterns in the river Ganga have been altered due to number of run-of-the-river (ROR) hydro-electric projects in the head streams. These hydro-electric projects have fragmented the river and obliterated the migration routes of some important fishes viz., Schizothorax sp. and Tor sp. It is necessary to ensure longitudinal connectivity – along with adequate water and sediment flows – throughout the Ganga river network.

2. **Habitat Alteration:** In addition to changes in the flow regime, the river morphology and habitat are also altered steadily. Large scale gravel and sand mining, dumping of construction wastes and other solid wastes have lead to changes in flow direction causing erosion, channelization and river realignment. This reduces stream width, altering flood plains

and riparian vegetation. The ecology is seriously impaired with changes in habitat. The alteration in habitat, changes benthic flora and fauna, fish breeding sites and egg laying sites, for soft and hard shell turtles.

3. Habitat Shrinkage: Large anthropogenic water abstractions are being effected from the Ganga River Network all over the basin, thereby considerably shrinking the aquatic space of river species. Many of the dams and barrages on the rivers are used to divert river flows. River water abstractions are generally high during lean flow seasons but low (or nil) during the wet seasons. This results in the river channel carrying extremely low flows during the dry season but with the original high flows of the wet season almost intact. In fact, peak runoff rates from the basin into the rivers may have increased in many places due to urbanization and land-use changes over the past one or two centuries, thereby increasing the river flood peaks from their earlier levels. Overall, the extremes of the river's natural hydrological regime have certainly accentuated, thus exerting considerable further survival pressures on the biota.

4. Habitat Pollution: Pollution from domestic and industrial wastes is extensive in the Ganga river downstream of Haridwar, and it assumes alarming proportions below Kannauj (after the confluence of Ramganga and Kali rivers) at least up to Varanasi. High levels of pollutants in the river have fatal effects on river biota.

5. Habitat Invasion by Alien Species: Exotic species of fish especially common carp Cyprinus carpio and Tilapia Oreochromis niloticus have invaded Ganga water downstream of Prayagraj. These fishes have gained access through water of Yamuna at Sangam. Downstream Prayagraj up to Bhagalpur and beyond they have grown in large numbers. They compete with Indian Major Carps (IMC) and have out grown them due to their adaptability in variable flows. Seven species of exotic fish have been reported in river Ganga including Thai magur, (Clarias gariepinus) and Grass carp (Ctenopharyngodon idella). But it is not only the middle and lower reaches that have been invaded. The sighting of another exotic fish – the brown trout (Salmo trutta fario) downstream of Jhala – is an important signal of the presence of invasive species reaching up to Bhagirathi. Now, invasion of ecosystems by alien species can occur only after their introduction into the ecosystem, which is often anthropogenic. But, even after their introduction, alien species have to out-compete the native species in the ecosystem. Often, this competitive advantage in river ecosystems accrues from manmade changes in rivers to which indigenous species are not well adapted. Habitat invasion of the Ganga River Network by alien species is also essentially of anthropogenic origin. The adverse consequences of such invasions include the propagation of new diseases and parasitic organisms, and disruption of the river's ecological balance. It is, therefore, imperative that exotic species that have invaded the river network be eliminated and appropriate control measures be devised against introduction of any new alien species.

6. Habitat Encroachment: Human beings have been encroaching upon rivers since long ago especially by occupying much of the flood plains and parts of river banks for various purposes. In modern times, however, the encroachments have become extensive with widespread construction activities on floodplains and even farming on river beds during lean flow seasons. On the one hand, the increased constructions on flood plains have led to altered runoff patterns into rivers, increased pollution inflows with runoff, reduced groundwater recharge and, hence, decreased base flows in rivers, and curtailed ecological linkages between the river, its floodplains, and floodplain wetlands. On the other hand, river bed farming

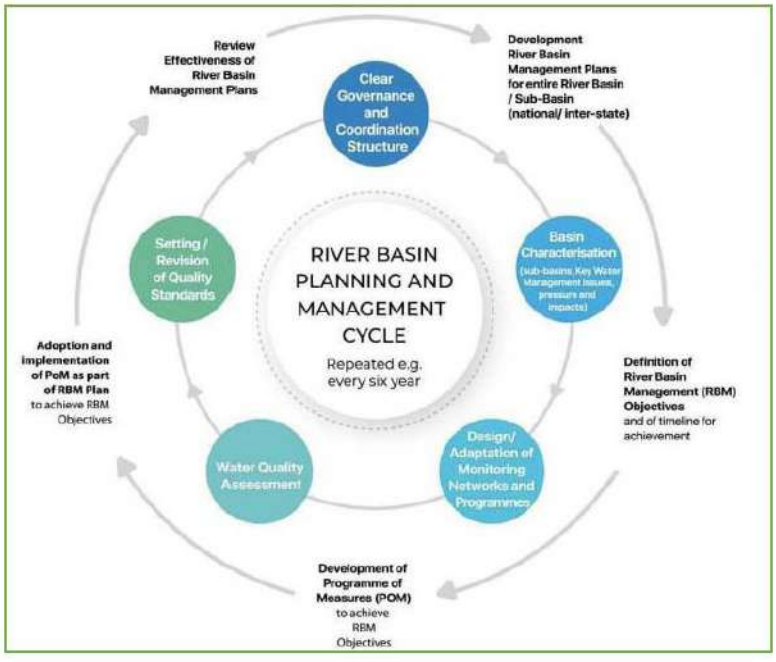
together with modern chemical pesticides such as DDT and HCH, have polluted the river bed, thus affecting the health of aquatic creatures, especially the hyporheic biota, and disturbing the breeding sites of higher aquatic animals.

7. Habitat Disturbances: Frequent disturbance of the Ganga river habitat by humans has received little attention, but this is a definitive threat to riverine creatures. In particular, dredging and plying of noisy ships, especially in the Hooghly river stretch of the lower Ganga, have evidently affected major aquatic animals such as the Gangetic dolphin so significantly that they have vanished from these reaches. With the possibility of commercial navigation in much of the Middle and Lower Ganga stretches in future, the issue is of considerable importance.

8. Habitat Malnutrition: While anthropogenic pollution or increase of harmful substances in the Ganga river habitat is a matter of grave concern, the reverse phenomenon of anthropogenic nutrient deprivation in the river has received little attention. The general notion of anthropogenic effects on nutrient concentrations in rivers is that of nutrient enrichment, i.e. increased concentrations of nitrogen (N), phosphorous (P) and other nutritional elements commonly present in agricultural, domestic and industrial wastewaters. But the opposite phenomenon of nutrient depletion is often overlooked.

Ecosystem Restoration Measures under Namami Gange

Namami Gange programme, implemented by National Mission for Clean Ganga (NMCG) is an integrated mission for conservation of Ganga and its tributaries. NMCG's vision is to restore the wholesomeness of the River by ensuring Aviral and Nirmal Dhara, and maintaining its geo-hydrological and ecological integrity. The holistic approach and innovative features in policy making, project management, financial planning, sustainability of investment, scientific research, knowledge management, institutional development, basin management and



River basin planning management cycle

planning has helped Namami Gange program to evolve as a pioneering river rejuvenation programme. One of the bottlenecks for a comprehensive planning for a river rejuvenation is the lack of scientific data, which requires detailed research studies. To overcome these issues, NMCG has sanctioned different research projects touching different aspects of river rejuvenation using basin approach. These research projects cover the historical part, cultural part, Ecological part as well as scientific and technological part.

NMCG is ensuring several activities as restoration of longitudinal connectivity along with E-flows across dams/ barrages; maintenance of lateral connectivity across floodplains; restoration of unpolluted river flows; restrictions on river bed farming, gravel and sand mining, plying of vessels, dredging, and bed and bank modifications; control of alien species invasions, overfishing and fishing during spawning seasons; river nutrient assessment and release of dammed sediments into the river; bio-monitoring of Ganga river network etc. NMCG is leading to the development of Arth Ganga model linking economic development of Ganga Basin with ecological improvement and Ganga Rejuvenation. The nature has capacity to rejuvenate itself if human interventions are controlled and the same was witnessed during the national lockdown period. The lesson to be learnt is that we need to have a better enforcement and also keep working for behavioural change as everything cannot be achieved by regulatory approach only. People's participation is key to transformation. Sustainable development increasingly depends upon successful management of urban growth and water resources. Ganga Rejuvenation is critical for implementation of 2030 agenda of Sustainable Development Goals (SDGs). Namami Gange has developed a framework for river rejuvenation which is now being followed for several rivers beyond Ganga basin.

Ganga is in the heart of millions who have been drawn to it since time immemorial. In essence, Ganga represents all rivers and several river streams are also named after Ganga. It has always been and will remain a great unifying force. Its rejuvenation requires the efforts of all and its rejuvenation is needed by all.

Addressing Societal Challenges to Reduce Deforestation in Himalayas using Climate Sensitive Restoration Planning

Shalini Dhyani

Senior Scientist, Critical Zone Research Group,

Water Technology and Management Division

CSIR-National Environmental Engineering Research Institute, Nagpur

Email: shalinidhyanineeri@gmail.com

India is home to a bewildering range of exceptional and spectacular biodiversity elements, but in last few years natural ecosystems have come under relentless onslaughts due to land degradation that leads to huge economic losses every year. Fast-expanding urban sprawls, rampant mining of minerals, rapid industrialisation, groundwater dependent and chemically supported intensified agricultural practices, growing incidence of disasters and climate change impacts are further accelerating land degradation.

The phenomenon of land degradation has enhanced food insecurity along with poverty that is expected to worsen in future due to climate variabilities and interlinked vulnerabilities. In last more than five decades human induced pressures have severely manipulated natural ecosystems of our country. Various direct and indirect drivers of biodiversity loss have drastically modified our natural ecosystems. However, we all are still not very sure about the larger impacts of these mega and hidden drivers of biodiversity loss as they have been seldom analyzed comprehensively and hence many of these drivers are still either unidentified or not assessed appropriately.

Due to inadequate representation and mainstreaming of the value of natural ecosystems and biodiversity in decision-making, many of the natural ecosystems across different agro-climatic zones of the country are undergoing rapid decline and degradation. Globally, there has been a huge consensus on the importance and role of healthy ecosystems in solving a string of environmental crises. Climate change and spread of zoonotic are some of the immediate risks that we are facing presently, and it has challenged our very survival. There is a growing need to assess nature's contributions to people for human well-being and multiple values of natural ecosystems as also to identify various anthropogenic and environmental drivers affecting them to understand the trends and scenarios for appropriate policy planning.

Mountain ecosystems are vital for maintaining nature's contribution and well-being of people living upstream as well as downstream. The forests in Indian Himalayan Region (IHR) are biodiversity hotspots and a source of many ecosystem goods and services for the entire country and South Asia at large. Forests are vital need for subsistence rural lifestyle of locals

as they are significantly dependent on these rich and biodiverse ecosystems. These forests are unlimited storehouse of provisioning, regulating and supporting cultural ecosystem services.

Unfortunately, the Himalayan forests have been severely exploited in the last few decades for diverse essential and subsistence demands of local inhabitants as well as larger demands for fuelling the development of the country. Degraded forest ecosystems are not sufficiently able to supply required goods and services to support good quality of life of marginal hill communities. In my last fifteen years of research on natural and man-made pressures on forests in Central Himalayas, the conclusion, with a clear evidence, was that anthropogenic pressure has severely affected moist temperate mixed broad leaved forests and also other forest types of the region. The dominance of seral species and pioneers in these forests instead of climatic climax species that are keystone species in many cases is a clear indication that forest ecosystems in the region are struggling and might be undergoing a hidden collapse. Continuous encroachment and pressure might jeopardize functioning of these forests and flow of ecosystem services from them.

There was a clear observation about the vital need to take stock of scattered but relevant scientific findings to develop scientific planning based management of broad leaved forests in the Central Himalayas. Loss and degradation of spring sheds in IHR is one such crucial problem highlighted by the Niti Aayog that has been addressed through continuous and ongoing research and developmental activities. It was also observed that addressing societal challenges can help planning conservation initiatives to achieve long-term and short-term biodiversity conservation targets.

Climate variability, vulnerability and the Himalayas are synonyms that are well-addressed and, hence, have also been included in the National Action Plan for Climate Change (NAPCC) as it is the most influential driver that is rapidly altering the natural habitats of keystone and threatened species in the region. It was important to understand the climatic niche of vulnerable species and predicting its shift due to impending climate change to assess the damage. It was also relevant to use this approach to plan and implement long term *ex-situ* or *in-situ* strategies to protect the species and their fragile habitats.

Though various important species across IHR are exploited for their economic and medicinal benefits, yet the impact of climate change for important species has not been very efficiently documented till date. We studied two important species of which first was *Quercus leucotrichophora* (A. Camus or Banj oak), a keystone tree species in moist temperate forests of Uttarakhand. Banj oak forests are highly diverse with high soil organic matter as also water holding capacity that supports human well-being across the region. We found that climate variability, coupled with anthropogenic pressure, has affected the regeneration and succession patterns of Banj oak in the region. It is also important to understand that conservation of Banj oak is more of socio-ecological challenge that requires more interdisciplinary approach with local participatory efforts.

Our results concluded that the estimated potential habitats of the *Q. leucotrichophora* forests will decline by 84-99 per cent in the coming three to five decades as per the Intergovernmental Panel on Climate Change (IPCC)'s Representative Concentration Pathways (RCPs). It was clear that shift of the species from its present habitats due to climate variability requires climate adaptive management for forest landscape restoration (FLR) through active community involvement. Our study also provided information about the suitable niches for

the species of Banj oak forests in the state to address the growing concern of spring shed rejuvenation using climate adaptive FLR in the Central Himalayas.

In another study, habitat suitability of *Hippophae salicifolia* (Seabucktorn) was undertaken that is a high value species which grows particularly on the riparian fronts of river Ganga in all high altitude valleys in the Central Himalayas. Species can be considered as an indicator of riparian forest health in higher reaches of river Ganga. Species has huge slope stabilisation potential that can be used for reducing landslide risks and also its fruits have important bio-prospecting and value addition potential. Natural habitats of the species in Uttarakhand are severely degraded due to their continuous destruction. Shift of species from its micro-habitats was observed and it was projected that suitable area for it might be lost by 87 per cent following all the IPCC climate change scenarios by 2050 and 2070, making the species highly vulnerable. An upward shift of species habitat was also observed from 2,800 to 4,500 m amsl (above mean sea level) that is alarming for the survival of alpine, subalpine and timberline ecosystems and species. The research highlighted the need for *in-situ* and *ex-situ* conservation of species to harness its potential for sustainable development of marginalised communities.

