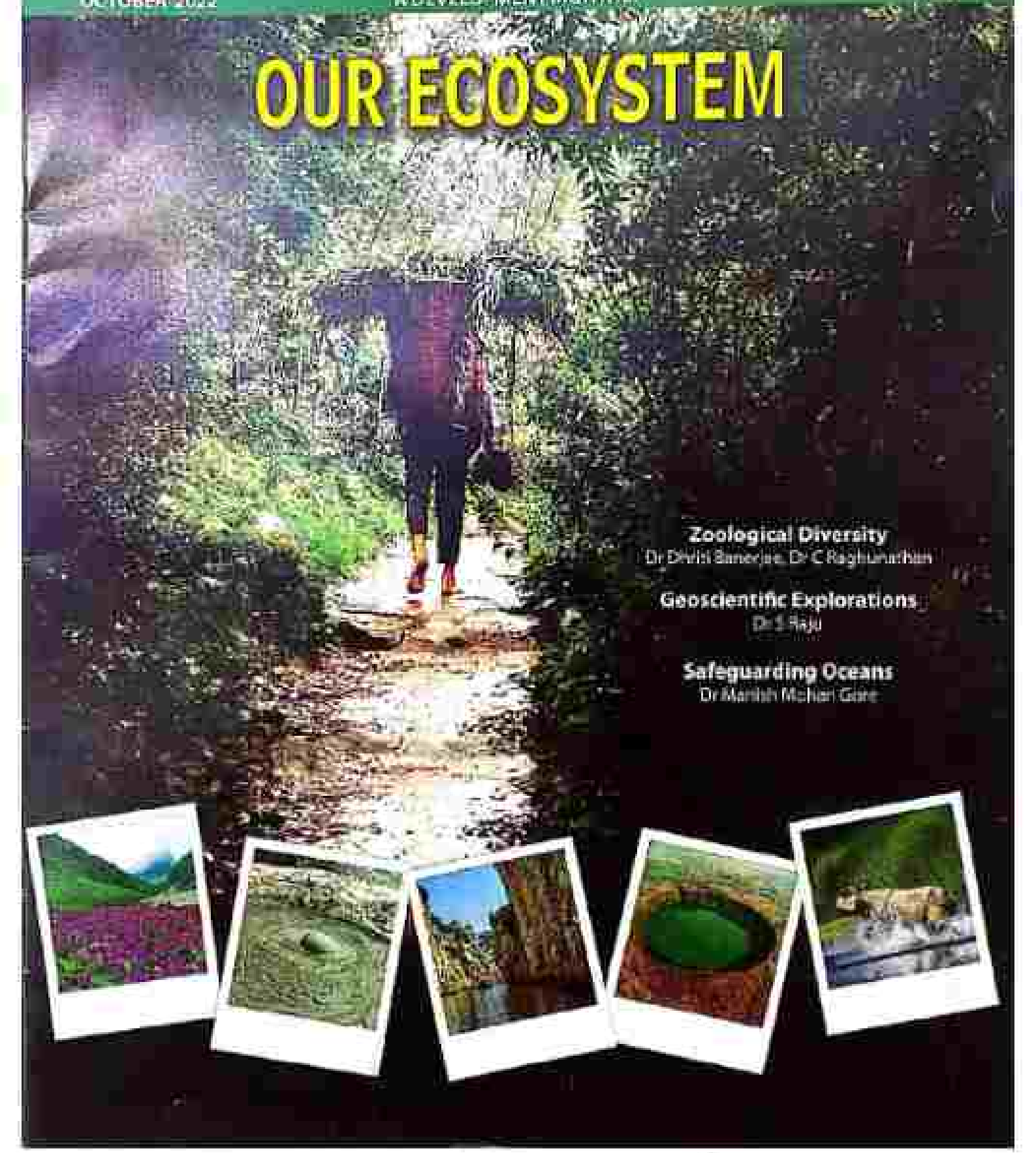
YOJANA

OCTOBER 2022 A DEVELOPMENT MONTHLY ₹22

OUR ECOSYSTEM



Zoological Diversity
Dr Divisti Banerjee, Dr C Raghunathan

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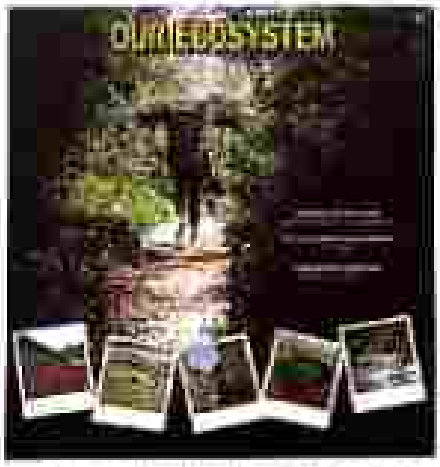
The World Around Us



Humankind represents a very small fraction of the universe, which encompasses innumerable species of plants and animals around us. We might not even see most of them in our lifetime. The life, as we see around us, is said to be a phenomena of around 3.8 billion years with signs of biological activity even before that. Where we live today took shape when the Indian subcontinent drifted apart from the bigger landmass of Gondwana and almost settled itself to the lower part of the existing landmass. It also brought along with it the species from its parent land and waters that adapted and evolved according to the newer environment. Humans emerged much later when all these changes had mostly settled down.

The delicate balance between these lives and us is what forms the ecosystem. It is our basic life support system – abiotic system that includes the air we breathe, the land we live on, the water we drink as well as the biotic system, i.e., the vegetation that provides us the food, and the living beings that surround us. The realisation that this balance determines the socio-economic development and economic growth led the policies and practices towards sustainable development in India. The critical relationship between water, environment and ecosystems was acknowledged, built upon, shaped and transformed in a sustainable way to meet the challenges without compromising on the health of the natural world.

The unique topography of Indian subcontinent has blessed the land with various landforms, forests, water bodies, wetlands, and climate due to which forms of lives flourish around us. Different organisms are found in different ocean depths, providing a colourful spectrum to marine life and its ecosystem. According to scientific studies, so far, about 2.5 lakh marine life species have been identified all over the world. Scientists estimate that two million more species existing in the ocean are yet to be discovered. The Andaman and Nicobar Islands, for example, support a luxuriant and rich vegetation due to tropical hot and humid climate with abundant rains. The coral reefs of these islands is the second richest found in the world. They provide different varieties of animal life of which, the coral reefs ecosystem constitutes the most fragile and interesting faunal element as elsewhere in the Indo-Pacific Reefs. Odisha is one of the rich biodiversity States, which is indicated by the presence of 7,500 species of flora and fauna, of which 2,550 are angiosperms, 1,366 are vertebrate species, 574 are bird species and rest are mammals, reptiles, amphibians, fish, etc.

Biodiversity plays a pivotal role in maintaining the ecological balance in nature and is found in abundance in Northeastern region (NER). The region sharing Himalayan and Indo-Burma biodiversity hotspots, serves as the native habitat for valuable natural flora and fauna. Nowadays, indigenous bioresources of NER have experienced a number of challenges, such as habitat destruction due to rise in human population, illegal mining, landslide, and eutrophication and illegal trading of medicinal plants. The government is undertaking several initiatives to overcome these as well.

With the intent to have a holistic view for maintaining and conserving ecological balance, India is taking several measures. It has banned the manufacture, import, stocking, distribution, sale and use of identified single use plastic items, which have low utility and high littering potential, all across the country from 1 July 2022. Another initiative taken by the Government is National Mission for a Green India. It is one of the eight Missions under the National Action Plan on Climate Change and was launched in order to safeguard the country's biological resources and associated livelihoods against the perils of Climate Change. It aims at protecting, restoring, and enhancing India's forest cover and responding to Climate Change. It also aims at recognising the vital impacts of forestry on ecological sustainability, biodiversity conservation, and food, water, and livelihood security for the nation.

Zoological Diversity

Dr Dhriti Banerjee
Dr C Raghunathan

India is one of the mega-biodiversity countries in the world with unique biogeographical locations, diversified climatic conditions and wide array of ecosystems from deep sea to high mountain ranges at Himalayas. During the century, a variety of terrestrial and marine ecosystem areas, especially the diversity-rich areas in the forest ecosystems, grasslands, coastal plains (terrestrial ecosystem types), and varying coastal/ marine ecosystems, including coral-reef ecosystems have been explored in India.

According to world biogeographic classification, India represents two of the major realms, the Palaearctic and Indo-Malayan, and three biomes viz. Tropical Humid Forests, Tropical Dry Deciduous Forests, and Warm Deserts/Semi-Deserts. Indian landmass has been classified into 10 Biogeographic Zones and ZSI documented the faunal resources in all biogeographic zones to the extent of 30,377 species in the Himalayas, 3,324 species in Trans-Himalayas, 11,009 species in Islands, 18,527 species in Northeast, 3,346 species in Desert, 7,424 species in Semi-Arid, 11,883 species in Coasts, 17,099 species in the Western Ghats, 14,640 species in Gangetic Plains, and 15,239 species in Deccan Peninsula. In order to protect biodiversity, 960 Protected Areas spreading over 5.27% of the country's geographical areas have been designated, of which faunal communities have been thoroughly listed among 120 Protected Areas by the Zoological Survey of India (ZSI).

The ZSI under the Ministry of Environment, Forest and Climate Change (MoEF&CC) is a more than a century-old organisation, established in 1916, for inventorying the faunal resources of the country right from Protozoa to Mammalia. It has contributed to the revision of the Wildlife (Protection) Act, 1972 by Govt of India and has advised on the matter related to faunal diversity and conservation in different international forums. Headquartered in Kolkata, with its 16 Regional Centres spread across the country, ZSI is studying the Indian fauna of all the States, UTs, and Protected Areas present in different ecosystems.