In last less than a decade there has been tremendous advancement around the world in terms of conceptualisation, research, implementation and policy uptake for Nature-based Solutions (NbS) to address and reduce the severity of disaster risk and climate vulnerability. There is also growing momentum in ongoing international policy dialogues by Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), International Union for Conservation of Nature (IUCN), Ramsar Convention, and Sendai Framework on Disaster Risk Reduction. These are aimed at understanding, including and facilitating implementation of NbS for solving societal challenges by addressing disaster risk reduction, climate change adaptations and mitigations.

NbS have proven potential to achieve and localise goals and targets proposed in international agreements related to biodiversity conservation, disaster risk reduction, climate change adaptation, and mitigation. Situation and target-based applications of appropriate NbS that support livelihood for the local community have proven success in poverty alleviation and skill development while overcoming restoration challenges. Restored landscapes through FLR as an NbS solution are biodiverse, productive, carbon-rich and climate-resilient regions that can fulfil the requirements for localising Sustainable Development Goals (SDGs) 1, 2, 6, 13, 14 and 15 and also support Intended Nationally Determined Targets (INDCs) under Paris COP, 2015. This research-based effort was to understand that restoration is required to be planned and conducted with due recognition and acceptance of growing climate uncertainty that comes after better understanding of the future restoration targets and accordingly planned initiatives.

I proposed an integrated climate sensitive restoration framework that involves locals, especially indigenous communities, in mapping degraded lands and identification of species as they have an in-depth understanding of their ecosystems that can be supported by advanced scientific tools and approaches to better understand and address climate uncertainty.

We tried to explore the potential of NbS in traditional Indian societies based on their indigenous and traditional ecological knowledge (ITEK) systems. Traditional agroforestry

systems in the Himalayas were one of them that have historically supported millions of small-holding farmers. However, from 2007onwards, agroforestry has started receiving attention in global climate discussions for its huge carbon sink potential under the tree outside forest category. It can play an important role in offsetting greenhouse gases (GHGs), ensuring live-lihood diversification, realising SDGs and achieving post-2020 global biodiversity targets. We included novelty to the approach on fodder banks that can not only reduce pressure from forests resulting in reduced degradation but also reducing women drudgery. One successful fodder bank model was developed with financial support from Department of Science and Technology (DST)'s SYSP scheme in Upper Kedar valley by using fast-growing, high biomass yielding and nutritious fodder species by active participation of women folk. This model has huge replication potential that helps the Forest Department of the state in general and other Himalayan states at large for developing fodder supply zones by developing fodder banks and introducing fast-growing and high biomass yielding plants also in cropland bunds.

The larger advantage of developing fodder banks can reduce the burden for women; help to preserve and store surplus fodder; increase availability of nutritious fodder during the period of fodder scarcity (lean winter months); enhance nutritive value of crop residue and other cellulosic waste for animal feeding by conventional and nonconventional fodder; and increase milk and meat yield. It was appreciated as a successful model by IUCN and also SAARC Forestry Center, Bhutan and is presently governed by *Mahila* and Y*uvak Mangal Dals* of the village.

This fodder model judiciously addresses the need of sustainable land restoration. It is a key to restoring degraded land, halting biodiversity loss, and reinstating ecosystem services across IHR. If replicated and adopted, it can help localise the national commitments and tar-gets of Bonn Challenge and also the recently started United Nations Decade on Ecosystem Restoration (2021–2030) for restoration of 150 M ha of degraded lands by 2020 and 350 M ha by 2030. Such climate sensitive NbS can help in sustainable land restoration and bring transformative changes for achieving the targets of UN Decade on Ecosystem Restoration (2021–2030) and Sustainable Development Goal 15, and addressing the post-2020 Global Biodiversity Framework. However, to better realise success, climate finance mechanisms to drive restoration are equally important to be considered for reducing bias and enhancing opportunities of equitable sharing and this is where corporates can get involved under their CSR and Corporate Ecological Responsibility (CER) projects. We are also trying to explore involvement of citizen scientists for their broader presence that can help in post-plantation monitoring to ensure success and reduce mortality of restoration programmes.

Study reveals the ill effects of unscientific waste disposal on environmental parameters

Joystu Dutta[*1] and Tirthankar Sen*[2,3]

[1]*Department of Environmental Sciences, Sant Gahira Guru Vishwavidyalaya, Sarguja, Chhattisgarh*

[2]*Department of Biotechnology, Techno India University, Kolkata, West Bengal*

[3]*IUCN Commission on Ecosystem Management (CEM) South Asia Regional Office, New Delhi*

Email: joystu.dutta@gmail.com

Introduction:

Unscientific management of municipal solid waste is one of the direct sources of contamination in developing countries like India. The first step to manage these anthropogenic stressors is to accurately assess its impact on the environment. Research and datasets pertaining to it are important as they provide a robust actionable quantitative assessment of the biogeochemical parameters in play. Although there is a substantial body of research about soil and water contamination in the developed, fully urbanized metropolitan cities of India; rapidly developing cities like Silchar in Assam lack such rich datasets and research. Our investigation carried out during October–December 2019 was an attempt to assess parameters such as the quality of groundwater and soil near a dumping site in Silchar, which is the state's second largest city.

Soil and groundwater samples were sourced from several sampling points around the vicinity of the dumping site. The pH, electrical conductivity (EC), moisture content, porosity and bulk density of the soil samples were analysed whereas the pH, EC, total suspended solids (TSS) and total dissolved solids (TDS) of the groundwater samples were also evaluated. Further, the soil samples were also assayed for the presence of heavy metals using Atomic Absorption Spectrometry. The detailed analysis of the soil and groundwater samples we carried out in and around the municipality dumping site at Nagapatty in Silchar established beyond doubt that it has been affected by the rampant and reckless dumping of untreated municipal sewage.

The soil and groundwater analysis

The overall pH of the soil samples was observed to vary between 4.2 and 7.0, indicating an acidic tendency of the soil. This was, however, not surprising as the production of acidic leachate is common around waste disposal sites. A wide range of trace metals was also observed to be present in the soil, including Zn, Fe, Ni, Cu and Cr. This presents a matter of immense and grave concern as each of these metals poses serious threats to humans.

Using the trace metal concentrations, we calculated a metric known as the Geo-accumulation Index which is essentially the ratio of the measured concentration of a particular trace metal in a soil sample and its geochemical background value in the average shale. To our utter dismay, we discovered that the Geo-accumulation Index of all the trace metals we assayed for fell into the "extremely contaminated soil" category.

The groundwater analysis revealed a picture remarkably similar to the one obtained from the soil sample analysis. Most of the groundwater samples exhibited pH levels below the desired limits. The standard limit of pH for drinking water is 6.5–8.5. In the present study, we found that the pH of 64% of the water samples was below 6.5, therefore rendering it unfit for drinking purposes.

TDS is a water quality metric signifying the concentration dissolved particles or solids in water whereas TSS is a measure of the fine inorganic particles suspended in water. Although the TDS values were within the WHO prescribed limits, the high TSS was indicative of the fact that the water was aesthetically unacceptable for domestic purposes.

Groundwater samples were analysed for the trace elements such as iron, copper, chromium, nickel, arsenic and zinc. The iron, copper and nickel levels in groundwater samples exceeded the guideline values but the chromium and zinc concentrations were found to be within limits. The findings obtained from this assessment demonstrated that the groundwater of the study area was unreliable and unsuitable for drinking purposes and the soil was also unfit for agricultural purposes unless extensive remediation measures are taken as soon as possible.

The team consisted of (late) Mr. Rahul Das and Mr. Gaurav Roy who, in association with Voice of Environment, a non-governmental organization of the youth based out of Guwahati, led the pilot study that included laboratory sampling of water and soil samples. The preliminary study was done under the scholarly guidance of Assam-based Moharana Choudhury, a reputed environmentalist and Secretary, Voice of Environment (VoE); Dr. Dibakar Deb, Head of Chemistry Department, Karimganj College; and Dr. Sumita Paul Purkayastha, Assistant Professor, Dept of Chemistry. The study was followed by detailed data analysis and stakeholder engagement programmes which include community sensitization and mobilization. The team was further enriched by the scholarly expertise and peerless supervision of eminent scientists such as Prof K G Bhattacharya, Department of Chemistry, Gauhati University, Assam; Dr. Darpa Sourav Jyethi, Scientist, Indian Statistical Institute, North-East Centre, Tezpur, Assam; Dr. Joystu Dutta, Assistant Professor and Head of Department, Environmental Sciences, Sant Gahira Guru Vishwavidyalaya, Sarguja, Chhattisgarh; and Tirthankar Sen, an M.Tech student of Department of Biosciences and Bioengineering, Indian Institute of Technology (IIT) Guwahati. The entire research team would like to pay tribute to one of their members Rahul Das whose life was tragically cut short in a road mishap in Guwahati.

The highlights of the research findings were accepted and published by International Journal of Energy and Water Resources, Springer-Verlag on March 4, 2021. It is imperative that such studies are consistently undertaken to ensure environmental resource and solid waste management in other prominent cities of India and the world.

Major Ocean Initiatives

Cdr. P. K. Srivastava

Scientist-F, Ministry of Earth Sciences, Government of India

Email: srivastava.pks@gov.in

India has an abundance of natural wealth. A megadiverse nation with four of the 35 biodiversity hotspots of the world, the country has excellent environment-related policies in place though it needs stringent implementation and efforts to make genearal populace more concerned.

The ocean is the largest and a most critical ecosystem on Earth. It is one of the most biologically diverse and highly productive systems on the planet, and potentially the largest provider of food, materials, energy, and ecosystem services. It is also a great potential driver of economic growth, jobs, and innovation, and is expected to provide economic opportunities in the future. However, the value of ocean is dimished by environmental pressures from overfishing, climate change, pollution, loss of habitats and biological diversity, and urban development of coasts.

To improve the health and productivity of ocean ecosystems, and reverse the current cycle of decline, many initiatives have been taken by the government. Here is a glimpse of major oean initiatives in making India self-reliant through contributions to GDP.

Blue Economy Policy

The Ministry of Earth Sciences (MoES) recently rolled out the Draft Blue Economy policy for India in the public domain, inviting suggestions and inputs from various stakeholders, including industry, NGOs, academia, and citizens. The draft blue economy policy document outlines the vision and strategy that the Government of India can adopt to utilise the plethora of oceanic resources available in the country. This was disseminated for pubic consultation on several outreach platforms, including websites and social media handles of MoES and its institutes. Stakeholders were invited to submit inputs and ideas by 30th April 2021. The policy document aims to enhance the contribution of the blue economy to India's GDP, improve the lives of coastal communities, preserve marine biodiversity, and maintain the national security of marine areas and resources.

India's blue economy is understood as a subset of the national economy comprising an entire ocean resources system and human-made economic infrastructure in marine, maritime, and onshore coastal zones within the country's legal jurisdiction. It aids the production of goods and services that have clear linkages with economic growth, environmental sustainability, and national security. The blue economy is a vast socio-economic opportunity for coastal nations like India to utilise ocean resources responsibly for societal benefit.

With a coastline of nearly 7.5 thousand kilometres, India has a unique maritime position. Nine of its 29 states are coastal, and the nation's geography includes 1,382 islands. There are 199 ports, including 12 major ports, that handle approximately 1,400 million tons of cargo each year. Moreover, India's Exclusive Economic Zone (EEZ) of over 2 million square kilometres has a bounty of living and non-living resources with significant recoverable resources such as crude oil and natural gas. Also, the coastal economy sustains over four million fisherfolk and coastal communities. With these vast maritime interests, the blue economy occupies a position of vital potential in India's economic growth. It could well be the next multiplier of GDP and well-being, provided sustainability and socio-economic welfare are kept centre-stage. Therefore, India's draft blue economy policy is envisaged as a crucial framework towards unlocking the country's potential for economic growth and welfare.

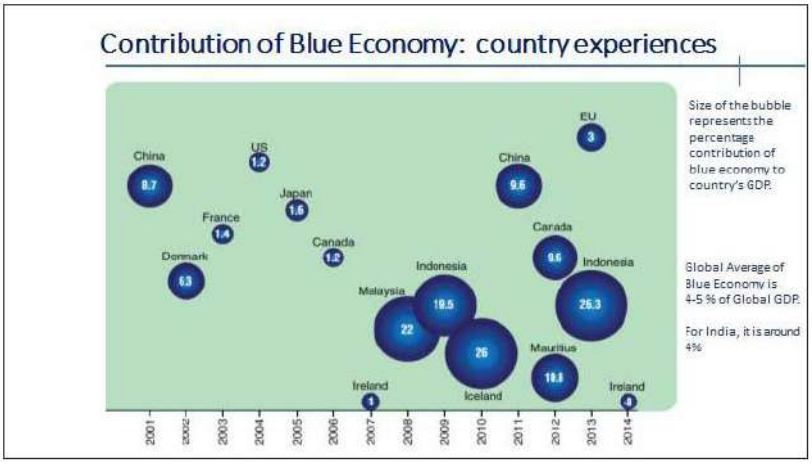


Fig 1: Size of countries Blue Economy to GDP[i]

The draft policy framework emphasises policies across several key sectors to achieve holistic growth of India's economy. The document recognises the following seven thematic areas:

- National accounting framework for the blue economy and ocean governance
- Coastal marine spatial planning and tourism
- Marine fisheries, aquaculture, and fish processing
- Manufacturing, emerging industries, trade, technology, services, and skill development
- Logistics, infrastructure and shipping, including trans-shipments
- Coastal and deep sea mining and offshore energy
- Security, strategic dimensions, and international engagement

The United Nations member states, including India, adopted 17 Sustainable Development Goals (SDGs), also known as the Global Goals, in 2015 as a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030. SDG 14 seeks to conserve and sustainably use the oceans, seas and marine resources for sustainable development. Several countries have undertaken initiatives to harness their blue economy. For instance, Australia, Brazil, the United Kingdom, USA, Russia, and Norway have developed dedicated national ocean policies with measurable outcomes and budgetary provisions. Canada and Australia have enacted legislation and established hierarchal institutions at the federal and state levels to ensure progress and monitoring of their blue economy targets. With a draft blue economy policy framework of its own, India is now all set to harness the vast potential of its ocean resources.

Marine Spatial Planning (MSP)

Ensuring sustainable planning and management of the ocean space is of paramount importance. Marine spatial planning is globally a topic of increasing significance in the scientific and policy realms. However, despite acceptance and use, development and implementation of marine spatial planning still face myriad of conceptual and practical challenges, from political to institutional, social, economic, scientific and environmental sources.