Great Indian Bustard in Desert National Park, Rajasthan

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Golden Langur found primarily in Assam

Alligator, 1,03,258 species have been documented in India. Among the animals reported from the country, 2,941 species are protected under different schedules of the Wildlife (Protection) Act, 1972 for better conservation.

Coastal and Marine Biodiversity

India is endowed with a long coastline of 7,516.6 km on the mainland, Lakshadweep, and the Andaman & Nicobar Islands. The country has the 18th largest Exclusive Economic Zone (EEZ) with a total area of 2.37 million square kilometres. In the Indian Ocean region, India is one of the highest marine biodiversity countries for 20,444 species. Besides, 9,457 species from freshwater, 3,939 species from estuarine, and 5,747 species from mangrove ecosystems have been recorded in the country. Among the Indian fauna, 5,652 species have been included in various categories on 'IUCN Red List' which requires much attention for conservation.

State Fauna

ZSI has made notable progress in its mandatory scientific function of faunistic survey/exploration of India towards documenting its faunal wealth. During the last 107 years, a variety of terrestrial and marine ecosystem areas, especially the diversity-rich areas in the forest ecosystems, grasslands, coastal plains (terrestrial ecosystem types), and varying coastal/marine ecosystems, including coral-reef ecosystems, were explored. The faunal diversity of 28 States and Union Territories has been published.

New Discovery

Scientists of ZSI are describing new species at the rate of 125 to 175 per year. Till December 2021, a total of 5,300 species have been described as new to science. In 2021, ZSI discovered one new genus and 131 species and recorded 102 species.

Status Survey

Significant progress made in the monitoring of the status of the endangered/rare species of animals was undertaken: Arthropods: Horseshoe Crabs (*Carcinoscorpius rotundicauda* and *Tachypleus gigas*); Robber Crab (*Birgus latro*); Cnidaria: corals of Andaman and Nicobar Islands and corals of Gulf of Kutch, and Lakshadweep waters; amphibians of Western Ghats; birds viz. Great Indian Bustard (*Ardeotis nigriceps*, Vigors), Nicobar Megapode and Black-necked Crane (*Grus nigricollis*); Golden Langur (*Trachypithecus geei*, Khajuria); Hoolock Gibbon (*Hoolock hoolock*, Harlan); Himalayan Musk Deer (*Moschus chrysogaster*, Hodgson); Crab-eating Macaque (*Macaca fascicularis umbrosa*, Miller); Swamp Deer (*Rucervus duvaucelii*, Cuvier); Wild Ass (*Equus hemionus khur*, Lesson); and Himalayan Blue Sheep (*Pseudois nayaur*). Moreover, long-term monitoring of sea turtles and other threatened fauna are also being undertaken by ZSI. Recently, ZSI has taken an initiative of a massive tagging programme of Olive Ridley sea turtles along the Odisha coast and Leatherback turtles in Great Nicobar Island for tracking their migration and movement between feeding and breeding areas in the Bay of Bengal and the Indian Ocean. ZSI has also initiated several innovative programmes from the molecular level to the monitoring of fauna. There are at least 37 species of mammals genetically identified from Himalayan regions through non-invasive genetic study techniques. Similarly, the population genetics of Arunachal Macaque (*Macaca munzala*) and population genetics of Barking Deer (*Muntiacus muntjak*), as well as Chinese Pangolin, have been carried out by scientists of ZSI. Studies viz. phytogeography patterns of ibex and adaptive spatial planning of Protected Area network for conserving the Himalayan brown bear, as well as distribution of modeling and climate change risk assessment strategy for rare Himalayan Galliformes species using archetypal data abundance with cohorts for adaptation planning and other such research taken up by ZSI contributes substantially towards conservation and management of the threatened fauna of India. Adding to this, advanced research on soundscape (acoustics) through spectrogram of vocalisation of animals, and impact of forest fire on faunal diversity in the Northeastern Region of India are vital contributions by ZSI.

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Long Term Monitoring of Fauna

Long Term Ecological Observatories (LTEO)– Monitoring Arthropods in LTEO sites funded by MoEF&CC, is also being implemented through ZSI. A pilot project on Biodiversity Corridor-Baseline Survey and Feasibility assessment under Project for Improvement of Himachal Pradesh Forest Ecosystem Management & Livelihoods has been

initiated by ZSI. Moreover, in order to understand the impact of climate change, long-term monitoring plots have been established in Andaman and Nicobar Islands and Lakshadweep.

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Forensic Study

ZSI is designated as a Forensic Laboratory by the Ministry of Home Affairs, Government of India, for solving wildlife case materials and supporting the MoEF&CC. Studies dealing with chromosomal mapping, PCR, and DNA Barcoding of animals including threatened species have been taken up by ZSI and more than 8,000 DNA sequences have been barcoded and registered in the NCBI database.

Mapping of Fauna

ZSI has implemented a number of geospatial modelling studies including the mapping of biological corridors, landscape change analysis, and climate change risk modelling for several studies of Himalayan as well as other areas in collaboration with the State Forest Department. Out of 5.7 million specimens, 3.8 million specimens are identified and geo-tagged to 4.2 unique localities, pertaining to about 40,000 animal species. Mobile Application and Web GIS have been developed in collaboration with National Remote Sensing Centre, ISRO, to provide specific information on different animals in Protected Areas of India. A geospatial database has been created for the threatened vertebrates of the Indian Himalayan Region. The database will be useful in understanding the diversity and richness of wildlife species in the Himalayan region. ZSI is currently working on developing the geospatial repository of the fauna of India based on the National Zoological Collections. It has undertaken a range-wide study on Red pandas to establish a fine-scale spatial pattern of genetic variation and contemporary gene flow with respect to landscape connectivity to cover the entire distribution range of Red pandas in India.

Himalayan Blue Sheep

Reef Restoration

Approximately, 1050 sq metre area of degraded reefs has been restored with branching coral species belonging to the family Acroporidae, which are the dominant reef contributors in all world reefs, in collaboration with the Government of Gujarat through World Bank-ICZM. Presently, the translocation of corals in the Gulf of Kutch is being carried out for Indian Oil Corporation.

Studies on pollinators, invasive and alien species, and climate change with reference to faunal diversity and conservation have been envisaged. An attempt has also been made to understand the impact of forest fire in Northeast India and also to predict the fire-prone area.

The results of the research finding of ZSI were brought out in the form of scientific publications/ documents contributing a considerable quantum of taxonomic knowledge on Indian fauna. Scientific documents related to State fauna, Conservation Areas, records, monographs, pictorial handbooks, occasional papers, and scientific papers have been published in national/international journals by scientists of ZSI. Altogether, 1,704 documents (books and monographs) and 13,192 scientific papers have been published by ZSI till 2021. Over 181 documents and 2,465 scientific papers have been published during the last five years. During the period of the last two years, more than 770 publications have been completed.

ZSI has contributed towards the revision of the Wildlife (Protection) Act, 1972, of Govt of India, has advised on the matter related to faunal diversity and conservation at the national level viz. for MoEF&CC, ESZ, wetlands conservation, curbing wildlife crime, MoES on ocean science and technology, marine biodiversity, alien and invasive species for Ministry of Agriculture and Ministry of Commerce and Department of Science & Technology, Govt. of India. ZSI is also contributing services for various Ministries of Government of India viz. Ministry of Jal Shakti on freshwater and wetland data to Central Water Conservation, to the Ministry of Fisheries, Animal Husbandry & Dairying on information pertaining to exotic fishes, for Project Dolphin of MoEF&CC. ❑

Geoscientific Explorations

Dr S Raju

Acquisition and dissemination of pre-competitive baseline geoscience data of the highest standards and probing deep-seated/concealed mineral deposits are primary requisites to promote mineral exploration in the country. The baseline geoscience data collected by the Geological Survey of India is the core for generating more mineral exploration work which leads to mineral discoveries. Thrust has been given to exploration for strategic and critical minerals like tungsten, molybdenum, nickel, lithium, cobalt, REE/RM, rock phosphate, potash, etc., and to probe deep-seated and concealed deposits.

The Geological Survey of India (GSI) is the premier geoscience organisation involved in mineral exploration in the country since its inception in 1851. The growth of the mineral industry is directly linked to the mineral endowment of a country. This mineral endowment is established through successive efforts in mineral exploration by discoveries and resource augmentation. The baseline geoscience data collected by GSI is the core for generating more mineral exploration work which leads to mineral discoveries. During the inception of GSI, the prime mandate was to carry out (i) geological survey of the country, and (ii) exploration in specific parts of the country with special objectives to locate mineral resources.

Today, after 171 years, the mandate primarily remains the same, but with changed priorities. Baseline geological data at 1:50,000 scale exists for almost the entire country; efforts are being made to generate similar data on geochemical and geophysical themes. Natural resource assessment and augmentation are now the prime thrust area, along with activities in public good and geoscience. Dissemination of geoscientific knowledge and capacity building are two other major mandates of GSI. It operates through a Region-Mission hybrid matrix, comprising six geographically distributed Regions representing administrative verticals and five Missions designating different activity domains representing the broad thrust areas.

Recent Thrust Areas

Mission-I Baseline Geoscience Data Generation: The National Mineral Exploration Policy (NMEP), 2016, emphasises that acquisition and dissemination of pre-competitive baseline geoscience data of the highest standards, the creation of a geoscience data repository and a special initiative to probe deep-seated/concealed mineral deposits are primary requisites to promote mineral exploration in the country.

Image 1: Research Vessel Samudra Ratnakar inducted (2013) in GSI's fleet of vessels

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Image 2: Drilling activity by GSI in Himachal Pradesh

Accordingly, GSI is on a mission to generate nationwide baseline geoscience data, eg. geological, geochemical, geophysical, and airborne geophysical data which are of paramount importance for planning mineral exploration activities. GSI has geologically mapped 99.15% of the mappable part of the country at 1:50,000 scale. Presently, GSI is carrying out pan-India mapping projects like National Geochemical Mapping (NGCM), National Geophysical Mapping (NGPM), National Aero Geophysical Mapping (NAGMP), and Specialized Thematic Mapping (STM) programmes with a primary aim to identify new target areas for prognostication of natural resources, and to address fundamental geological problems as well as geo-societal issues.

A total area of 16.2 lakh sq km has been covered through NGCM, involving 4.5 lakh samples and the generation of 64-elements geochemical dispersion data. NGPM has been done over 10.6 lakh sq km area, generating valuable information about the gravity and magnetic properties of the underlying terrain. Around 4.7 lakh sq km has been flown through NAGMP in parts of Rajasthan, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, and Uttar Pradesh identifying numerous potential areas for further exploration. STM projects covering 3.8 lakh sq km in selected stretches of the country have yielded valuable information towards the prognostication of mineral resources.

GSI has also been engaged in spectral mapping of potential zones using multi-spectral and hyperspectral imageries. So far, alteration or mineralised zones have been identified over an area of 1.2 lakh sq km and a spectral library is being generated.

In the field of Marine Geology, GSI has been contributing immensely with its state-of-the-art research vessel, R V Sagar Kanyika (Image 3). RV SKI and other coastal vessels in seabed mapping over an area of 20.5 lakh sq km and reconnaissance of mineral resources evaluation.

Mission-II Natural Resource Assessment: GSI is augmenting natural mineral and coal resources for subsiding the Mining Sector's contribution in the GDP of India (Image 2&4). GSI carries out a 'reconnaissance survey' [G4], 'preliminary exploration' [G3] and 'general exploration' [G2] following the UNFC guidelines with an aim to augment resources for various mineral commodities.

In response to the national requirement, thrust has been given on exploration for strategic and critical minerals like tungsten, molybdenum, nickel, lithium, cobalt, REE/RM, rock phosphate, potash, etc., and to probe deep-seated and concealed deposits under Project "Uncover India", in collaboration with Geoscience Australia. Regional Mineral Targeting (RMT) projects have been introduced for the scanning of larger areas with a multi-thematic data integration approach for the identification of promising areas for further exploration.

In the field of Offshore Marine Mineral Exploration, GSI has so far delineated 5.9 lakh sq km offshore prospective area for focused explorations for various mineral commodities like Lime Mud, Fe-Mn concretions, hydrothermal minerals, and phosphorite/phosphatic sediments, etc.

Since the amendment of MMDR– Mines and Minerals (Development and Regulation) Act in 2015, GSI has handed over 170 nos. resource bearing G2/G3 reports on various mineral commodities like gold, base-metal, iron, manganese, bauxite, rare earth elements, limestone, etc., to the concerned State Governments for auctioning of mineral concession.

Further, to boost the mining sector, GSI has recently handed over 252 Geological Memorandums to the concerned State Governments for auctioning as composite license following the guidelines of Mineral (Evidence of Mineral Contents) Amendment Rules, 2021 (amended MMDR Act 2021).

Around 40 mineral blocks developed by GSI on different minerals, commodities have been auctioned since the amendment of the MMDR Act in 2015 by the respective State Governments.

Mission-III Geoinformation: GSI has implemented Online Core Business

> Studies including long-term monitoring of snow/ice accumulation-ablation pattern, observation of glacial mass balance and its correlation with meteorological parameters, etc., are being conducted regularly in the Himalayan glaciers to decipher the effect of climate change on the cryogenic environment and its impact on the water balance of Himalayan River systems feeding the fertile Indo Gangetic Plain.

integrated System (GCHIS) portal to fulfil the responsibility to disseminate multi-thematic geoscientific information freely for the use of all concerned stakeholders through "Bhukosh," (Image 4) the flagship Geoportal portal of GSI, following extant policies and guidelines.

This data can be utilized by anyone for mineral prognostication as well as to generate new knowledge through research. GSI is also taking up the lead role in setting up of National Geoscience Data Repository (NGDR) for hosting exploration-related geoscientific data collected by all stakeholders to facilitate, expedite and enhance the exploration coverage of the country. An MoU has been signed between GSI and Bhaskaracharya National Institute for Space Applications and Geo-Informatics (BISAG-N), under the Ministry of Electronics and Information Technology (MeitY) for the implementation of NGDR.

Mission-IV Fundamental & Multidisciplinary Geosciences and Special Studies: Fundamental geoscience research such as crustal evolution, tracing of mineral bearing paleoseas, tectonic studies, and geophysical research, all contribute to mineral exploration which in turn engenders research problems on structure and tectonics, coupled with geological and other thematic maps form input parameters to help comprehend the earth surface processes which helps in holistic studies on natural hazards and disaster management.

GSI has been systematically involved in geoscientific programmes for decades with an aim to contribute to the societal causes which include landslide studies, geodynamic/seismic studies, engineering geology/ geotechnical studies, environmental geology, climate study, glaciology & polar studies, and fundamental

Image 3: Fixed mineral hydrostatic drill machine of GSI employed in mineral exploration work

Desertification and its impact assessment, appraisal of geogenic and anthropogenic contamination of soil and groundwater in several parts of the country, impacts of conspicuous bank erosion and urban flooding, change in coastal land use and land cover are some of the other vital geo-societal studies.

geoscience research.

GSI is the nodal agency for landslide hazard studies in the country since 2004. Through the national programme — National Landslide Susceptibility Mapping (NLSM), GSI has prepared a seamless landslide susceptibility map on 1:50,000 scale over 4.3 lakh sq km area spanning the landslide-prone zones spread over parts of 18 States/UTs.

In collaboration with the British Geological Survey (BGS) under the National Environment Research Council (NERC), UK funded, multi-consortium LANDSLIP project, GSI is engaged in developing an experimental regional Landslide Early Warning System (LEWS) based on rainfall thresholds since 2017.

Since the 2020 monsoon, GSI has started issuing daily landslide forecast bulletins during monsoon to the district administrations in two pilot areas (Darjeeling district, West Bengal and the Nilgiris district, Tamil Nadu). The experimental regional LEWS will be made operational in phases after successful ground evaluation. To execute the above multi-disciplinary task, GSI is collaborating with multiple national and international organizations.

GSI has also been carrying out several seismic/ earthquake (MM), aftershock) studies, seismic hazard micro-zonation, active fault mapping, and geo-seismic studies over the years. GSI felt the necessity for continuous data acquisition, archiving and analysis of Seismo-Geodetic parameters which have a strong bearing on earthquake generating processes. Accordingly, during 2014-18, GSI established state-of-the-art permanent Seismo-Geodetic Observatories at 10 different strategic locations across India, viz. Jhajjar, Mangan, Agartala, Jammu, Nagpur, Lucknow, Jaipur, Pune, Thiruvananthapuram and Little Andaman. These observatories are equipped with broadband seismograph (Trillium 240), accelerograph and high-precision GPS geodetic instruments.

With an aim to build a permanent Global Navigation Satellite Systems (GNSS) network in India which can be used as the Crustal Movement Monitoring Network, GSI has established 35 permanent GNSS stations at Jammu, Agartala, Jhajjar, Manipur, Nagpur, Lucknow, Hathras, Jabalpur, Chennai, Kolkata, Jaipur, Thiruvanthapuram, Pune, Dehradun, Gandhinagar, Raipur, Bhopal, Chandigarh, Patna, Bhubaneswar, Visakhapatnam, Shillong, Aizawl, Imphal, Zawar, Faridabad, Mangalore, Chitradurga, Umrikashi and Pithoragarh, Kuju, Siliguri, Port Blair, Rangat, and Diglipur. All these stations have been installed based on the seismotectonic setup