India and Norway have signed a Memorandum of Understanding (MoU) establishing the India-Norway Ocean Dialogue in January 2019. In the MoU, the two sides emphasised "the need to move towards integrated and ecosystem-based approaches in the management of renewable and non-renewable natural resources" and identified Integrated Ocean Management as an area of mutual interest for future cooperation. Marine spatial planning is a tool for Integrated Ocean Management for Sustainable Development. It aims to create a framework for the ocean that minimises conflicts between economic sectors and maintains the good environmental status of the ocean through the identification of ocean spaces that are appropriate for different uses and activities. With its considerable experience and technical expertise in this field, Norway would be an ideal partner for India to develop this significant segment of marine space management.

MoES, through National Centre for Coastal Research (NCCR), Chennai, had previously developed Coastal Zone Management (CZM) plans for three areas, namely Chennai, Goa and Gulf of Kutch, which pertained only to the coast and near coastal areas. NCCR would lead the Marine Spatial Planning initiative and will evolve a framework to sustainably use the ocean and its resources to advance economic and social development in the coastal areas of the country. Initially, Puducherry and Lakshadweep have been identified as two distinct sites for developing a framework for marine spatial planning. Puducherry is a developing urban area with specific environmental and economic setting, with industries, fisheries and tourism being essential sectors in the coast. In contrast, Lakshadweep is a pristine, ecologically sensitive area with a lot of potential for tourism and fisheries. The marine spatial planning framework, once developed for these two sites, can be replicated for other coastal states and environments of the country with minor modifications.

Fig 2: Pilot areas for MSP as agreed between India and Norway as a part of integrated ocean management

Deep Ocean Mission (DOM)

Oceans play a vital role in regulating the climate. For a peninsular country like India, with around 30 per cent of the country's population living in coastal areas, the delicate balance of nature, ecology, environmental perspectives and climate change has resulted in the necessity for better development of the oceans. Only 5 per cent of the deep ocean has been explored so far while the rest remains unexplored. The global security issues involved with oceans dictate exploration of deep sea that needs specialised modern technology. Finance Minister Mrs Nirmala Sitharaman, during her budget speech of FY 2021-22 on 1st February 2021, announced, "To better understand our oceans and its living and non-living resources, we will launch a DOM with a budget outlay of more than Rs 4,000 crore over five years. This Mission will cover deep ocean survey exploration and projects for the conservation of deep sea biodiversity."

Six Major Themes of DOM

Development of Technologies for Deep Sea Mining, Manned Submersible, and Underwater Robotics: Under the contract with the International Seabed Authority (ISA), India has been allotted 75,000 sq. km area for exploring for Polymetallic Nodules (PMN) in Central Indian Ocean and 10,000 sq. km for Hydrothermal Sulphides (PMS) in Southwest Indian Ocean. The exploration studies of minerals will pave the way for the commercial exploitation of minerals which include manganese, cobalt, nickel and copper in the near future, as and when commercial exploitation code is evolved by ISA. The technologies required for deep sea mining are not commercially available at present. Since there are strategic implications, developing technology in-house for deep ocean exploration assumes importance.

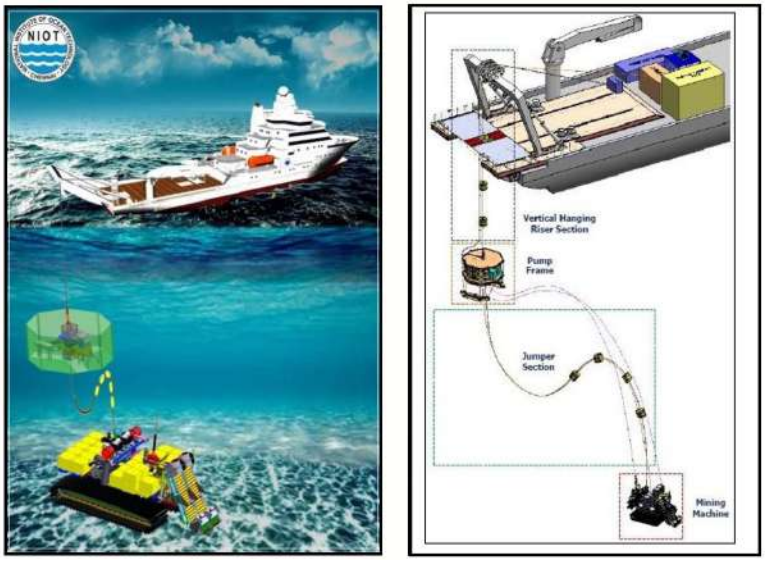


Fig 3: Conceptual diagram of the Integrated Deep Sea Mining System[ii]

Development of Ocean Climate Change Advisory Services: The development of ocean climate change advisory service on mission mode will include long-term predictions on increasing intensities of cyclones, storm surges, fishery, stocks, and sea level rise. To monitor the changes occurring in the ocean, the deep ocean observations will be taken up in a more significant way involving autonomous observing systems.

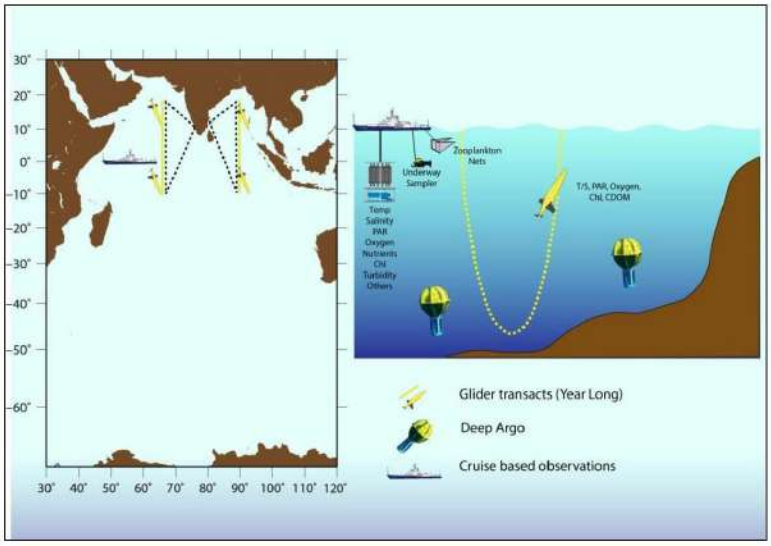


Fig 4: The proposed observation network and the schematic of the open ocean and the coastal ocean mooring systems[iii]

Technological innovations for exploration and conservation of deep sea biodiversity: Despite the enormous significance, India's deep sea environments are meagrely explored and cutting edge technologies for harnessing the deep sea living resources are scarce. Under this initiative, developing an inventory of deep sea fauna and flora of hotspots like sea mounds, capacity building on deep sea taxonomy and genomic studies, development of biodiversity grid, implementation of National Biodiversity Targets, bio-prospecting of deep sea flora and fauna, including microbes, are some of the major areas which are proposed to be focused upon.

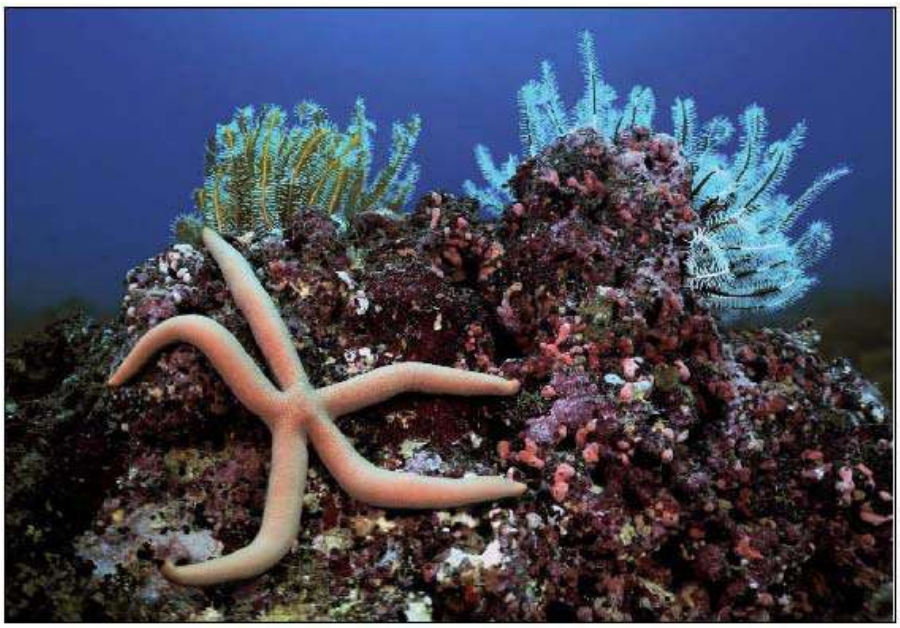


Fig 5: Deep Sea Biodiversity Exploration

Deep Ocean Survey and Exploration of Minerals from Hydrothermal Vents: Exploration of hydrothermal sulphides is a challenging task for various reasons, including its hostile marine environment. Indigenous and collaborative efforts are required to motivate India's ambitions

in advancing science in frontier areas of marine and seabed mineral exploration. To this objective, a new research vessel with special scientific instruments would be an ideal platform for the Indian oceanographic and fishery research fraternity. This research vessel will be built in an Indian shipyard as a part of Atmarnirbhar Bharat initiative of the government.

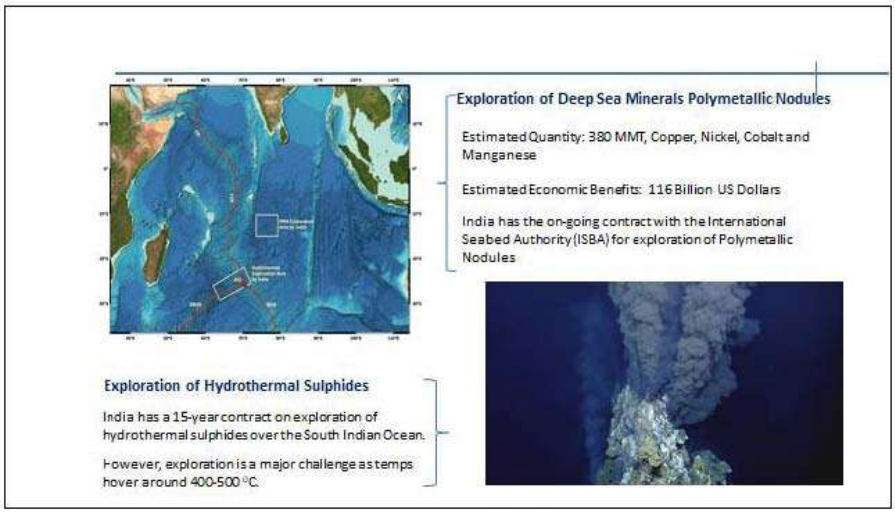


Fig 6: Exploration of Deep Sea Minerals

Energy and freshwater from the Ocean: There is a massive potential for deriving clean and green energy and freshwater from the oceans and the development of offshore technologies for the same. Under this mission, scaled-down field and laboratory studies will be implemented for the design of the offshore components towards setting up an indigenously developed large-scale offshore plant in deep waters for energy and freshwater.

Fig 7: Low Temperature Thermal Desalination (LTTD) plants in Lakshadweep set up by NIOT at Kavaratti, and Agatti

Advanced Marine Station for Ocean Biology: The Advanced Marine Station is envisaged as a 'hub and spokes' model and will help the Mission strengthen its networking with various organisations across research institutes for marine sciences within India and globally. This will allow India to be at the helm of knowledge-driven progress and innovation in ocean biology, which includes bio-prospecting. The translation of applied research into marketable products will be strongly encouraged through interactions with industries and the hosting of incubator facilities for ocean science entrepreneurs.

UN Decade of Ocean Science

The UN General Assembly has declared the decade of 2021-2030 as the United Nations Decade of Ocean Science for Sustainable Development ('the Ocean Decade'), which aims to stimulate ocean science and knowledge generation to produce new opportunities and create public awareness on the usefulness of ocean for its sustainable use. Ministry of Earth Sciences (MoES) has taken a proactive role by constituting a National Decade Coordination Committee (NDCC) under the chairmanship of Secretary, MoES and involving various national institutions and stakeholders. Its mandate is to coordinate existing activities and develop new programmes at the national level to meet the objectives and goals of the Ocean Decade and also to enhance national access to Decade benefits.

Fig 8: UN publications on the decade of ocean science[iv]

During the first meeting of the NDCC held on 3rd February 2021, it was presented that in response to the first "Call for Decade Actions" by the International Oceanographic Commission (IOC-UNESCO), Ministry of Earth Sciences, Government of India, through Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, had submitted its bid for establishing an Indian Ocean Region - Decade Collaborative Centre (IOR-DCC) to coordinate, facilitate and initiate research in the Indian Ocean by exchange of knowledge, ideas and collaborations with other national and international scientific programmes. The outcome of this proposal will be known in due course of time. Additionally, INCOIS, National Centre for Polar and Ocean Research (NCPOR) and NCCR have also been invited as important partners along with other leading international institutions to collaborate in large-scale programme proposals submitted against first "Call for Decade Actions" such as 2nd International Indian Ocean Expedition (IIOE2), Global Ecosystem for Ocean Solutions (GEOS) proposed by a consortium of academic institutions led by University of Maryland, USA and the Biomolecular Ocean Observing Network (BOON).

The National Committee has recommended that INCOIS develop a National Ocean Decade implementation plan document, in consultation with other national institutes and stakeholders, highlighting India's thematic contribution to the 'Ocean Decade'. It has also recommended that India should continue to contribute to regional programmes and capacity building initiatives in operational oceanography for Indian Ocean Rim countries as part of the Ocean Decade. Further, a major national outreach campaign should be launched as part of the Ocean Decade to create awareness among school and college students as well as the general public on the importance of oceans.

Marine Plastics/litter Prevention and Management

Plastic accumulating in our oceans and on our beaches has become a global crisis. Thousands of tonnes of plastic can be found that make up about 40 per cent of the world's ocean surfaces. Whereas the plastic debris floating on the ocean surface accounts for only 5 per cent of all the plastic trash dumped into the sea, the other 95 per cent is submerged beneath the surface. About 8 million tonnes of plastic enters the sea every year, and global plastics consumption is predicted to grow dramatically, reaching close to 400 million tonnes a year by 2025.