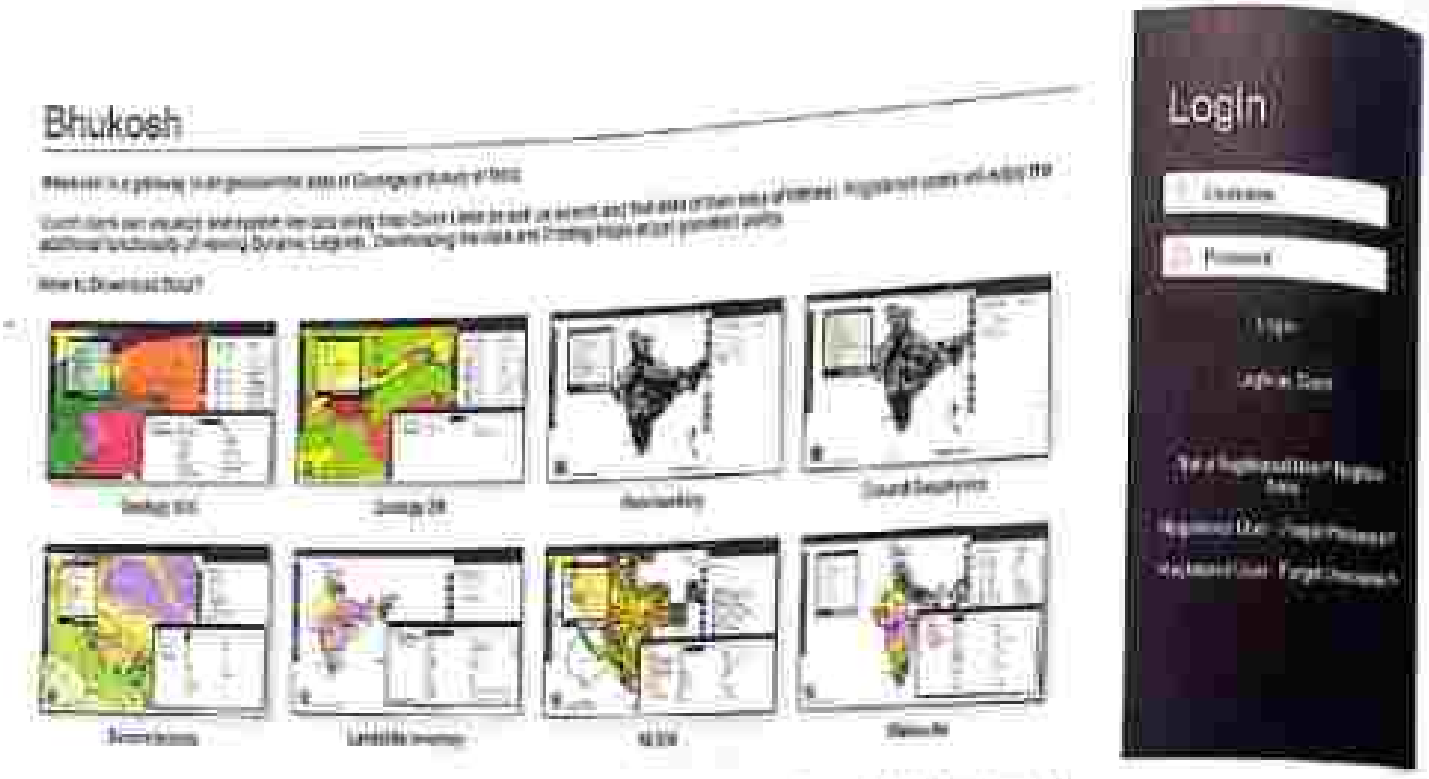

Image 4. Bhukosh, the Geospatial data repository [https://bhukosh.gsi.gov.in]

of India. The computational processing and archival of the voluminous GNSS data are done in a state-of-the-art computational laboratory of GSI.

Climate Change is now the biggest threat to human civilisation. The predicted effects of climate change on the ecosystem are extremely diverse and ominous. Glaciers are excellent proxy indicators of changing climatic patterns. Since 1976, GSI has been closely monitoring several glaciers in the Himalayan states of Himachal Pradesh, Uttarakhand, Sikkim and UTs of Jammu & Kashmir and Ladakh. Studies including long-term monitoring of snow/ice accumulation-ablation pattern, observation of glacial mass balance and its correlation with meteorological parameters, etc., are being conducted regularly in the Himalayan glaciers to decipher the effect of climate change on the cryogenic environment and its impact on the water balance of Himalayan River systems feeding the fertile Indo-Gangetic Plain.

In addition, for a better understanding of the global ecosystem, GSI has also been conducting glaciological and limnological studies in the Polar Region of Antarctica and Arctic to decipher the climate change pattern in the frozen continent and its impact on the global climate.

Apart from the glaciological and limnological studies, desertification and its impact assessment, appraisal of geogenic and anthropogenic contamination of soil and groundwater in mineral parts of the country, impacts of precipitation, bank erosion and urban flooding, changes in coastal land use and land cover are some of the other vital geo-environmental studies which figure prominently in the annual programme of GSI every year.

GSI presently a platform like Central Geological Programing Board (CGPB) which facilitates synergy, and avoids duplication and waste of resources, where all State Governments, central ministries, PSUs, and academic institutes participate and GSI's programmes are discussed. GSI formulates its national programmes through this consultative process and ensures that its programmes are in consonance with the current global and national thrust areas, and align to the national and international policy directives and SDGs.

The application of multi-disciplinary geoscience research with advanced geoscience skills of data acquisition, accumulation and analysis with intensive field and lab studies become imperative for discovering new mineral deposits of economic significance all over the world. Earlier, the discoveries were mainly a result of mapping with the study of exposed outcrops. Now the challenge has increased manifold as easily discoverable deposits showing surface manifestation are a rarity now. Current discovery efforts mandate the combined efforts of advanced geoscience research activities like dating of mineralising events, fluid inclusion studies, isotopic systematics, quaternary studies, glacial geoscience, active fault mapping, crustal research, seismotectonics, in situ microprobe analysis, ore characterisation, petrogenesis, etc., apart from the wide use of baseline geoscience data, statistical and spatial analysis with corresponding capacity building of geoscientists. Such an intensive integrated approach is in vogue across all the advanced countries in the world for new discoveries and GSI is also following the same path.

Safeguarding Oceans

Dr Manish Mohan Gore

About two-thirds of our Earth's surface is covered by water, and the oceans hold about 96.5 per cent of the entire Earth's water. Thus, the oceans are the most significant source of our present and future energy requirements. Water exists everywhere, in the ocean, river, pond, lake, glacier, air or soil moisture. There is about 70 per cent water in the protoplasm of millions of cells, the basic biological unit of plants, animals and human beings. We are all aware that water is vital for life, hence rich biodiversity is found in the ocean.

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Different organisms are found in different ocean depths, providing a colourful spectrum to marine life and its ecosystem. According to scientific studies, so far, about 2.5 lakh marine life species have been identified all over the world. Scientists estimate that two million more species exist in the ocean, yet to be discovered. Evidence of diversity is also found in their size. They range from decimal zero 2 centimetres of small sea creatures to about 110 feet long blue whales found in the sea.

Sunlight penetrates about 200 metres below the sea surface called the sunlight or Epipelagic Zone. Sunlight and warmth bestow many colourful life offerings to this zone. In the zone, from 200 metres to 1000 metres, the faint light of the sun percolates, hence it is called twilight or mid-water zone or Mesopelagic Zone. Darkness prevails here and to overcome it, the creatures use bioluminescence similar to fireflies found on the land. Many unique fish species are found in this area. It is an exclusive area lit with dim light where many creatures are not visible due to lack of light and because almost transparent.

Below the midwater zone comes the bottom depth of the sea, i.e., the depth from 1000 to 4000 metres. It is called the midnight or Bathypelagic Zone. The organisms found here are illuminated by bioluminescence. The water pressure in this zone is very high. But surprisingly, despite such adversities, innumerable creatures are found here. The sea creatures here are primarily black or red in the absence of light. The average temperature here remains below 4°C.

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The Abyssal Zone or ocean womb is the part of the sea with a depth of 4000 to 6000 metres. Here, it is stark dark and the temperature is very low (almost equal to the freezing point). Only a few creatures are found in this depth, mostly invertebrates like squids.

Layers of Ocean's Depth and Organisms

Below the Abyssal Zone lies the ocean floor. The deepest point in the world is located in the Mariana Trench in Japan, about 11,000 metres deep from sea level. The water temperature here is always above freezing point and the pressure is beyond imagination. But notice the charisma of nature, even in these harsh and adverse conditions, invertebrates like telescope octopus, starfish and amphipods inhabit here.

> Trace metals (manganese, cobalt, iron, nickel, copper, zinc) found in the oceans help in the growth of organisms. These trace metals present in small amounts in the tissues of living beings mainly act as catalysts in the enzyme system and energy metabolism. They settle in the oceans through continental water flow and atmospheric and hydrothermal activities.

On one hand, the unique and colourful world of the ocean plays a vital role in maintaining the ecological balance of the carbon, nitrogen and phosphorus cycles present in nature. On the other hand, the ocean, its living organisms and natural resources are in danger due to human activities. Land waste is dumped in the oceans in the form of oil, pesticides, plastics and industrial waste, due to which the ocean's ecosystem is badly affected. The existence of millions of creatures living in it is in danger. The existence of coral reefs is being threatened by pollution and fossil fuels. Besides marine pollution, climate change is the second main reason for the destruction of coral reefs. Scientific studies have proved that when foreign substances enter the ocean, they cause serious harm to the marine ecosystem and the environment.

Marine instrumentation submersible vehicle Samudrayaan developed by the Ministry of Earth Sciences, Government of India

Innovative Scientific Research Initiatives

Research on ocean organisms, minerals and other natural resources is going on in India's laboratories. Many innovative research works are being carried out by Indian scientists dealing with the effects of environmental pollution, anthropogenic interference and climate change on the ocean. Here are some glimpses of such efforts.

RV Sindhu Sadhana: Scientific Research Focused on the Indian Ocean

Indian scientists are constantly involved in research to understand all the factors of environmental pollution and the gradually worsening current problem of climate change and its effect on the ocean and vice versa, i.e., how the ocean responds to the environment and human life.

The National Institute of Oceanography (NIO), headquartered in Goa, is the laboratory of Council of Scientific and Industrial Research (CSIR), India's most prestigious scientific research organisation. It has been conducting research in the field of oceanography since 1966. NIO is constantly undertaking research projects related to the ocean, including the organisms living in it and the minerals found there. Last year, a vital project in this laboratory completed research work in the Indian Ocean named 'R V Sindhu Sadhana.' NIO's 23 scientists were members of the Sindhu Sadhana Abhiyan team. The duration of this oceanographic research, which started from the Visakhapatnam beach of Andhra Pradesh, was about 90 days. This marine research vessel of CSIR-NIO measures 80 metres long and 56 metres wide. During this significant journey, the team of scientists profoundly explored ocean life and its natural resources.

Scientific Objectives of RV Sindhu Sadhana Abhiyan

With the help of this 90-day scientific expedition RV Sindhu Sadhana, our understanding of the study and research of the Indian Ocean has transformed considerably. This scientific expedition of CSIR, which ventured out to decode the secrets of the Indian Ocean, was unique for India and the whole world. This sea expedition had two main objectives, which are discussed here.

Gene Mapping of Marine Microorganisms

The first main objective of the team of 23 scientists on board the RV Sindhu Sadhana Marine Research Ship was to map the genomic and proteomic diversity of the Indian Ocean. The expedition team conducted scientific analysis of proteins and genes in marine organisms to understand the processes occurring at the cellular level of marine microorganisms. Proteins act as markers and

80 metre long and 18 metre wide 'RV Sindhu Sadhana Research Vessel' in the Indian Ocean

catalysts in the biochemical reactions which occur in organisms that survive in different ocean conditions. This study, a branch of biology, is called proteomics. In this, all these cellular biochemical changes occurring in the body of organisms and their responses to climate change, increasing pollution and stress of trace metals and nutrients are studied. The study made it possible to understand how climate change, pollution and stress from trace metals and nutrients affect ocean organisms, as well as how the cellular biochemistry of organisms responds to these external interferences. A variety of samples were collected from the Indian Ocean under the RV Sindhu Sadhana Abhiyan, which will open new avenues for understanding the effects of climate change and pollution on the cellular processes of marine organisms.