International experts agree that to address the problem of marine plastic waste, there is a need to promote a comprehensive life-cycle approach to effectively prevent and reduce plastic litter discharge in the oceans through environmentally sound waste management practices, ecologically sound clean-up of marine plastic litter and innovative monitoring/observations through the use and application of geo-spatial technologies. Since the problem of plastic pollution is cross-boundary and cross-cutting, it requires systemic solutions covering policy, technology, management, financing, knowledge and research, awareness raising and behavioural change. There is also a need to engage in bilateral and regional cooperation and share best practices through relevant initiatives and programmes.

MoES is leading this research and collaborating with Centre for Environment Fisheries and Aquaculture Sciences (CEFAS), UK and with Japanese institutions in the project "Assessment of Micro Plastic Impact on Marine Organism in Coastal and Estuarine habitats". It is being carried out by NCCR, Chennai. The programme's main aim is to understand the current distribution and abundance of marine litter and microplastics in the Indian coastal sediment, water and biota. Such information is critical for developing management strategies that can help to reduce plastic waste at the source. The future plan includes modelling the fate of plastics from source to sink and adapt beaches for awareness campaign as part of coastal clean sea programme of UNEP to understand the dynamics of marine litter on beaches.

Fig 9: Field sampling and instruments demonstration[v]

It is evident that land-based sources are the major contributor to marine plastics/litter to the marine system. Relevant sources and the environmental fate still remain to be investigated from most regions. This is particularly important for countries like India that is vulnerable to extreme weather events (floods, cyclones) that have become a major source of leakage of plastics in the marine system. Besides the surface waters and oceanic gyres, there is also a need to understand the role of coastal zones, including backshore, as potential sinks for plastics. To reduce further litter/plastics pollution load to the ocean, modelling studies of plastics already present in the marine system also need to focus on the fate of debris originating from the point sources. Such models may allow predicting the probable pathways and endpoints for the plastics, which would help identify the potential location to place the barrier/clean-up systems (e.g. floating trash barrier), which could reduce the further input of plastics into the coastal system. An essential aspect of successful management strategies for plastics is to understand their fate from source to sink. Therefore, interdisciplinary studies will be carried out to link the sources, transport pathways and fate of plastic debris.

At an international level, the G-20 nations have pledged to cooperate and collaborate with relevant Regional Seas Programmes, Regional Fisheries Management Organisations and other regional initiatives to empower governments, communities, and the private sector to advance measures to address the problem of marine plastic waste. It is expected that the topic on marine plastic will be further highlighted during the G20 summit, which Government of India will be hosting in 2022. The Prime Minister of India has announced to tackle the plastic waste issue at its root, phasing out single use plastics by 2022 and popularising the idea of “Swachh Sagar” akin to “Swachch Bharat”.

Fig 10: A snapshot of activities during beach clean-up campaign[vi]

These initiatives of the Ministry of Earth Sciences are in addition to several ongoing programmes and projects which have substantial socio-economic impacts on the lives of coastal communities. The flagship projects include the advisory services, like Potential Fishing Zones, Ocean State Forecasts, Tsunami and Storm Surge Warnings, Oil Spill trajectory, Rip currents and High Wave alerts; development of eco-friendly technologies for restoration of coastal erosion; using ocean thermal gradients for generating portable drinking water for the island territories; assessment of shoreline changes along the entire Indian coast; monitoring of coastal water quality; and undertaking consultancy works for the state governments and Public Sector Undertakings (PSUs) besides training and capacity building in operational oceanography at its UNESCO recognised Category 2 Centre, (ITCOocean) at Hyderabad. The upcoming 'ocean initiatives' would further strengthen India's position as a vital fulcrum for sustainable development of ocean resources globally.

References

i. Working Document on Blue Economy

ii. Deep Ocean Mission Document

iii. Deep Ocean Mission Document

iv. IOC-UNESCO website

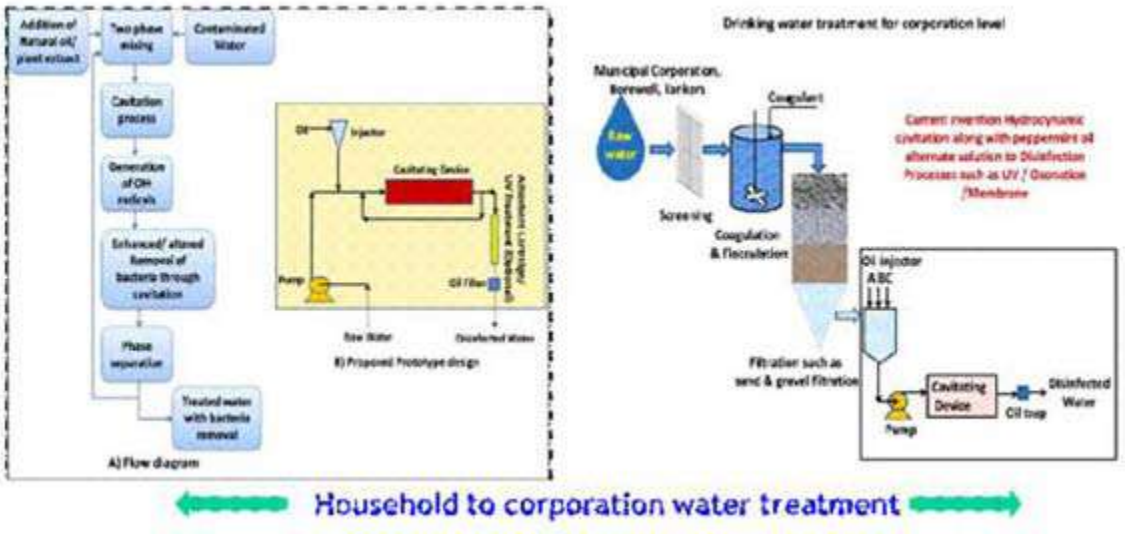
v. Annual Report NCCR-2020

vi. Annual Report NCCR-2020

Modern technology and Indian traditional knowledge combine to bring safe & healthy drinking water

DST Commiunication Team

Modern technology and Indian traditional knowledge of Ayurveda have been combined for a solution to disinfect water completely and also offer possible health benefits of natural oils.

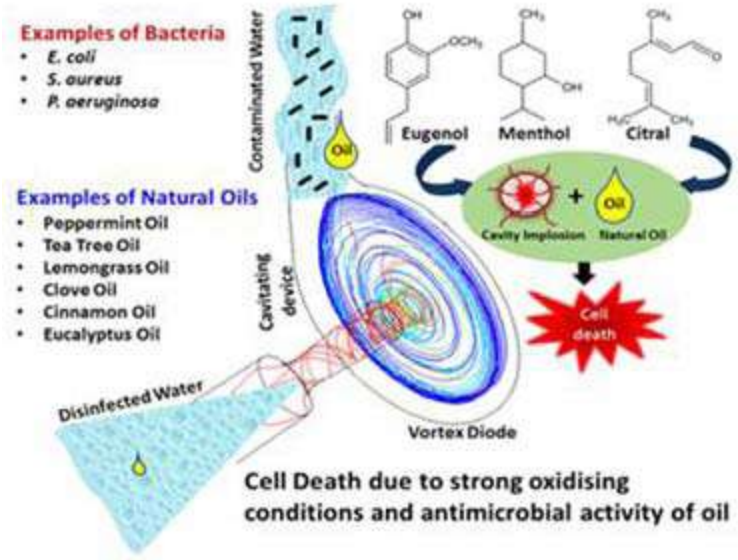


Process flow diagram and possible prototype for household and corporation water treatment plant

Disinfection of water is essential for removing pathogenic microorganisms that are responsible for causing a number of water-borne diseases. However, the common drawbacks of chemical methods such as chlorination include formation of harmful/carcinogenic disinfection by-products. Therefore, it is pertinent to develop technology that provides safe and healthy drinking water at low cost with substantial ease of operation, scale-up, and without harmful disinfection by-products.

Scientists, Dr. VM Bhandari and his group at CSIR-NCL Pune, with support from the Water Technology Initiative of the Department of Science and Technology (DST), Government of India, has developed the novel hybrid technology called SWASTIIK' that involves boiling of a liquid as a result of pressure reduction (cavitation) and also uses natural oils having antimicrobial properties. This technology can eliminate harmful bacteria, including antimicrobial-resistant bacteria, economically. It not only integrates Indian traditional knowledge of Ayurveda for complete disinfection of water but also may offer possible health benefits of natural oils.

The technique used - hydrodynamic cavitation combines chemistry, biology, and chemical engineering along with natural resources in the form of natural oils and plant extracts. The process, which draws inspiration from Indian traditional knowledge, has resulted in increased efficiency and reduced cost of water treatment. The team achieved complete elimination for gram-negative *E. coli* and gram-positive *S. aureus* bacteria and even AMR bacteria/ difficult opportunistic pathogenic bacteria typically in 5-10 minutes. It was observed that increased rates of disinfection using oil can drastically reduce the time of operation and consequently reduce cost as compared to other advanced treatment processes.



Mechanism of the new hybrid activation technology using natural oils

The novel strategy of SWASTIIK (Safe Water and Sustainable Technology Initiative from Indian Knowledgebase) can have significant benefits in terms of providing SAFE WATER and also possible health benefits that can also boost immunity, an important aspect as underlined in the current COVID-19 era.

Biodegradable yoga mat developed by 6 young girls from Assam may save lakes from water hyacinth menace

DST Commiunication Team

A biodegradable and compostable yoga mat developed from water hyacinth by six young girls from the fishing community in Assam could turn this water plant from a nuisance to wealth.

The girls belong to the fishing community living in the fringe of the Deepor Beel, a permanent freshwater lake in south west of Guwahati city, recognised as a Ramsar Site (a wetland of international importance) and a bird wildlife sanctuary. The lake has been a source of livelihood for 9 villages of the fishing community who shared this biome for centuries, but over the years suffered from excessive growth and accumulation of water hyacinth.

The innovation by the girls, whose families are directly dependent on the wetland for survival, could contribute significantly towards the environmental conservation and sustainability of Deepor Beel and also ensure local livelihood. The mat called 'Moorhen Yoga Mat' will soon be introduced to the world market as a unique product.

The intervention was triggered through an initiative by North East Centre for Technology Application and Reach (NECTAR), an autonomous body under Department of Science & Technology (DST), Govt. of India to involve the entire women community associated with a collective called 'Simang' meaning dream, led by the 6 girls to create wealth from water hyacinth plants.

Considering all aspects of water hyacinth's properties and the functional requirements of a product like a mat, a hand-woven 100% biodegradable and 100 % compostable mat

to be used for doing Yoga was ideated as a means to provide multiple ecological and social benefits. The mat developed through fiber processing and technological interventions could improve the aquatic ecosystem of the wetland through removal of water hyacinth, help sustainable production of utility products with community engagement and generate livelihood for indigenous communities to become completely 'Atma Nirbhar'.

As the collection, drying and preparation of the water hyacinth before using it for weaving is the most important process, small interventions of technology were introduced like using 'solar dryer' which reduced the drying time to about 3 days. It could also compensate for the loss in time due to heavy rains that take place very frequently in this part of the country over a six month long rainy season (May-October).

The women wove water hyacinth using a traditional Assamese loom with the help of different combinations of techniques, materials and tools to develop a high quality, comfortable and thoroughly biodegradable and compostable Yoga Mat. It has resulted in the engagement of 38 women from 3 fringe villages (Keotpara, NotunBasti and Borbori). Technology intervention could also increase the production rate.

"7 WEAVES", (a sister concern of the Simang Collectives) team provided expertise on natural dyeing from locally available natural materials of Loharghat Forest Range, Kamrup District enabling NECTAR to include naturally dyed cotton yarns from lac, onion skins, iron and jaggery, in various patterns for the mat. Various equipment of the loom was changed to adapt to the woven structure of the mat.

The 'Moorhen Yoga mat' named after Kam Sorai (Purple moorhen, a resident bird of Deepor Beel Wildlife sanctuary), comes in a cotton canvas cloth bag where no zip or metal closures are used. The bag has an adjustable strap and closures effectively designed to be in sync with biodegradability.

Integrated Solar Dryer and Pyrolysis pilot plant will help smart cities transform urban organic waste into biochar & energy

DST Commiunication Team

The Solar Dryer and Pyrolysis pilot plant at Chennai will soon offer an innovative approach for smart cities to transform urban organic waste into biochar and energy.

The foundation stone of the Integrated Solar Dryer and Pyrolysis pilot was laid by Dr. K J Sreeram, Director, CSIR- Central Leather Research Institute (CLRI), Chennai on the occasion of 74th foundation day of CLRI on 23rd April 2021.

The pilot is part of the Indo-German project 'Pyrasol' launched to transform urban organic waste into biochar and energy in smart cities. It was awarded to CSIR-CLRI by the Indo-German Science & Technology Centre. The project will ultimately lead to technology development for the joint processing of Fibrous Organic Waste (FOW) and Sewage Sludge (SS) of Indian smart cities into hygienic and highly valuable biochar associated with energy recovery, carbon sequestration and environmental improvement.

Indo-German Science & Technology Centre (IGSTC) was established by the Department of Science & Technology (DST), Govt. of India & Federal Ministry of Education and Research (BMBF), Govt. of Germany to facilitate Indo-German R&D networking with emphasis on industry participation, applied research and technology development.

IGSTC through its flagship program '2+2 Projects', catalyses innovation centric R&D projects by synergising the strength of research and academic institutions and public/private industries from India and Germany.

Under this program, the project titled 'Pyrasol: Smart Cities integrated energy supply, carbon sequestration and urban organic waste treatment through combined solar sludge

drying and pyrolysis' was awarded by IGSTC to CSIR-CLRI, Chennai; Ramky Enviro Engineers, Chennai; Leibniz Universität, Hannover and Biomacon GmbH, Rehburg.

The project focuses on managing and organising collection, treatment, and disposal systems of urban wastes in Indian Smart Cities as well as in other urban centres with an integrated and interactive approach. Through this Pyrasol project, simple and robust processing technologies for urban organic waste will be combined in a synergistic manner and further developed to improve sanitation and welfare, supply regenerative energy, convert waste into products and reduce the carbon footprint of smart cities by an innovative organic waste drying system using the solar natural chimney effect followed by a high efficient single-chamber pyrolysis.