During this expedition, samples of water and sediments up to 6000 metres deep in the Indian Ocean were collected to study trace metals, genomes and proteins. The scientific team used modern molecular biomedical techniques, genetic sequencing and bioinformatics to understand the dynamics of the Indian Ocean ecosystem through these samples. This genomic library will serve as a vast repository for future biological research.

Oceans are immense source of future food and natural resources. For the sustenance of life on Earth, the existence of ocean species is essential. Climate change and pollution continue to threaten the existence of life on the Earth, the marine ecosystem, and marine life. In the Sindhu Sadhana Abhiyan, scientists from the disciplines of zoology, geology, chemistry, biochemistry, and geochemistry conducted extensive research to study the biochemical changes occurring in the marine organisms in response to these problems at the gene level. Scientists also studied if there is any adaptive behaviour in the genes of marine organisms in response to climate change and pollution which would help in the conservation efforts of marine species.

Samudrayan mission comprises an automatic manned submersible vehicle designed to carry three persons to a depth of 6000 metres under the sea. This vehicle is equipped with various scientific instruments for deep-sea exploration. The active exploration duration of the Samudrayan is 12 hours, but in case of emergency, it can remain operational for up to 96 hours.

Study of Trace Metals

Trace metals (manganese, cobalt, iron, nickel, copper, zinc) found in the oceans help in the growth of organisms. These trace metals present in small amounts in the tissues of living beings mainly act as catalysts in the enzyme system and energy metabolism. They settle in the oceans through continental water flow and atmospheric and hydrothermal activities. To fully understand the cycling and productivity of nutrients found in the oceans, it is essential to know the relationship between marine organisms and trace metals. The second main objective of the RV Sindhu Sadhana Abhiyan was to unearth new information related to trace metals present in little-known regions of the Indian Ocean.

This 90-day marine research campaign by RV Sindhu Sadhana will significantly contribute to the UN Decade of Ocean Science (2021-2030) and the achievement of the Sustainable Development Goals. An essential objective of this campaign has also been to use ecological principles to discover important marine biomolecules and their metabolites. Fulfilling this objective would ensure economic growth, better living conditions and employment opportunities while maintaining the health of the ocean ecosystem.

Development of Indus Sadhana's Marine Laboratory

CSIR-NIO acquired India's first multidisciplinary oceanographic research vessel 'RV Gaveshani' in 1976. This ship enabled India in the field of oceanographic research. It was decommissioned in 1994 after 18 years of commendable service. Subsequently, a second marine research vessel, Sagar Sukti, was acquired. In 2012, NIO acquired a new indigenously built marine research vessel, 'RV Sindhu Sadhana', which enables Indian oceanographers to conduct marine research not only in the adjoining sea of India but also in any part of the Indian Ocean. The ship is equipped with several state-of-the-art instruments, with the help of which scientists can continue their research during the voyage. The ship's official registration number is 3435 and its flag symbol is AVCO.

This research vessel houses several small laboratories and is equipped with world-class instruments like Echo Sounder, Acoustic Doppler,

Team of 23 scientists of RV Sindhu Sadhana Research Mission

Profiler, Autonomous Weather Station, and Air Quality Monitor for ocean technology and research. The Sindhu Sadhana Research Project has placed India on the world map of ocean technology.

The first indigenous ocean research vessel was dedicated to the nation in July 2014.

Deep Ocean Mission

Humans have yet to discover about 95 per cent of the deep ocean. About 30 per cent of India's human population inhabits the coastal areas. Hence, the sea is the primary source of livelihood for this population. Keeping in mind the significance of the ocean, the United Nations has declared the decade 2021-2030 as the Decade of Ocean Science for Sustainable Development. India has a unique maritime position. Its 7517 km long coastline is home to nine coastal states and 1382 islands. Given the Government of India's Vision of New India by 2030 framework of its torchbearer, Blue Economy has been constituted. It is in this context, the Cabinet Committee on Economic Affairs has approved the 'Deep Ocean Mission' of the Ministry of Earth Sciences. An estimated budget provision of Rs 4077 crores has been kept for the next five years to develop deep-sea technologies and sustainable use of ocean resources.

> **Given the Government of India's Vision of New India by 2030 framework, Blue Economy has been constituted. It is in this context, the Cabinet Committee on Economic Affairs has approved the 'Deep Ocean Mission' of the Ministry of Earth Sciences.**

The Deep Ocean Mission consists of the following six major components:

- Development of Technologies for Deep Sea Mining and Manned Submersible
- Development of Ocean Climate Change Advisory Services
- Technological Innovations for Exploration and Conservation of Deep-Sea Biodiversity
- Deep Ocean Survey and Exploration
- Energy and fresh water from the ocean
- State-of-the-art Marine Centre for Ocean Biology

Samudrayan: India's First Manned Submersible for Deep Ocean Exploration

To unravel the secrets of the deep sea, India has launched an ocean expedition named 'Samudrayan' to explore deep sea organisms, minerals and other natural resources. This unique ocean submersible 'Samudrayan' was launched in October, 2021. With this, India joins the world's elite group using specialised technology for deep-sea scientific exploration. Other major countries in this group include the United States, Russia, Japan, France, and China.

Samudrayan mission comprises an automatic manned submersible vehicle designed to carry three persons to a depth of 6000 metres under the sea. This vehicle is equipped with various scientific instruments for deep-sea exploration. The active exploration duration of the Samudrayan is 12 hours, but in case of emergency, it can remain operational for up to 96 hours. Sitting inside it, scientists can directly explore the unknown regions of the deep sea.

The Earth and its environment are in peril in the present century. Besides air and land, the crisis looms over the ocean also. Scientists predict that the oceans will be the primary custodians of human existence in the future. Biologists have constantly been researching to explore the ocean rather than the Earth's landmass to discover its innumerable organisms and natural resources. Keeping these things in mind, it is logical that we should save our land and the sea. Man-made dead zones are formed when there is a lack of oxygen in the ocean due to physical and chemical interventions arising from human activities. Sea organisms start perishing. The sea becomes a biological desert instead of a natural habitat for aquatic organisms. The increasing human population, tourism, release of industrial chemicals, and pollution in the coastal areas are primary causes of creating dead zones. It is essential to curb these human activities to save the ocean and its ecosystem. We must make every possible effort to conserve the ocean and its ecosystem. ❑

A Biological Paradise

C Sivaperuman

The Andaman and Nicobar archipelago consists of 836 islands, islets, and rocky outcrops, extending over 800 km. They are truly oceanic islands, never having been connected to the mainland during Pleistocene glaciations.[1] The separation of these islands from the Asian continent was brought about by geological change about 100 million years ago, during this period. The Andaman and Nicobar islands were once a part of the Asian landmass but then got disconnected some 100 million years ago during the Upper Mesozoic Period due to geological upheaval. The chains of these islands are in fact the camel backs of the submerged mountain ranges projecting above the sea level running north to south between 6° 45' and 13° 30' N latitudes and 90° 20' and 93° 56' E longitudes with an extent of 8,249 km².

The Islands can be generally divided into two groups, i.e., the Andamans and the Nicobars and are separated by the Ten Degree Channel which is about 150 km wide and 400 fathoms deep. The highest elevation is Saddle Peak (732 m) in North Andaman and Mount Thuillier (642 m) in Great Nicobar Island. The annual precipitation is slightly higher in Nicobar with an average of 3000 to 3500 mm. Andaman and Nicobar Islands support very luxuriant and rich vegetation due to tropical, hot and humid climate with abundant rains. Classification of Forest Types[2] belong to four groups, i.e., Tropical Wet Evergreen, Tropical Semi Evergreen, Tropical Moist Deciduous and Littoral and Swamp Forests, in addition to this, 13 different types of forests are classified. The total geographical area is under forest land i.e., 6,742.78² km (81.74 per cent) as per the State Forest Report of 2019. An extraordinary variety of habitat types, ranging from sandy beaches to coral reefs, mangroves and mountains with dense forests, characterise the Andaman and Nicobar Islands. The least disturbed and the finest preserved mangroves in India are found in the region. The coral reefs of Andaman and Nicobar is the second richest found in the world.[3] These islands provide different variety of animal life of which, the coral reefs ecosystem constitute the most fragile and interesting faunal elements as elsewhere in the Indo-Pacific Reefs.

According to the available literature, a total of 21,645 marine species have been reported from India, which includes marine algae and mangroves. Out of these, 20,444 species contributed by animals have been distributed in Indian seas. Andaman and Nicobar Islands is very rich in marine biodiversity (9,624 species; 29.74%) and the terrestrial ecosystem harbours 3,736 species. Highest level endemism found in Andaman and Nicobar Islands is estimated to be about 1,423 species, of these 871 species are from terrestrial ecosystem

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while 252 species are from marine counterpart. Overall, 1,200 species of terrestrial and marine fauna of Andaman and Nicobar Islands have been listed under various Schedules of Wildlife (Protection) Act, 1972. The long isolation of these islands from the sub-continent has resulted in high endemicity of terrestrial faunal and floral elements. More than 10% of the plants are endemic and, estimated about 871 species from terrestrial ecosystem. Among the invertebrates, butterfly has more than 70% of endemism to sub-species level.