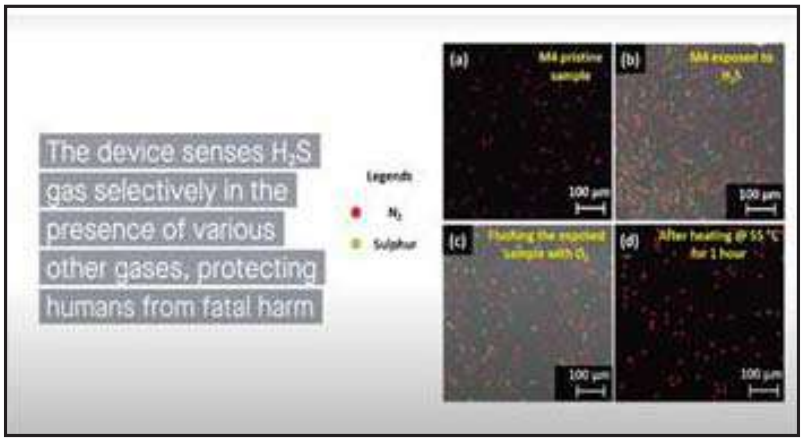
New electronic nose with biodegradable polymer and monomer can detect hydrogen sulphide from sewers

DST Commiunication Team

Scientists have developed an electronic nose with biodegradable polymer and monomer that can detect hydrogen sulphide (H_2S), a poisonous, corrosive, and flammable gas produced from swamps and sewers. H_2S is the primary gas produced from the microbial breakdown of organic matter in the absence of oxygen, and this necessitates easy detection of its emission from sewers and swamps.

Responding to this challenge, scientists from the Centre for Nano and Soft Matter Sciences (CeNS), Bangalore, an autonomous institute of the Department of Science & Technology, Government of India, in collaboration with their counterparts from Saudi Arabia, have developed an exceptionally sensitive and selective H_2S Gas sensor developed by impersonating the neuron responsible for identification of airborne molecules or olfactory receptor neuron (ORN). The impersonation of ORN with the help of an organic electronic device consisting of biodegradable polymer and monomer under Dr. Channabasaveshwar Yelamaggad from CeNS and Prof. Khaled N. Salama, Sensors lab, Advanced Membranes, and Porous Materials Center, King Abdullah University of Science and Technology (KAUST), Saudi Arabia has been published in the journals *'Materials Horizon'* and *'Advanced Electronic Materials'* recently.

The fabricated sensor consists of a heterostructure consisting of two layers – the top layer a monomer and is realized with a novel chemical tris (keto-hydrazone), which is both porous and contains H_2S specific functional groups, and the bottom layer is the active channel layer which plays a key role in altering the current and mobility of charge carriers.



Thus, the synergistic combination helps to pre-concentrate the H_2S molecules, initiate an acid-base chemical reaction, and thereby brings a change in the majority carriers (holes) of the channel region in the device. The capacitance sensor (a sensor that detects nearby objects by their effect on the electrical field created by the sensor) developed by the scientists showed an excellent sensitivity in detecting H_2S gas with an experimental limit of detection of around 25 parts per billion. It also has high ambient stability of around 8 months without compromising sensing performance.

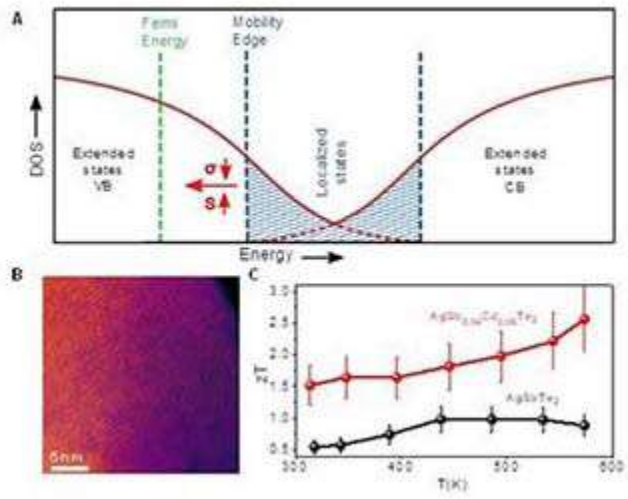
Publication links: https://doi.org/10.1039/D0MH01420F

New material found can efficiently convert waste heat to electricity to power small home equipment & vehicles

DST Commiunication Team

Scientists have found a new lead (Pb) free material which can efficiently convert waste heat to power our small home equipment and automobiles.

Thermoelectric energy conversion allows generation of electrical voltage when one end of a material is heated while keeping the other side cold. Finding an efficient material to realize this scientific principle has been a daunting task for scientists. It entails fitting in three seemingly different properties into a single material - high electrical conductivity of metals, high thermoelectric sensitivity of semiconductors, and low thermal conductivity of glasses.



(A) Schematic of the atomic ordering optimization strategy and its impact on thermoelectric parameters: electrical conductivity (σ) and Seedbeck coefficient (S). (B) Electron microscopic image exhibits the formation of cation ordering in 6 mol% Cd doped $AgSbTe_2$. (C) Temperature dependent thermoelectric figure of merit, ZT of pristine $AgSbTe_2$ and 6 mol% Cd doped $AgSbTe_2$.

Most efficient thermoelectric materials developed by scientists so far use lead (Pb) as a major constituent element, restricting their use for mass-market applications.

Scientists from Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, an autonomous institution of the Department of Science & Technology (DST), Government of India led by Prof. Kanishka Biswas have now identified a lead-free material called Cadmium (Cd) doped Silver Antimony Telluride ($AgSbTe_2$) which can efficiently allow

recovery of electricity from 'waste heat' marking a paradigm shift in the thermoelectric puzzle. They have reported this major breakthrough in the journal Science.

Prof. Kanishka Biswas and his group doped (internally introduced) Silver Antimony Telluride with Cadmium (Cd) and used an advanced electron microscopy technique to visualize the resultant ordering of atoms in nanometer scale. The nanometer-scale atomic ordering scatters phonons that carries heat in a solid and enhances electrical transport by delocalizing the electronic state in the material.

Previously reported state of the art material is exhibiting the thermoelectric figure of merit (ZT) in the range 1.5-2 in the mid-temperature range (400-700 K). The team reported a record increase in thermoelectric figure of merit (ZT) to 2.6 at 573 K, which can provide the heat to electrical energy conversion efficiency to 14 %. Prof. Biswas is now trying to commercialize the high-performance thermoelectric materials and devices; in collaboration with TATA steel where lots of waste heat is generated in steel power plant.

This work is supported by Swarna-Jayanti fellowship and project fund from *Science and Engineering Research Board (SERB) and Department of Science & Technology (DST), India, along with support from New Chemistry Unit (NCU) & International Centre for Materials Science (ICMS), JNCASR, Bangalore*

Study shows significant reduction of heavy metal pollution during COVID-19 pandemic

DST Commiunication Team

Efforts to minimize industrial wastewater can substantially reduce heavy metal pollution in the Ganga water in a short time span of a few months, a study carried out during the COVID-19 pandemic has shown.

The COVID-19 pandemic lockdown provided a team of scientists from Indian Institute of Technology Kanpur a rare opportunity to quantify the impact of restricted anthropogenic activities on the water chemistry resilience of large rivers.

Photographs shot at downstream locations in the plains during the research work

They analyzed the daily geochemical record of the Ganga River and showed that reduced industrial discharge during 51 days of mandated nationwide lockdown decreased the dissolved heavy metal concentrations by a minimum of 50%. In contrast, inputs from agricultural runoff and domestic sewage like nitrate and phosphate remained almost the same as these sources were not impacted by the nationwide confinement.

The research is supported by the Indo-U.S. Science and Technology Forum (IUSSTF), a bilateral organization under the Department of Science and Technology (DST), Government of India and U.S. Department of States, and recently published by '*Environmental Science and Technology Letters*', showed the high resilience of dissolved heavy metals. The study, which

adds to the body of research on the world's large rivers, has been intensely studied to better understand the impact of climate change and direct human interventions on river water quality and quantity has found pace in the cover page of the journal.

Publication link: https://pubs.acs.org/doi/full/10.1021/acs.estlett.0c00982

Innovative low-cost intervention tackles water supply challenges in Maharashtra towns

DST Commiunication Team

Two little towns with a population of around 20,000 in Palghar district of Maharashtra have become a model of how challenges like intermittent supply, water losses, deteriorating water infrastructure can be tackled at a reasonable cost. IIT Bombay has come up with 'Shaft with Multiple Outlets' as an intervention for improving the performance of existing piped water distribution networks. The intervention consists of a new strategy of optimal water supply operation by use of scheduling and decentralizing infrastructure.

With support from the Department of Science and Technology (DST)-Water Technology Initiative, IIT Bombay & IIT Madras, with participation of local gram panchayat, implemented the solution in the towns of Saphale, and Umerpada, in Palghar district, Maharashtra, which is currently provided with water from a multi village water supply system.

Photographs from the project site

These solutions will minimize the need for costly infrastructure components and improve the operation of the system. Typically, for a population of 2000 habitations, conventionally, ESR (half-day storage capacity) will require a cost of about Rs. 10 lakhs, whereas a shaft with multiple outlets will cost Rs. 2 lakhs. As per census population 2011, in India, there are about 5 lakhs such habitations with a population less than 2000. Hence, adoption of shafts with multiple outlets will save thousands of cores expenditures in ongoing governments Jal Jeevan Mission and other urban water supply systems. Apart from cost, the multioutlet provision in the shaft provides great operational ease, better pressure management, and better response to future population growth. This low-cost intervention, which has minimised the need for costly infrastructure components and improved the operation of the system, has

been recommended by the Ministry of Jal Shakti for implementation in all the states as part of Har Ghar Jal under Jal Jeevan Mission. Many public health engineering departments, municipal corporations, and water authorities have come forward to adopt these solutions as these will lead to huge cost savings. The solution supported by DST under Water Technology Initiative for Demand-Driven Convergent Water Solutions will minimize the need for costly infrastructure components and improve the operation of the system.

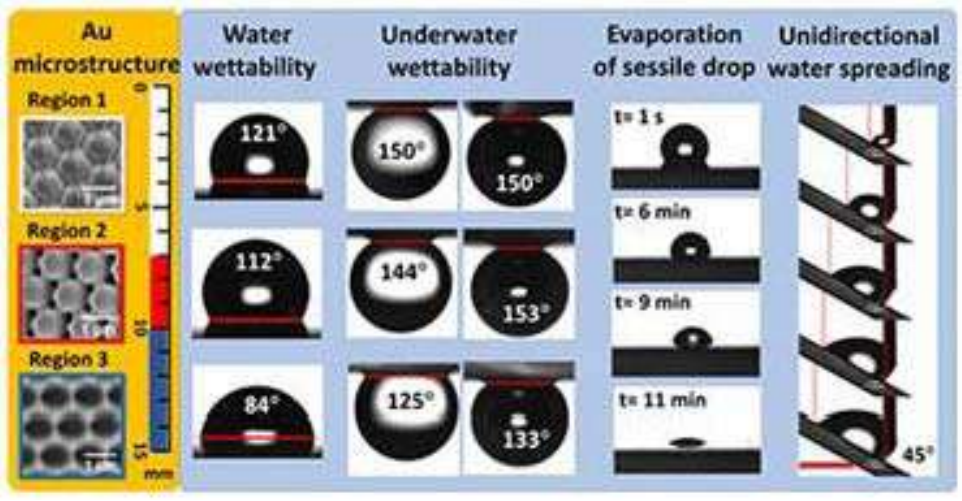
Scientists develop gold microstructure substrate with tunable wettability useful in water transportation & self-cleaning

DST Communication Team

Scientists have developed a gold microstructure substrate with the ability to repel water as well as bubbles with tunable wettability, which can be used in designing microfluidic devices, biosensors and useful in water transportation and self-cleaning.

Wettability, or the ability of a liquid to maintain contact with a solid surface, is an important property in surface and interface science. Its influence is seen in many biochemical processes, sensing, microfluidics, water transportation, self-cleaning, and industrial processes. The tunable wettability results from tunability in surface energy of the substrate, which can be utilized to regulate the direction of flow in water transportation and self-cleaning applications.

According to the recent work published in '*Journal of Applied Physics*', Dr. P. Viswanath and his group from the Centre for Nano and Soft Matter Sciences (CeNS), an autonomous institute of the Department of Science and Technology (DST), have developed a substrate exhibiting morphological gradient that helps one to tune the wettability because of surface energy change. The morphological gradient in the substrate ranges from domes to elliptical holes.



Water and oil wetting studies at each position on the substrate revealed that wetting is tunable with morphology. The substrate showed hydrophobic nature, which gets magnified

when coated with a self-assembled monolayer of octadecane thiol - a water-soluble sulfur compound with a carbon alkyl chain. The coating results in a reduction in surface energy, which in turn facilitates an enhancement in hydrophobic behaviour.

Underwater wettability investigations on the substrate showed that it mainly repelled bubbles and when functionalised with a coating of octadecanethiol, it repels mainly oil. Ms. Brindhu Malani S, a research scholar working on this, pointed out that these studies would be useful in designing microfluidic devices, biosensors, and water transportation.

Publication link: https://doi.org/10.1063/5.0017763

For more details, contact Dr. P. Viswanath (Email: viswanath@cens.res.in).

New technology can make power generation from waste steam more efficient

DST Commiunication Team

Waste steam from industrial processes could be a significant source of power if the variability of steam pressure and flow can be corrected. A new technology developed by scientists has introduced a method of correcting such pressure and flow inconsistencies. This can save substantial power wasted in industrial processes in the form of steam, hence contributing to energy efficiency.

While large thermal power plants are improving their efficiency of power generation, the efficiency of use of steam in the process industry has received inadequate attention. Steam in process industries can be used for power generation as well, however, one of the main challenges being the variability of steam pressure and flow.

The Energy and Emission Research Group (EnERG) at IIT Madras, with the support of the Department of Science & Technology (DST), Government of India under the **Clean Energy Research Initiative,** has developed a steam expander (power generator) technology to correct irregularities in steam pressure and flow.

While many small steam engines exist in the world, the expander from EnERG lab can dynamically handle process steam and produce 25 – 50% more power output for the same range of flow and pressure conditions. An International Patent for the steam expander has also been filed by the Inventors Vipin Venugopal and Satyanarayanan Seshadri.

The new expander technology controls the port opening duration to regulate the mass flow through it, thus enabling the expander to operate at maximum pressure available at inlet for entire turn down. Conventional expander typically uses throttle governing for controlling the mass flow rate. This leads to reduction in admission and thus reduces the energy (energy that is available to be used) of steam prior to admission in the expander. By adjusting

the port opening duration dynamically by sensing the process load, the technology developed in EnERG lab completely avoids throttling ahead of admission for variable load operation and hence can maintain the efficiency of the expander for a wider range of turndown conditions.

In order to maximize the energy utilization of steam in the steam expander, admission volume is dynamically adjusted. This is achieved by changing the valve profile on the rotating inlet valve by moving it back and forth with the help of a spline mounted cam (which is a 3D geometry providing smooth and continuous motion of the mechanism controlling the valve motion). The valve is in synchronous motion with the crankshaft by using timing gears. The operation of the valve is automated by using process pressure as a signal to a piston mounted on the backside of the valve.

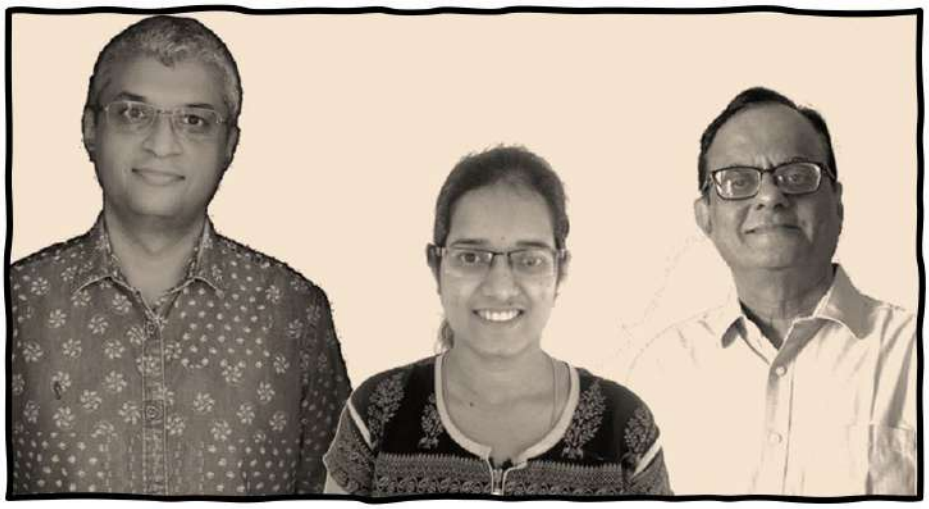
About 15 GW of power generation potential is mostly untapped in process industries due to the use of Pressure Release Valve (PRV) for pressure reduction from boiler pressure to process pressure. This is almost equivalent to adding 75 – 100 GW of solar Photovoltaic installed capacity and available at a fraction of cost at Rs1.1/kWh. Incremental fuel consumption of the boiler is negligible, making this technology to reduce carbon footprint.

Demystified transformation of glass to crystal that helps in dispose of liquid nuclear waste

DST Commiunication Team

Glass is a non-crystalline, often transparent amorphous solid which is mostly formed by rapid cooling of its molten form. However, under certain conditions, during its formation, molten glass may rebel and transform to a crystal - the more stable state, an avoidable process called devitrification.

However, the process of devitrification remains poorly understood as this process can be extremely slow, and this makes it difficult to study it. Scientists have now visualized devitrification in an experiment, thus taking a step closer to understanding it. This could help avoid devitrification in processes of pharma industries – a sector in which dodging this is of paramount importance. This is because an amorphous drug dissolves faster than after devitrification, and ensuring that it remains amorphous is therefore essential during storage.

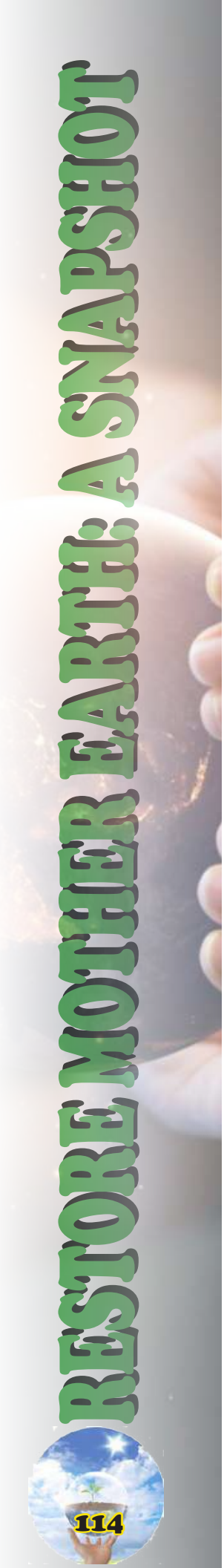


A team of researchers led by Shanti Swarup Bhatnagar Prize recipient in Physical Sciences (2020) category Prof. Rajesh Ganapathy from Jawaharlal Nehru Centre for Advanced Scientific Research, an autonomous institute of the Department of Science & Technology (DST), Government of India in collaboration with Prof. Ajay Sood (IISC) and their graduate student Ms. Divya Ganapathi (IISC) observed glass made of colloidal particles and monitored their dynamics over several days.

Using real-time monitoring of the particles with an optical microscope and machine learning methods to determine subtle structural features hidden in the glass, they identified a parameter called 'softness', which determines the extent of devitrification. They found that regions in the glass which had particle clusters with large "softness" values were the ones that crystallized and that "softness" was also sensitive to the crystallization route.

The authors fed their machine learning model pictures a colloidal glass, and the model accurately predicted the regions that crystallized days in advance. The authors suggest that techniques to tune "softness" by introducing impurities may help realize long-lived glass states, which has numerous technological applications. The research published in the journal Nature Physics can also help in vitrification of liquid nuclear waste as a solid in a glass matrix to safely dispose it deep underground and prevent hazardous materials from leaking into the environment

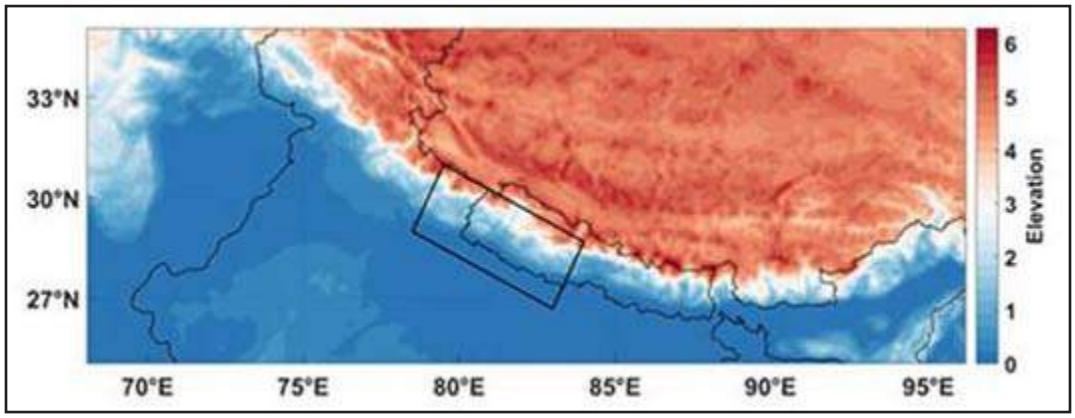
For more details, Prof. Rajesh Ganapathy's (george@jncasr.ac.in; 98806 71639) can be contacted.



Aerosols in Indo-Gangetic Plain enhanced high rainfall near the Himalayan foothills

DST Commiunication Team

Scientists have found that aerosols like black carbon and dust, which makes the Indo-Gangetic Plain one of the most polluted regions of the world, have led to increased incidents of high rainfall events in the foothills of the Himalayan Region.



Map of Global Multi-resolution terrain Elevation Data 2010 (GMTED2010) in kelometers, provided by the US Geological Survey. Thin black lines mark country borders. The black rectangle marks the domain on the foothills of the Himalayas that was used in this study.

The Indo-Gangetic Plain, one of the most polluted regions of the world, is located South and upwind of the Himalayan foothills. The region is associated with high aerosol loading, much of which is black carbon and dust, and thus provides an opportunity for studying how aerosol effects affects extreme rainfall events, particularly when air mass is forced from a low elevation to a higher elevation as it moves over rising terrain technically called orographic forcing.

A team of researchers from National Institute of Technology Rourkela, Leipzig Institute for Meteorology (LIM), University of Leipzig, Germany, Indian Institute of Technology Madras, Indian Institute of Technology Kanpur supported by the Department of Science & Technology, Government of India under DST Climate Change program have highlighted the crucial role of the aerosol direct radiative effect on high precipitation events over the Himalayan region. The findings of the current work have been accepted for publishing in the scientific journal 'Atmospheric Chemistry and Physics' recently. They showed that particulate emissions can alter the physical and dynamical properties of cloud systems and, in turn, amplify rainfall events over orographic regions downwind of highly polluted urban areas.

The study used 17 years (2001–2017) of rainfall rate, aerosol measurements called aerosol optical depth (AOD), meteorological reanalysis fields such as pressure, temperature, and moisture content at different altitudes are used to compute the thermodynamic variable "moist static energy" and outgoing long-wave radiation from Indian region to investigate high precipitation events on the foothills of the Himalayas. The team found clear associations between high precipitation events, high aerosol loading, and high moist static energy (MSE) values (Moist static energy of an air mass includes the potential energy due to its height above the ground and the latent heat due to its moisture content). The findings also highlight the crucial role of the radiative effect of aerosol on high precipitation events over the Himalayan region.

The results of the study indicate that aerosols can play a vital role in exciting high precipitation events over the Himalayas during the monsoon season. Thus, aerosols, including chemistry, are essential to consider when forecasting HP events over the Himalayan region in regional modelling studies.

Publication link: https://acp.copernicus.org/preprints/acp-2020-440/

For further details, Bhishma Tyagi (bhishmatyagi@gmail.com) and Goutam Choudhury (goutam3003@yahoo.com) can be contacted.

Exploring Himalayan geological dynamics, natural hazards, climate variability, and natural resources

DST Commiunication Team

The Wadia Institute of Himalayan Geology (WIHG) at Dehradun has acquired a significant place in the national and global community exploring earth science aspects of the Himalaya. The sui generis nature of this institute possesses nearly all state-of-the-art earth sciences equipment under one roof that provides flawless data to whole geosciences academia nationwide on a range of areas like settling the stratigraphy of Himalaya, landslide and flood hazards, river landscape of Himalayas, as well as the seismic network.

The age of the Lesser Himalayan rock was a hot debate amongst the geoscientists and considered to be Upper Palaeozoic (~570-500 million years ago). The year 1983 dawned with WIHG putting to rest all controversies. Abundant, index conodont fossils were discovered from the Tal rocks which fixed the age as Late Precambrian (4600-540 mya) to Cambrian (540-485 mya). The subsequent discovery of acritarchs and microfossils of Ediacaran age from Infra Krol and Krol A rocks confirmed this changing the chronology of rock superposition in Himalaya and shifting the global biotic correlations and configuration continental assembly of Gondwana land.

Striving to understand how the geology of Himalaya and rainfall distribution play an important role in identifying hotspots of mass wasting, the institute has played a leading role in treating chronic landslide at Varunavat in Uttarkashi. Landslide hazards zonation has been delineated in Itanagar Capital Complex.

Having developed new tools for mapping and understanding large floods and their impact on the Landscape of Himalaya, which are vulnerable to the society, WIHG played a pivotal role in helping understand the devastating 2013 Kedarnath floods under the “Mapping the Neighbourhood in Uttarakhand (MANU)” initiative of DST and helped in preparing a guideline on alleviating societal vulnerabilities during large floods.

The institute has produced the largest database on the chronology, sedimentary architecture, and landscape evolution of rivers Indus, the Ganga, the Brahmaputra and tributaries in the Himalaya. A study comprising details on the Indus, the Ganga, the Brahmaputra and their tributaries flowing across full climatic and tectonic spectrum of Himalaya established the concept of climate change leading to river erosion and formation of terraces with known hotspots of deposition, has been globally accepted.

WIHG established a seismic network in 2005 to monitor the seismicity pattern of the central seismic gap comprising the regions of Garhwal, Kumaun, and Himachal Himalaya recording observations which have gone a long way to assess earthquake and landslide risk in these areas. Further, exploring deep earth structures of the crust and lithosphere below the Himalaya has also been frontline research of WIHG leading to passive seismological studies that defined the geometry of the Main Himalayan Thrust (MHT) and identified seismically active areas and the propensity of other areas to such activity.

These reflect the tip of the iceberg of the achievements of this institute at Dehradun, an autonomous institute of the Department of Science & Technology (DST) which has been pursuing basic and applied research to unravel the orogeny of the majestic Himalaya for improved understanding on sciences (geodynamics, seismogenesis, climate-tectonic interactions, evolution and extinction of life) and providing implications for society (natural hazards due to earthquakes, landslides, floods etc., natural resources (glaciers, river and spring waters, geothermal, hydrocarbons, minerals and precious ores, anthropogenic influence etc.). It is driven by the vision - 'Questing for Himalayan Seismogenesis, Geodynamics, Natural Hazards, Climate Variability and Natural Resources through Geoscientific study to fulfil the Societal Needs and pursue Basic Sciences'.

The research activities in understanding the mountain-building processes and its impacts to the surface and subsurface processes to address the above are based on observations made by several branches of geosciences: structural geology, petrology, paleontology, stratigraphy, sedimentology, geomorphology, passive & active seismology, geophysics, remote sensing, engineering geology and so on. Special emphasis has been laid on providing implications of upstream climate change on the Himalayan glaciers and their consequences to the downstream river system, which is the lifeline of tens of millions in the plain. The study of slope instability for landslides, and flash floods, and lake-outburst floods are other important areas of research.

The WIHG is well equipped with sophisticated analytical instruments. The facilities are being utilized not only by the research scientists of WIHG but also by the researchers of the state & central universities, other institutes, and organizations.

Desalination membranes using graphene oxide liquid crystals may soon help bring down costs of clean water access

DST Commiunication Team

Large-area desalination membranes to be developed using graphene oxide liquid crystals may soon help access clean water at low cost through energy efficient means.

Access to clean water is an increasing challenge. Current strategies to address the problem are plagued with high cost and energy.In order to address the problem in a sustainable manner Dr. Suryasarathi Bose, Associate Professor Indian Institute of Science (IISc), Bangalore one of the recipients of Swarnajayanti Fellowship of the Department of Science and Technology (DST) plans to develop large-area 'printed' desalination membranes derived from external stimulus like magnetic and electric field and shear forces aligned graphene oxide liquid crystals.

Dr Bose's research group is already involved in designing membranes, using polymeric blends as a template which are robust and easy to fabricate and with a unique set of properties like high flux, low fouling, chlorine resistant and so on. To further improve the properties of the membrane, he proposes to design membranes with amphiphilic (having both hydrophobic and hydrophilic properties) graphene oxide (GO) consisting of both polar (oxygen containing functional groups like COOH, OH and -O-) and non-polar parts (graphitic structure) that can be explored for nanofiltration and desalination applications.