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Marine Ecosystem

Porifera: Sponges are worldwide in their distribution, from the Polar regions to the tropics. The highest numbers of sponges were generally found on firm surfaces such as rocks, but some sponges can attach themselves to soft sediment by means of a root-like base. Generally, the more species of sponges are found from shallow, and also distributed in deep ocean. Around 512 species of sponges are recorded from Indian waters. Among them, Andaman and Nicobar Islands represent 130 species. A total of 12 species of calcareous sponges were reported from Indian waters and are protected under the Schedule III of Indian Wildlife (Protection) Act 1972.

Scyphozoa: The Scyphozoans are commonly known as true jellyfish. The Scyphozoan fauna comes under the phylum Cnidaria. According to the recent estimates, 191 species belonging to three orders, and 29 families were recorded.[4] A total of 5 scyphozoan species were reported from Andaman and Nicobar Islands.

Anthozoa (Scleractinian corals): The Scleractinian corals of Indian water are highly diverse than other parts of the tropical reefs. A total of 424 species of Scleractinian corals belonging to 19 families were reported from the Andaman and Nicobar Islands.[3] The reefs are mainly dominated by the family Acroporidae, Faviidae, Poritidae, Fungiidae and Agariciidae.

Octocorals: Octocorals are commonly called as Alcyonarians. Order Octocorallia (eight polyp tentacles) are distinguishing from the hard corals (six or multiple of six polyp tentacles) by their number of polyp tentacles. They consist of soft corals, seafans, seawhips, sea pens, tubecorals and blue corals. A total of 413 species of Octocorals were recorded from Indian, about 228 species from the continental shelf region of A&N Islands.[3]

Platyhelminthes: Flatworms, also known as polyclads belong to the Order Polycladida, Class Turbellaria under the phylum Platyhelminthes. They are exclusively marine and free-living organisms. These animals are one of the common inhabitants of the coral reefs. Zoological Survey of India has documented 47 species under 10 genera which includes 7 new records to Indian waters and 6 new species.

Crustacea: Crustaceans belong to the phylum Arthropoda, and include both marine and terrestrial forms of life. These highly diverse animals consists of economically important groups such as crabs, shrimps and lobsters. Out of 2,394 species of the crustaceans that have been reported from India, marine species (94.85%) contribute the most. A total of 897 species were recorded from Andaman and Nicobar Islands of which 388 species brachyuran crabs and 129 species are shrimps.

Mollusca: Molluscs are the mainly reported phylum in reef ecosystems and also, this fauna is the second species-rich phylum in the world after the arthropods. Molluscs comprise six groups such as Polyplacophora, Monoplacophora, Gastropoda, Bivalvia, Scaphopoda and Cephalopoda. In India, 5,670 species of Molluscs have been recorded from freshwater (143 species), land (1,487 species) as well as from marine habitats (3,570 species).

Echinodermata (Holothuroidea – Sea cucumbers): The Holothuroidea, commonly known as Sea cucumbers, are an abundant and diverse group of worm-like and usually soft bodies echinoderms. About 1,150 species recorded worldwide till now whereas India represents 179 species.[3]

Ascidians: Ascidiacea is a marine invertebrate animal, specified as class which is commonly known as the sea-squirts or sea squirts. They are categorised under the subphylum Tunicata and phylum Chordata, which includes all animals with dorsal nerve cords and notochords. A total of 442 species were recorded from Indian waters while 57 ascidians were recorded from Andaman and Nicobar Islands.[4]

Pisces: The Ichthyofaunal diversity of India accounts for a total of 2,735 species, of which Andaman and Nicobar Islands contribute to 58% of the total diversity. Ichthyofaunal diversity of the Islands has been enriched with a total of 1,583 species belonging to 177 families under 36 orders.[3]

Mammalia: Marine mammals include representatives of three major orders, namely Cetacea (whales, dolphins and porpoises), Sirenia (manatees and dugong) and Carnivora (sea otters, polar bears and pinnipeds). A total of 26 species of marine mammals were recorded from Indian waters. Andaman and Nicobar Islands represented 7 species of marine mammals.

Protozoa: Importance of protozoa as bio indicators for pollution and environmental bio monitoring has been recognised since long, particularly in water purification plants and activated sludge processes.[6] A total of 2,577 species of protozoan were reported from India. A total of only 9 species of Protozoans were recorded from Andaman and Nicobar Islands.

Molluscs (Land and freshwater): Land snails form an important component in the forest ecosystem. Globally, about 35,000 species of land molluscs have been reported, besides, there may be 30,000 to 60,000 additional species yet to be described.[7] There are about 5,070 species of molluscs which have been recorded from India of which 283 species are freshwater and 1,487 species are land molluscs. A total of 152 species of freshwater and land molluscs were reported from Andaman and Nicobar Islands.

Annelida: The Annelida, known as the ringed worms or segmented worms, are a large phylum, with over 17,000 extant species including rag worms, earthworms, and leeches.[8] A total of 840 Annelids were reported from India and 192 species were recorded from Andaman and Nicobar Islands.

Insects: The insects are known to be the most successful and diverse animals on earth. They have evolved even before the origin of dinosaurs. They have adapted to almost every conceivable type of environment from the Equator to the Arctic and from sea-level to the snow fields of highest mountains, on land, in air and water and few species also inhabit the sea. The composition of insect group indicates that seven orders viz. Lepidoptera, Coleoptera, Hemiptera, Diptera, Hymenoptera, Orthoptera and Odonata comprise bulk (93 per cent) of the fauna, while Thysanoptera, Neuroptera, Dictyoptera and ten other orders are represented by a small number (7 per cent) of species.

Camel cricket and cockroach in the caves

Lepidoptera (Butterflies & Moth): This group has small to very large in size insects, commonly known as butterflies and moths. So far, 305 species belonging to 125 genera under 9 families of butterflies are reported from Andaman and Nicobar Islands. Of them, 155 species are endemic to these islands. About 622 species belonging to 423 genera under 37 families of moths are known from Andaman and Nicobar Islands so far.

Odonata: These are amphibiotic insects commonly known as dragonfly or damselfly. The adults are large predacious flying insects. They have a colourful body, clear wings and make swift flying manoeuvres. 72 species belonging to 39 genera, pertaining to 11 families are reported from Andaman and Nicobar Islands so far. Only 11 species are endemic to these Islands.

Arachnida: The current knowledge of spiders in Andaman and Nicobar is still in its preliminary stage. Around 103 species have been reported, of which 20 spider species are endemic to Andaman and Nicobar Islands.

Pisces: Freshwater fish are those that spend some or all of their lives in freshwater, such as rivers and lakes, with a salinity of less than 0.05%. A total of 951 species of freshwater are reported from Indian freshwater of which 77 species are recorded from Andaman and Nicobar Islands.[9]

Amphibia: A total of 284 species of amphibians were documented by Dinesh (2006). Most of the amphibian studies were carried out at western part of India.[10] Conservative works of Dinesh et al. (2010, 2011, 2012, 2013, 2015) enriched the database up to 304 species. A total of 19 species of amphibians were recorded from Andaman and Nicobar Islands.[11]

Reptilia: A total of 82 species were recorded from Andaman and Nicobar Islands including 39 species of snakes, 15 species of geckos, 11 species of skinks, nine species of lizards, seven species of turtles and one species of crocodile who have contributed for description of species of reptiles.[12] Later, Das (1994) prepared the checklist of the amphibians and reptiles of Andaman and Nicobar Islands.

Aves: A total of 377 species/sub species (268 species and 81 sub species) of birds are found. Around 30 species are endemic, of which 21 species are recorded from the Andaman Island group and 9 species from the Nicobar Island group are known to be limited in distribution to the Islands. A total of 42 species are threatened birds.

Mammalia: A total of 426 species of mammals were reported from India. A total of 60 species of mammals were recorded from Andaman and Nicobar Islands.[13]

Birgus latro (Linnaeus, 1767)

Long-tailed Macaque: Macaca fascicularis umbrosa Miller, 1902

Representative Fauna of A&N Islands

Coconut Crab *Birgus latro* (Linnaeus, 1767)

The coconut crab or robber crab or palm thief crab (*Birgus latro* Linnaeus, 1767) comes under the family of Coenobitidae and infraorder Anomura. The coconut crab is the largest terrestrial arthropod in the world which is related to hermit crabs and lobsters. This is the only species of the genus *Birgus* that can be adapted to exist on land and also dependent on marine water for the pelagic larvae. The size of adult coconut crabs can be varied; can grow up to 40 cm; a leg can reach more than 0.91 m. This species carries an empty gastropod shell for protection at juvenile stage, but the adults develop a strong exoskeleton on their abdomens and stop carrying a shell.

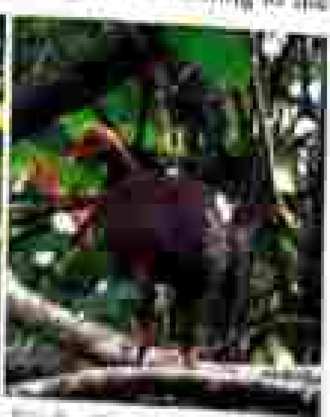
Long-tailed Macaque: *Macaca fascicularis umbrosa* Miller, 1902

It inhabits Great Nicobar Island, Katchal island and Little Nicobar Island in Nicobar Islands. Their preferred habitats are mangroves and coastal forests. They are also found in inland forest at altitude of up to 600 m above sea level. The long-tailed Macaque is an endangered primate in India and it has been listed in Schedule-I of the Wildlife (Protection) Act, 1972.

Narcondam Hornbill *Aceros narcondami* Hume, 1873

There are 55 different species of hornbills found in Asia and Africa, of which 31 species of hornbills are present within Asia. There are 9 species of Indian hornbills, of which 4 species are endemic in India, and among them one species is present in Narcondam Island. This species is considered as endangered according to the IUCN categories and protected under Schedule I under Wildlife (Protection) Act, 1972. It is roughly estimated that about 68-85 breeding pairs are present on the island, with a population of about 700-1100 hornbills.