Currently, his group at the Indian Institute of Science (IISc), Bangalore is involved in designing membranes using phase separation in polymeric blends like in polyethylene (PE) and polyethylene oxide (PEO) as a template with a gradient in pore sizes. Such structures can offer ample opportunities in various separation technology in general and water remediation in particular. The flux through these novel membranes is quite high as compared to conventional membranes owing to these unique nano-channels created by selective etching. This research work has been published in the '*Journal of Materials Chemistry A*.'

His research group has also developed novel materials that can trap heavy metals, are antibacterial, and can resist biofouling-- one major concern in separation technology as it affects the performance of the membranes severely. Membranes derived using the above techniques can further be explored for water remediation in general and desalination applications in particular.

The membrane Dr Bose plans to fabricate pooling all these properties together and improving them further, will have potential applications in the desalination of brackish water,

will be affordable and less energy-intensive. The plan is quite relevant to the Indian context given that the freshwater aquifers are either getting contaminated due to rampant disposal of organic waste resulting in leachate that enters the nearby water bodies or are drying out due to rapid urbanization resulting in encroachment of aquifers.

Publication link: https://doi.org/10.1039/C4TA03997A

For further details contact Dr Suryasarathi Bose (sbose@iisc.ac.in).

Geological structure that triggers large concentration of micro and moderate earthquake near Kumaon Himalaya

DST Commiunication Team

Scientists have unearthed large concentrations of micro and moderate magnitude earthquakes in the Dharchula region and adjoining areas of the Kumaon Himalaya due to critical stress in the region and explored the geological structure behind the stress.

The region between the Kangra (1905) and Bihar-Nepal (1934) earthquakes has not yet experienced great earthquake of magnitude greater than 8.0 since last 500 years, and hence the region is known as Central Seismic Gap (CSG) region. However, the Kumaon Central Himalayan, which belongs to this CSG region, is one of the most seismically active regions of the Himalayan belt that experienced considerable number of moderate and strong earthquakes in the recent past.

Figure 14: Simplified geological map of the Kumaon Himalaya and adjacent regions with major tectonic features (modified after Srivastava & Mitra 1994). Seismological stations used in the study are shown by the red (WIHG Network) and blue (Kumaon University network) triangles (left side figure). Right side figure, (a) The common conservation point (CCP) depth migrated RF image along the A-B profile (a). Red and blue indicative positive and negative impedance contrast, respectively. The 1-D velocity models obtained for individual stations are superimposed over the CCP image. The CCP image, as well as the shear wave velocity models, suggest a lower crustal low-velocity zone (LVZ) marked by a green dotted ellipse. (b) The depth variations of Vp/Vs ratio estimated at each station are shown in the depth projection along the AB profile.

Scientists from Wadia Institute of Himalayan Geology (WIHG), Dehradun, an autonomous institute under the Department of Science & Technology, Govt. of India, established a seismological network comprised of 15 broadband seismological stations along the Kali River valley to investigate the subsurface configuration and causes of frequent felt earthquakes in the Kumaon Himalaya region with support from the Ministry of Earth Sciences (MoES), New Delhi.

They found that the stress was caused by a ramp (thin-skinned thrust fault geometry that forms a step-like pattern) on the Main Himalayan Thrust (a gliding plane between two rock masses under the Himalayan Range) beneath the Chiplakot Crystalline Belt, a geological unit in the lesser Himalayas.

The results published recently in the 'Geophysical Journal International' revealed the crust to be thinner (38-42 km thick) compared to the similar litho tectonic unit of northwest Himalayas. The ramp structure (of slope around 20o) found on the MHT beneath the

Chiplakot Crystalline Belt (CCB) facilitates the exhumation of the CCB. The cluster of seismicity coincides with the ramp on the MHT beneath the CCB, suggesting that the region is critically stressed. Although, in contrast to the brittle upper crust where stress builds up until fracture occurs, a ductile lower crust can dissipate stress by the flow on a geological timescale. Any rapid drop in stress or high strain rates can cause a ductile lower crust to behave in a brittle-elastic manner under the same temperature conditions, according to the WIHG team.

Publication Link: https://academic.oup.com/gji/article-abstract/224/2/858/5917988?redirectedFrom=fulltext

SUCCESS STORIES

Dedicated efforts and years and months of campaigning makes millions of significant change that contributed towards protecting our environment. Throughout the nation, initiatives and programmes to protect our nature and conserve our natural resources were driven by governments, scientists, NGOs, and indigenous communities. Many of these efforts have been widely successful and able to make a difference. Here we enlisted some of the national-level programmes with their success stories.

Section Guidelines

Energy Science and Waste to Value Programme

Environmental Biotechnology Programme

Green Skill Development Programme

The MONTREAL PROTOCOL: India's Success Story

A Compilation on "CLIMATE FRIENDLY LIFESTYLE PRACTICES IN INDIA"

Energy Science and Waste to Value Programme

The Energy Bioscience Division of the Department of Biotechnology (DBT) has been promoting cutting edge research in biofuel areas through Centre of Excellence, extramural projects, fellowship schemes and international cooperation. The focus of the 'Energy

Science & Waste to Value Programme' is to make available cost-effective biofuel technology by improving feedstock or developing new feedstock, improve biofuel production technologies, and develop enzymes/microorganisms for higher yields of biofuels. It also seeks to develop advanced biofuels, and value added products from by-products. For this task, DBT has set up four Bioenergy Centres at DBT-ICT Centre for Energy Biosciences, DBT-IOC Centre for Advanced Bioenergy, DBT-ICGEB Centre for Advanced Bioenergy Research and DBT Pan-IIT Centre for Bioenergy.

Technologies/ products developed at these DBT-Bioenergy Centres are taken forward for scale-up/ demonstration at pilot scale.

For more details: https://dbtindia.gov.in/schemes-programmes/research-development/energy-environment-and-bio-resource-based-applications-1

Environmental Biotechnology Programme

The Environmental Biotechnology Programme of the Department of Biotechnology supports research and development (R&D) programme in the areas relevant to waste management and environmental improvement; development and demonstration of wastewater-specific effective bioremediation options like natural attenuation to bio-stimulation, bio-augmentation or a combination of filtration, phytoremediation and microbial degradation; and bio-restoration technologies for restoration of degraded ecosystems. New R&D programmes / projects have been initiated on various aspects of development of treatment process of industrial effluent, bioremediation of xenobiotic compounds, biodiversity conservation & characterization of biodiversity, carbon sequestration, etc. The river cleaning programme has also been launched to develop and demonstrate various wastewater clean-up options.

Along with that, the Department has also initiated R&D projects on remediation and reclamation of Hexa-Chloro-Cyclo-Hexane (HCH) dumpsites by using microbial bioremediation technology; bioconversion of CO_2 to platform chemicals through microbial catalyzed electrochemical approaches; development and demonstration of pulp paper mill effluent detoxification technology after secondary treatment by a combination of bio-augmentation and constructed wetland treatment process for re-use and prevention of river pollution; design of biosensor for detecting xenobiotic pollutants in river water; and development of novel fluorescent platforms for the detection of heavy metals in water.

For more details: https://dbtindia.gov.in/schemes-programmes/research-development/energy-environment-and-bio-resource-based-applications-0

Green Skill Development Programme

Realising the need for developing green skills in the general public, the Ministry of Environment, Forest & Climate Change (MoEF&CC) launched the Green Skill Development Programme (GSDP) under the ongoing Environmental Information System (ENVIS) Scheme in June 2017 to skill youth in environment, forest and wildlife sectors, which would enable them to be gainfully employed or self-employed. The full-fledged programme has been launched

through the mobile app on GSDP (gsdp-envis). It contains all the basic information about the training programmes being conducted under GSDP.

Currently, 44 GSDP Courses are being offered at 87 identified institutions which include ENVIS Hubs (hosted by the Environment/ Forest Department of State Governments/ UT Administrations), ENVIS Resource Partners or RPs (hosted by environment-related governmental and non-governmental organisations/ institutes of professional excellence), and autonomous bodies/ institutes under the Ministry. With duration ranging from 80 hours to 550 hours, they cover diverse fields. All skilling programmes are being aligned with the National Skills Qualifications Framework (NSQF), and requirement of the National Skill Development Agency (NSDA), Ministry of Skill Development and Entrepreneurship (MSDE).

For more details: http://moef.gov.in/en/division/environment-divisions/environmental-information-ei/green-skill-development-programe/

The MONTREAL PROTOCOL: India's Success Story

The Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer are the first treaties in the history of the United Nations to achieve universal ratification. India has played a proactive role in the implementation of phase out activities related to ozone depleting substances in the country and also adhered to the phase out schedule of the Montreal Protocol.

Adequate attention has also been given to synergize the refrigeration and air-conditioning servicing sector training under Hydrofluorocarbons Phase Out Management Plan (HPMP) Stage-II with the Skill India Mission of the Government of India. It is designed to multiply the impact of skilling and training. Under the Pradhan Mantri Kaushal Vikas Yojana (PMKVY), around 38,000 service technicians in the refrigeration and servicing sector have been upskilled and certified. The skilling and certification of service technicians will not only bring significant environmental benefits, but also have a positive influence on livelihoods. In the year 2020, India celebrated 35 years of the Vienna Convention and 35 years of global ozone layer protection. The Ministry of Environment, Forest & Climate Change has launched a compilation to showcase India's success story so far.

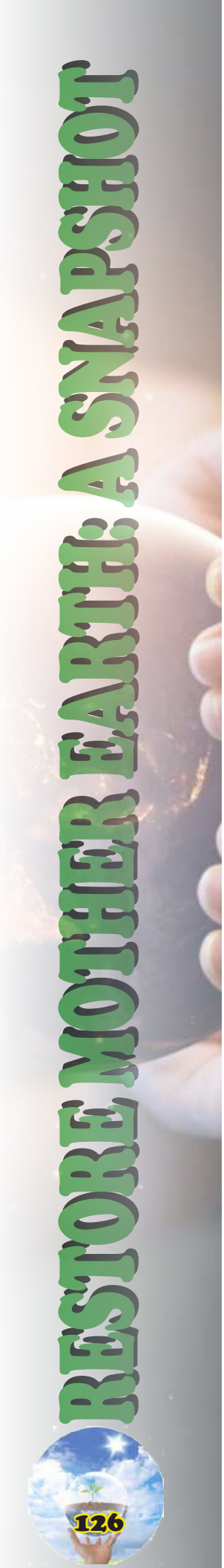
For more details: http://moef.gov.in/wp-content/uploads/2021/01/Success-Story-Book-2020.pdf

A Compilation on "CLIMATE FRIENDLY LIFESTYLE PRACTICES IN INDIA"

According to the Intergovernmental Panel on Climate Change (IPCC), anthropogenic greenhouse gas emissions (GHGs) are mainly driven by population size, economic activity, lifestyle, energy use, land use patterns, technology and climate policy. In contrast to

its population, Indians are the top-scoring environmentally sustainable consumers in the 2014 National Geographic/ GlobeScan Consumer Greendex. In India, traditional practices that are sustainable and environment-friendly continue to be a part of people's lives. India has had a history of low carbon footprint and lifestyle. These need to be encouraged rather than replaced by more modern but unsustainable practices and technologies. A communication resource developed by MoEF&CC aims to document some of these traditional, sustainable and climate-friendly lifestyles for wider outreach and dissemination.

For more details: http://moef.gov.in/wp-content/uploads/2017/08/Lifestyle-Brochure_web_reordered.pdf



REPORTS/DOCUMENTS

Section Guidelines

National

1. Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework
2. Assessment of climate change over the Indian region: A report of the Ministry of Earth Sciences (MoES), Government of India
3. India's National Report 2018 submitted to UNCCD
4. INDIA – Third Biennial Update Report to the United Nations Framework Convention on Climate Change
5. Rapid Assessment of the CDM and VCM Portfolio Report of India

International

1. The Climate Transparency Report 2020
2. Climate Change Performance Index 2021
3. Climate Change Performance Index 2021: Background and Methodology
4. The State of the Global Climate 2020
5. Emissions Gap Report 2020
6. IPCC Reports
7. Global Biodiversity Outlook (GBO)

8. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)
9. The Living Planet Report
10. State of Finance for Nature
11. Climate Change 2021: The Physical Science Basis

NATIONAL

1. Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework

The report, titled 'Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework', identifies the most vulnerable states and districts in India with respect to current climate risk and key drivers of vulnerability. Released by the Department of Science and Technology (DST), it was submitted by Indian Institute of Technology Mandi and Indian Institute of Technology Guwahati, in collaboration with Indian Institute of Science, Bengaluru. A total of 94 representatives from 24 states and 2 Union Territories participated in the nationwide exercise jointly supported by the DST and the Swiss Agency for Development & Cooperation (SDC).The report identified Jharkhand, Mizoram, Orissa, Chhattisgarh, Assam, Bihar, Arunachal Pradesh, and West Bengal as the states highly vulnerable to climate change. These states, mostly in the eastern part of the country, require prioritization of adaptation interventions.

https://dst.gov.in/sites/default/files/Full%20Report%20%281%29.pdf

2. Assessment of climate change over the Indian region: A report of the Ministry of Earth Sciences (MoES), Government of India

The report discusses and documents the impact of human-induced global climate change on the Indian subcontinent and regional monsoon, the adjoining Indian Ocean and the Himalayas. It also examines the regional climate change projections based on the climate models used by the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) and national climate change modelling studies using the IITM Earth System Model (ESM) and CORDEX South Asia datasets.

The IPCC assessment reports, published every 6–7 years, provide important reference material for major policy decisions on climate change, adaptation, and mitigation. While the IPCC assessment reports largely provide a global perspective on climate change, they offer limited information on the regional aspects of climate change. Regional climate change effects over

the Indian subcontinent, especially relating to the Indian monsoon, are unique to the region, In particular, the climate in this region is shaped by the Himalayas, the Western Ghats, the Tibetan Plateau, the Indian Ocean, the Arabian Sea, and the Bay of Bengal. Climatic variations in this region are influenced by (a) regional-scale interactions between the atmosphere, ocean, land surface, cryosphere and biosphere on different time scales; (b) remote effects from natural phenomena such as the El Nino/ Southern Oscillation, North Atlantic Oscillation, Indian Ocean Dipole, and Madden Julian Oscillation; and (c) human-induced climate change. The report presents policy-relevant information based on robust scientific analyses and assessments of the observed and projected future climate change over the Indian region.

http://cccr.tropmet.res.in/home/assessmentReport.jsp

3. India's National Report 2018 submitted to UNCCD

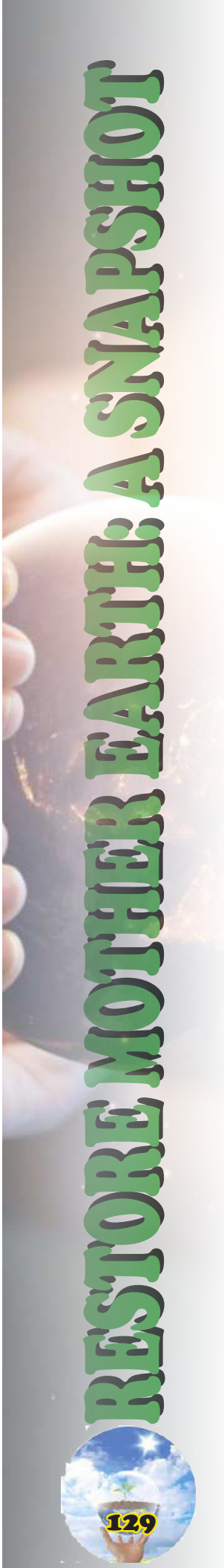
Desertification, climate change and the loss of biodiversity were identified as the greatest challenges to sustainable development during the 1992 Rio Earth Summit. Adopted in 1994, the United Nations Convention to Combat Desertification (UNCCD) entered into force in 1996 and became a legally binding international agreement linking environment and development to sustainable land management.

The Convention addresses specifically the issue of Desertification, Land Degradation and Drought (DLDD) in arid, semi-arid and dry sub-humid areas of drylands, which are home to some of the most vulnerable people and ecosystems in the world. The Convention's 195 parties work together to improve the living conditions for people in dry lands, maintain and restore land and soil productivity, and mitigate the effects of drought. India became a signatory to UNCCD on 14th October 1994 and ratified it on 17th December 1996. The Ministry of Environment, Forest and Climate Change (MoEF&CC) is the nodal ministry of the Government of India for the UNCCD, and Desertification Cell is the nodal point within the ministry to coordinate all issues pertaining to the Convention. As a party to the Convention, the Country Parties are obligated to submit national reports to the UNCCD periodically. The last report submitted by India was in 2018.

http://moef.gov.in/wp-content/uploads/2018/11/Indias-Report-Non-Editable.pdf.pdf

4. INDIA – Third Biennial Update Report to the United Nations Framework Convention on Climate Change

India is a Party to the United Nations Framework Convention on Climate Change (UNFCCC) and the Government of India attaches great importance to issues related to climate change. It recognises the urgency and importance of the actions that need to be taken collectively to meet the ultimate objective of the Convention, i.e., stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. India had submitted Initial National Communication in 2004, and Second National Communication in 2012. The Government of India has prepared the first Biennial Update Report (BUR) for submission to the United Nations Framework Convention on



Climate Change as an update to the most recently submitted National Communication, i.e., the Second National Communication. Recently, India has submitted its third BUR. This report embodies information on national circumstances, national greenhouse gas (GHG) inventory, mitigation actions, and an analysis of the constraints, gaps, and related finance, technology and capacity building needs, including information on domestic measurement, reporting and verification (MRV). The Ministry of Environment, Forest and Climate Change (MoEF&CC) is the nodal ministry of the Government of India (GoI) for coordination and management of climate change-related programmes, actions and reporting information under Article 4.1 of the Convention. The MoEF&CC, with its cross-ministerial and institutional network, is implementing and executing matters related to the National Communications and Biennial Update Reports (BURs).

https://cckpindia.nic.in/assets/KnowledgeRepository/Reports/INDIA_%20BUR-3_20.02.2021_High.pdf

5. Rapid Assessment of the CDM and VCM Portfolio Report of India

The Kyoto Protocol mandated country-by-country limitations or reductions in greenhouse gas (GHG) emissions. It set targets, allowing emission reductions to take on an economic value. This trading of Emission Reduction Units (ERs/ ERUs) allowed for developing carbon markets. The carbon markets help in reducing GHG emissions by enabling the trading of emission units, and further help in lowering the economic cost of reducing emissions. India is one of the few countries which responded initially to this carbon market mechanism and established the system in the country as per the requirement of the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). India currently has the second highest number of projects registered under the CDM (Clean Development Mechanism) after China. The objective of this report is to study the portfolio of projects and the potential generation of ERs (1 tCO2e) from Indian projects registered in the compliance market mechanism and the Voluntary Carbon Market (VCM) from 2013-2020 and 2020-2030.

https://cckpindia.nic.in/assets/KnowledgeRepository/Reports/FINAL_Rapid_Assessment_Report_CDM_VCM.pdf

INTERNATIONAL

1. The Climate Transparency Report 2020

The Climate Transparency Report (previously known as “Brown to Green Report”) is the world’s most comprehensive annual review of G20 countries’ climate action and their transition to a net-zero emissions economy. The review is based on 100 indicators for adaptation, mitigation and finance and aims to make good practices and gaps transparent. The summary report and profiles of 20 countries allow the report to be a clear reference tool for decision makers.

This year's report consists of two parts: the annual policy assessment based on data of the previous year(s) is complemented by an analysis of the impacts of the COVID-19 crisis and recovery efforts on countries' climate ambition.

https://www.climate-transparency.org/g20-climate-performance/the-climate-transparency-report-2020

2. Climate Change Performance Index 2021

The annual Climate Change Performance Index (CCPI), published since 2005, is an independent monitoring tool for tracking the climate protection performance of 57 countries and the EU. The CCPI aims to enhance transparency in international climate politics and enables comparison of individual countries' climate protection efforts and progress.

http://ccpi.org/download/the-climate-change-performance-index-2021/

3. Climate Change Performance Index 2021: Background and Methodology

The Climate Change Performance Index (CCPI) is an independent monitoring tool for tracking countries' climate protection performance. It aims to enhance transparency in international climate politics and enables comparison of climate protection efforts and progress made by individual countries. This publication explains how the CCPI 2021 is calculated. Furthermore, it lists the literature and data sources used for these calculations.

https://ccpi.org/download/background-and-methodology-ccpi-2021/

4. The State of the Global Climate 2020

The global climate system is complex. In order to unpack such complexity, the World Meteorological Organisation (WMO)'s annual State of the Global Climate report uses seven climate indicators to describe the changing climate—providing a broad view of the climate at a global scale and annually producing the State of the Climate report. It has been 28 years since the World Meteorological Organisation issued the first State of the Climate report in 1993. The report was initiated due to the concerns raised at that time about projected climate change. It is intended to help world leaders and citizens with the latest information about our earth system's behaviour and climate change impacts.

https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate

5. Emissions Gap Report 2020

For over a decade, the UNEP Emissions Gap Report has provided a yearly review of the difference between where greenhouse emissions are predicted to be in 2030 and where they should be to avoid the worst impacts of climate change.

The report finds that, despite a brief dip in carbon dioxide emissions caused by the COVID-19 pandemic, the world is still heading for a temperature rise in excess of 3°C this century – far beyond the Paris Agreement goals of limiting global warming to well below 2°C and pursuing 1.5°C. The report also analyses low-carbon recovery measures so far, summarizes the scale of new net-zero emissions pledges by nations and looks at the potential of the lifestyle, aviation and shipping sectors to bridge the gap.

https://www.unep.org/emissions-gap-report-2020

6. IPCC Reports

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. The IPCC prepares comprehensive Assessment Reports about knowledge on climate change, its causes, potential impacts and response options. It also produces Special Reports, which are an assessment on a specific issue, and Methodology Reports, which provide practical guidelines for the preparation of greenhouse gas inventories.

https://www.ipcc.ch/reports/

7. Global Biodiversity Outlook (GBO)

Global Biodiversity Outlook (GBO) is the flagship publication of the Convention on Biological Diversity (CBD). It is a periodic report that summarizes the latest data on the status and trends of biodiversity and draws conclusions relevant to the further implementation of the Convention.

The GBO-5 provides global summary of progress towards the Aichi Biodiversity Targets and is based on a range of indicators and research studies and assessments (in particular the IPBES Global Assessment on Biodiversity and Ecosystem Services) as well as the national reports provided by countries on their implementation of the CBD. The national reports provide rich information about the steps taken in countries worldwide in support of biodiversity conservation, sustainable use, and the fair and equitable sharing of benefits.

https://www.cbd.int/gbo/gbo5/publication/gbo-5-en.pdf

8. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

IPBES is to perform regular and timely assessments of knowledge on biodiversity and ecosystem services and their interlinkages at the global level. The overall scope of the assessment is to assess the status and trends with regard to biodiversity and ecosystem services, the impact of biodiversity and ecosystem services on human well-being and the effectiveness of responses, including the Strategic Plan and its Aichi Biodiversity Targets. It is anticipated that

this deliverable will contribute to the process for the evaluation and renewal of the Strategic Plan for Biodiversity and its Aichi Biodiversity Targets.

https://ipbes.net/global-assessment

9. The Living Planet Report

The Living Planet Report, the World Wildlife Fund (WWF)'s flagship publication released every two years, is a comprehensive study of trends in global biodiversity and the health of the planet. The Living Planet Report 2020 is the 13th edition of the report and provides the scientific evidence to back up what nature has been demonstrating repeatedly: unsustainable human activity is pushing the planet's natural systems that support life on earth to the edge.

Through multiple indicators, including the Living Planet Index (LPI), provided by the Zoological Society of London (ZSL), the report shows an average 68 per cent fall in almost 21,000 wildlife populations between 1970 and 2016. It calls on world leaders to come together to build a more sustainable, resilient and healthy post-COVID-19 world for people and nature.

https://livingplanet.panda.org/en-us/

10. State of Finance for Nature

The State of Finance of Nature tracks global trends in public and private investments in nature-based solutions, aiming to improve data quality and identify opportunities for governments, businesses and financiers. This year's report calls for investments in nature-based solutions to triple by 2030 and four-fold by 2050 from the current level. While an increase in public funding would help plug some of the gaps, there needs to be a significant increase in private sector investments in nature-based solutions. The report also offers recommendations and lays out opportunities to increase investment in nature-based solutions.

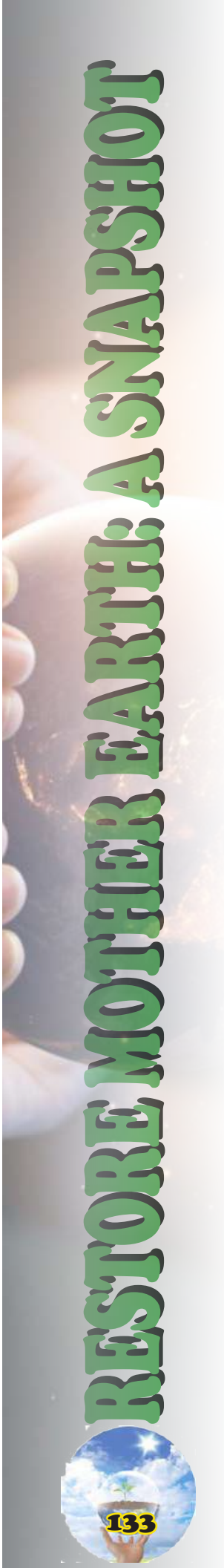
https://www.unep.org/resources/state-finance-nature

11. Climate Change 2021: The Physical Science Basis

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)

The IPCC Working Group I report, Climate Change 2021: the Physical Science Basis, is the first installment of the IPCC's Sixth Assessment Report (AR6), which will be completed in 2022. On 6th August 2021, the report got approval by 195 member governments of the IPCC, through a virtual approval session.

The report addresses the most updated physical understanding of the climate system and climate change, bringing together the latest advances in climate science, and combining multiple lines of evidence from paleoclimate, observations, process understanding, global and regional climate simulations. It shows how and why climate has changed to date, and the



improved understanding of the human influence on a wider range of climate characteristics, including extreme events. There will be a greater focus on regional information that can be used for climate risk assessments.

The report suggests that scientists are observing changes in the Earth's climate in every region and across the whole climate system. Many of the changes observed in the climate are irreversible over hundreds to thousands of years. However, strong and sustained reductions in emissions of carbon dioxide (CO2) and other greenhouse gases would limit climate change.

https://www.ipcc.ch/report/ar6/wg1/

DAYS TO REMEMBER!

JANUARY

05 January	National Bird Day
24 January	International day of Education
30 January	National Cleanliness Day

FEBRUARY

02 February	World Wetland Day
27 February	International Polar Bear Day
28 February	National science day

MARCH

03 March	World Wildlife Day
14 March	International Day of Action for Rivers
15 March	World consumer Right day
18 March	Global Recycling Day
20 March	World Sparrow Day
21 March	World forestry day

RESTORE MOTHER EARTH: A SNAPSHOT

22 March	World Water Day
23 March	World Meteorological day & World Resources Day
27 March	Earth Hour

APRIL

07 April	World Health Day
18 April	World Heritage Day
22 April	Earth Day
30 April	Arbor Day

MAY

04 May	World Asthma Day
08 May	World Migratory Bird Day
20 May	World Bee Day
21 May	Bike to Work Day
22 May	International Day for Biological Diversity
23 May	World Turtle Day
31 May	Anti-Tobacco Day

JUNE

05 June	World Environment Day
08 June	World Oceans Day
15 June	Global Wind Day
17 June	World Day to Combat Desertification and Drought
21 June	International Climate change day
22 June	World Rainforest Day

JULY

11 July	11: World Population Day
28 July	World Nature Conservation Day
29 July	World Tiger Day

AUGUST

10 August	World Lion Day & International Biodiesel Day
12 August	International Youth Day & World Elephant Day

19 August	International Orangutan Day
20 August	Akshay Urja Diwas

SEPTEMBER

07 September	International Day of clean Air for blue skies
16 September	World Ozone Day
18 September	International Coastal Clean Up Day
22 September	World Car-Free Day
26 September	World Rivers Day
28 September	Green Consumer Day

OCTOBER

04 October	World Animal Welfare Day & World Habitat Day
13 October	International Day for Disaster Reduction
14 October	International E-Waste Day
15 October	Global Handwashing Day
16 October	World Food Day
24 October	International Day of Climate Actions

NOVEMBER

15 November	International Jaguar Day
18 November	World COPD Day
19 November	World Toilet Day

DECEMBER

02 December	National Pollution Prevention Day
05 December	World Soil Day
11 December	International Mountain Day
14 December	National Energy Conservation Day

VIGYAN PRASAR

A-50, Institutional Area, Sector 62
NOIDA 201 309 (Uttar Pradesh) India
Phones: 0120-240 4430-35
Fax: 0120-240 4437
Email: info@vigyanprasar.gov.in