Narcondam Hornbill Aceros narcondami Hume, 1873



Nicobar Megapode Megapodius nicobariensis Blyth, 1846

Nicobar Megapode *Megapodius nicobariensis* Blyth, 1846

The Nicobar Megapode (*Megapodius nicobariensis*) belongs to the family of megapodes, Megapodidae. IUCN has categorised these megapode species and has listed them as vulnerable. These species are found only in the Nicobar Islands of India. The hatchlings have feathers at the time of hatching and are able to fly.

Conservation efforts: The Andaman and Nicobar Islands are located in the equatorial belt and have been endowed with an abundance of flora and fauna. Many species are endemic and restricted to small areas because of the island's geographic isolation. Due to the mentioned reasons, any change in the natural system can affect the ecosystem in a chaotic way. In order to conserve the ecosystem, 87% of the areas are declared as protected areas. There are 105 protected areas (nine National Parks and 96 Wildlife Sanctuaries) that have been established over an area of 1271.12 km² on land and 349.04 km² in surrounding territorial sea. Apart from this, the Great Nicobar is declared as Biosphere Reserve to protect the endemic fauna of these islands. ❑

Endnotes:

1. Ripley and Beehler, 1989
2. Champion and Seth (1968)
3. Turner et al., 2001
4. Mohanraj and Cornelius, 2015
5. Raghunathan et al., 2012
6. Rajendra et al., 2016
7. Sinnett et al., 2017
8. Mondal et al., 2016 & 2017
9. Rao, 2016
10. Kelloway and Morton, 1980
11. Budd and Jensen, 2000
12. Eckland et al., 2004
13. Chandra and Rajan, 2004
14. Alamraj and Cornelius, 2011
15. (Das, 1998 & 1999; Chandra and Rajan, 2004)
16. Whitaker, 1978; Biswas and Sanyal, 1965, 1977a,b, 1980, 1987
17. Chakravarti, 1969, Tikader and Das, 1985; Anon, 2002; Chandra and Rajan, 2004)

Wonder in the West

R K Sagour

The region in and around Gujarat is blessed with a plethora of varied ecosystems that accommodate numerous species of wildlife. The State can boast of a tremendous diversity of flora and fauna found in contrasting environments. It has many biodiversity hotspots that are abodes of several migratory birds and other rare and endangered species of flora and fauna.

Gujarat is one of the rich biodiversity States, which is indicated by the presence of 7,500 species of flora and fauna, among these 2,350 are angiosperms and 1,366 are vertebrate species of which 374 are bird species and rest are mammals, reptiles, amphibians, fish, etc.).

Gujarat State has many biodiversity hotspots like Little Rann of Kutch, Greater Rann of Kutch, Marine National Park, Jamnagar, wetlands and forests of Banni Sanctuary, Porbandar, Grasslands of Velavadar, Thol Lake and Nalsarovar, Northern part of Western Ghat in South Gujarat, etc. They are abodes of several migratory birds and other rare and endangered species of flora and fauna. The flora of this region is unique in nature as the species have developed many adaptations like resistance to salinity to sustain themselves in hostile and adverse climatic conditions in arid and semi-arid regions.

The region is blessed with a plethora of varied ecosystems that accommodate numerous species of wildlife. A diversity of flora and fauna is found here in contrasting environments. In order to conserve such rich and diverse natural heritage of wildlife in Gujarat, four National Parks, 23 Sanctuaries, and one Conservation Reserve have been established over a period of time. In spite of rapid industrialisation in the State, the Government has managed to succeed in not only preserving the ecosystems, but also in spreading awareness amongst general public. The National Parks and Sanctuaries of Gujarat are home to unique, rare and threatened species of animals and plants which attract the attention of national and international nature lovers. In fact,

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It has a unique ecosystem, i.e., the Gir National Forest which supports the last surviving population of Asiatic lions in the world.

A balanced ecosystem is a pre-requisite for the smooth functioning of everything in the environment. Any deliberate or unprecedented imbalance in biodiversity disturbs its surroundings causing an imbalance in the ecosystem which further trickles down to food chains and then to the food web. Maintaining the natural balance in an ecosystem is essential for multiple reasons. Any unforeseen disturbance as a result of natural hazards, unexpected extinction of a particular species, and the introduction of new species or man-made disasters in the ecosystem can shake the entire flow in the system. Realising the sensitivity of the overall impacts, various governments have deliberated and formulated policies to protect biodiversity of their respective lands.

The National Parks and Sanctuaries of Gujarat are home to unique, rare and threatened species of animals and plants which attract the attention of national and international nature lovers. In fact, it has a unique ecosystem, i.e., the Gir National Forest which supports the last surviving population of Asiatic lions in the world.

Apart from taking suitable conservation measures for the protection of wildlife in various terrestrial ecosystems, the State has also done commendable work for conservation and wise use of wetlands as per Ramsar Convention signed in 1971 in the city of Ramsar in Iran. Gujarat has four Ramsar sites, i.e., wetlands of International importance and several wetland-based important Bird and Biodiversity Areas (IBAs). The notable Ramsar sites of the State are Nalsarovar and Thol Bird Sanctuaries near Ahmedabad, Khijadia Sanctuary near Jamnagar and Wadhvana wetland near Vadodara.

With industrialisation, ecosystems across the world have been destroyed leading to an impact on humans themselves, therefore, the balance between technological development and nature becomes all the more critical. The conservation ethos is inbuilt in the tapestry of the State. Way back in 1977, a Natural History Museum was established in Gandhinagar. The area is now popularly known as Indroda Nature Park (INP). Later, this was subsumed into Gujarat Ecological Education and Research (GEER) Foundation which was founded in June 1982 by the Forests and Environment Department of Government of Gujarat to undertake activities such as ecological education, ecological research, natural history interpretation, climate change research, wetland monitoring, biodiversity monitoring of Sanctuaries and National Parks. INP now serves as the headquarters of GEER Foundation.

With a view to build the research capacity of GEER Foundation, a state-of-the-art Ecological Research and Monitoring Laboratory (EMRL) has been established under Integrated Coastal Zone Management (ICZM) Project during the year 2015. This laboratory has been set up for the purpose of Ecological studies and monitoring. Apart from the Central Laboratory, five field stations at Jamnagar, Mandvi, Surat, Mangrol, and Bhavnagar were also established as per the provisions of the ICZM project funded by the World Bank. These five stations have been used for the analysis of samples gathered from various sites of Gulf of Kutch/Khambhat and generate data for further research. During the year 2016-17, the Foundation procured very advanced and sophisticated equipment, so as to upgrade the Laboratory. Among the equipments are Scanning Electron Microscope (SEM), Fluorescent Microscope, PCR and Electrophoresis, High Performance Liquid Chromatography, Total Carbon Analyser, Mercury Analyser, Water purification system, Ultra-Micro-Balance, Gas chromatograph, Atomic Absorption Spectroscopy and Heavy Metal Analyser.

The Forest and Environment Department of Government of Gujarat has taken many initiatives to protect nature and wise ecosystems. Some of the completed research projects/ studies were very useful in preparing the Management/Bio diversity Conservation Plans of various Protected Areas of Gujarat. The GEER Foundation was also recognised as Scientific and Industrial Research Organisation (SIRO).

Gujarat State Centre on Climate Change by Department of Science and Technology, Government of India and Nodal Agency of Gujarat State Wetland Authority by State Government.

Considering the expertise of GEER Foundation, Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India has assigned the work of Long Term Ecological Observations (LTEO) Project under Climate Change Action Programme. This project of LTEO was launched during 21st Conference of the Parties (COP) of the UNFCC at Paris in December 2015. The main aim of this project is to know the biophysical and anthropogenic drivers of ecosystem in selected biomes as well as their effect on social-ecological responses. The GEER Foundation along with Indian Institute of Science (IISc), Bengaluru, has established three field stations in Arabic low landscape area viz. Bansat Gir, Bajana and Hingolgadh and one in Jessore for North Western Arid Zone under Forests and Soil Theme. The observations recorded at these sites will be correlated with data on various climatic parameters collected from Automatic Weather Stations (AWSs) which are installed therein as per the guidelines of World Meteorological Organisation to know the effect of climate change.

> "Cactus Garden" at "Statue of Unity" in Kevadia is said to be a "Grand Architectural Greenhouse" consisting of 450 species of cactus and succulents from India and 17 other countries. It has around 6 lakh plants including 1.9 lakh cactus plants in an area spread over 25 acres.

To fulfill its mandate on Ecological Education, the GEER Foundation under National Green Corps' Programme of MoEF&CC, GoI has been sensitising the young minds about the environment conservation through Eco-Clubs established in 16,500 school and 162 colleges in the State. Under State Government's Nature Education Scheme, GEER Foundation conducted a total of 3,950 Nature Education/ Ecological Camps for students from various schools and colleges of the State. Indroda Nature Park/Aranya Udhyan, Gandhinagar and Hingolgadh Wildlife Sanctuary, Rajkot have been recognised as Nature Education Centre to impart nature education by the GEER Foundation through which, till date, 2,29,292 students have been educated.

Apart from doing the ecological research, monitoring and education, the GEER Foundation is also involved in the creation of "Cactus Garden" at "Statue of Unity" in Kevadia. It is said to be a "Grand Architectural Greenhouse" consisting of 450 species of cactus and succulents from India and 17 other countries. It has around 6 lakh plants including 1.9 lakh cactus plants in an area spread over 25 acres. This garden is also a main attraction in Gujarat for nature lovers. ❑

Water Governance

Bharat Lal

It is fascinating to observe how Gujarat and the Indian water journey have been invaluable in showing the world how water management can be reinvented to make it sustainable and restore our environment. These initiatives, centred on people partnering technology aiming at sustainability, pave the way for affordable, scalable and reliable models for the entire world.

The State of Gujarat, today considered as the growth engine of India, witnessed a turnaround from being a water scarce State to water secure State in the first decade of the 21st century. The State transformed by adopting environment-friendly policies, climate-resilient engineering, and strengthening grassroots leadership stand out as an example of sustainable development and offers a path to follow. This article throws light on the steps taken in the State at the national level and has the potential to achieve Sustainable Development Goals and prosperity.

Two decades ago, the region was prone to repeated droughts and water scarcity, damage to life and livelihood due to devastating earthquake with epicentre in Kutch on 26 January 2001, and resultant economic crisis with shrinking economy. With the realisation that the paucity of water contributes negatively to socio-economic development and economic growth led to policies and practices to achieve long-term water security. Also, the critical relationship between water, environment and ecosystems was acknowledged, built upon, shaped and transformed to a sustainable way to meet the challenges without compromising on the health of the natural world.

Transformation

In the late 1990s, no one had imagined what Gujarat could look like. The western and northern parts were dried up due to severe droughts and the inflating desert of Kutch had left terrible impact on the livelihood. There were cases of mass migration of pastoral communities like

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Mahilsagar, who had to migrate outwards from Kutch and Saurashtra in search of fodder and water for their livestock. During this period, Gujarat was facing a skewed annual rainfall with Central and South Gujarat receiving 80-200 cm while areas like Kutch were receiving less than 40 cm. On an average, every third year was marked as a drought year leading to uneven distribution of water. Annually, thousands of tankers were deployed to mitigate drinking water scarcity and make water available to people. There were also times when special water trains had become the new norm for delivery of water. The State and district administration had devoted considerable resources and time to manage scarcity of water through such temporary fixes, but the emptying aquifers and damage to environment remained unattended.

> The 'Saurashtra Narmada Avtaran Irrigation' (SAUNI) Yojana was also taken up under which, during monsoon, surplus water from Narmada is transferred and stored in about 115 reservoirs of Saurashtra. This Yojana is expected to benefit 8.25 lakh acres of farm land in Saurashtra.

To address these challenges once and for all, water was placed at the centre stage of the State's developmental policy. Viable solutions were explored to conserve water and achieve an ecological balance while ensuring its greater adequacy and assured availability of clean water in every home became the top priority. A series of policy decisions, including the integration of the overall water sector to manage demand and supply, coherently ensured accountability at all levels. The long-term goal, however, was the sustainability of water sources, as it was rightly seen to be intricately linked with public health and people's livelihood.

A great value was placed on water as a 'finite resource' that needed to be replenished every year. As all water is received from precipitation during limited rainy days in the State, the focus was on making the State open-defecation free with emphasis on rainwater harvesting and efficient use of water. It led to an early realisation that water must be consumed wisely without polluting the sources.

A component of drought-proofing was adopted in building climate-resilient water infrastructure. The State-wide drinking water supply grid was planned to provide clean tap water free from chemical and bacteriological contamination. The groundwater sources were protected by transferring surface water from a distance through bulk water pipelines of about 2,000 km and distribution pipelines of over 1.15 lakh km along with numerous hydraulic structures, storage sumps, water filtration, treatment plants, etc. Simultaneously, undivided attention was given to complete the Sardar Sarovar dam on the Narmada River and the distribution canal network. The existing canal systems were further strengthened. Inter-basin transfer of water from reasonably water-rich South and Central Gujarat to North Gujarat, Saurashtra and Kutch was planned and executed in the form of a 532 km-long Sujalam Sufalam Canal with speed and scale. Not only were the people provided with water of prescribed quality in adequate quantity, but the State also observed a drastic reduction in the pumped out of groundwater from tube wells. This grid is providing potable drinking water to over 200 Urban Local Bodies and about 14,000 villages.

To promote sustainable agriculture in drought-prone North Gujarat, Saurashtra and Kutch, a unique approach to transfer Narmada floodwater to these regions through a series of the canal/pipeline networks was taken up. Further, to meet water requirements, especially in areas with groundwater salinity, desalination plants were set up. So far, four such plants producing 270 Mission Liquid Discharge (MLD) water have been taken up in the coastal areas of the State.

Enabling Water-Use Efficiency in Agriculture

With about 85% of all freshwater being consumed for agricultural purposes, micro-irrigation and Participatory Irrigation Management (PIM) were promoted in an extensive manner to optimise water use in farms. Agriculture extension activities to educate farmers on the concept of 'Per Drop, More Crop' were initiated as a campaign. Farmers were provided financial and technical support to build check dams, farm ponds, bori-bandhs, etc., in and around their farmlands to 'catch the rain where it falls.' As part of the water conservation campaign, about 1.45 lakh check dams, 3.22 lakh farm ponds and a large number of bori-bandhs were constructed to impound water in fields. About 31,500 ponds were desilted and deepened. Over 1,000 stepwells in the State were cleaned, revived and put to use. For a long time, many of these stepwells were left unattended and empty but with the help of rainwater harvesting and aquifer recharging, the traditional systems were restored and rejuvenated.

In 2002, Gujarat was the first State to plan a drought-proofing strategy on a long-term basis

Modern engineering marvel to ensure clean tap water to every home

Realising the potential of mission-mode campaigns in making the State water-secure, 'Sujalam Sufalam Jal Abhiyan' was initiated around the twin objectives of deepening water bodies before monsoons and enhancing water storage for rainwater collection. It entails numerous water conservation activities including the cleaning and deepening of ponds, canals, and tanks, check dams and reservoirs, repair of water storage structures, construction of rainwater harvesting structures, etc., through a participative approach.

In Gujarat, on an average, only 24% of the storage capacity of reservoirs and dams in North Gujarat, Saurashtra and Kutch used to be filled annually during the rainy season. The criticality of water storage can be gauged from the fact that the day the local reservoir in Bhuj city known to be as Hamirsar lake, overflowed, district administration used to declare it as a holiday. This day used to be celebrated as a festival. The 'Saurashtra Narmada Avtaran Irrigation' (SAUNI) Yojana was also taken up under which, during monsoon, surplus water from Narmada is transferred and stored in about 115 reservoirs of Saurashtra. This Yojana is expected to benefit 8.25 lakh acres of farm land in Saurashtra.

Taking full advantage of the expanding solar power availability in the State to address the electricity issues, solar pumps were commissioned significantly. Subsequent comprehensive energy audits for various group water supply schemes have also resulted in energy savings leading to an overall reduction of the carbon footprint in the water supply sector.

With the integrated water management approach and groundwater table continuously improving, the total irrigable area in the State increased by 77%, and the agriculture production in the State also increased by 255%, leading to a green economy. This has paved the way for a sustainable and environment-friendly model.

Following Gujarat's footsteps, a groundwater conservation plan was designed at the national level to carry out community-driven efforts to achieve water security. Under Atal Bhujal Yojana, a unique policy initiative was undertaken to empower local communities by ensuring their participation and improving their sense of ownership among all other stakeholders. The agricultural demand for water being the highest in India requires water-efficient practices like micro-irrigation. Under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), farmers are encouraged to adopt water smart irrigation technologies to improve productivity with reduced water wastage. One of the crucial measures undertaken is on improving rainwater harvesting under 'Catch the Rain' campaign.

Following the success of the transformative Clean India Mission and inspired by the success of an integrated approach to water management in Gujarat, the PM integrated the two water sectors – drinking water supply and water resources – forming a single Ministry of Jal Shakti in 2019. Soon after that, 'Jal Shakti Abhiyan' was launched as a campaign and mission-mode initiative to make the best of the monsoons and enable water conservation, especially in the 256 identified water-stressed districts. The effort was to make it a 'Jan Andolan', a movement of the people. These steps were in the right direction towards truly making water 'everyone's business' and achieving water security for all. The Abhiyan not only accelerated asset creation but also raised extensive awareness on building water sustainability.

Treating river as living entities and taking all the measures to make sure that they continue to breathe and live healthy was another transformative step in the same direction. 'Namami Gange' was launched for rejuvenation of the river Ganga and its tributaries by adopting a multi-level and multi-agency approach in four broad categories of pollution abatement, improving flow and ecology, strengthening people-river connect, and research, knowledge and management. With the success of Namami Gange, 12 more rivers have been taken up for rejuvenation and pollution abatement.

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Jal Jeevan Mission–Har Ghar Jal

On 15 August 2019, in his address to the nation from the ramparts of Red Fort, the Prime Minister announced Jal Jeevan Mission (JJM) with the promise of tap water supply to every

rural home in the country by 2024. This mission was designed in partnership with States and aimed to ensure long-term assured water service delivery rather than mere infrastructure creation.

Under JJM, Paani Samitis/WSCs are being set up across the 6 lakh rural villages of the country, where they are being empowered to plan, implement, manage their in-village water supply systems by adopting an end-to-end approach involving the four key components, viz. source sustainability, water supply, greywater treatment and reuse and operation & maintenance.

The Swachh Bharat Mission 2.0 focuses on reducing waste production and its suitable treatment, reuse or disposal. The key impact areas of this mission are bio-degradable solid waste, greywater, plastic waste, and faecal sludge management.

India, being the biggest user of groundwater on the planet, plays a significant role in influencing decentralised, demand-driven and community-managed programmes where local communities especially those involving women, are engaged in scientific water management for long-term water security in villages. In today's climate-risked world, especially this decade when more rain is predicted in fewer days, it is crucial more than ever to speed up the work to catch and store the rainwater, use it judiciously and make the most through treatment and reuse. The Government of India, over the last eight years, has taken multiple initiatives towards the circular economy of water in the spirit of people-driven programme.

The National Project on Aquifer Management (NAQUIM), one of the world's largest programmes of its kind, envisages the formulation of aquifer management plans to facilitate the sustainable management of groundwater. So far, more than half the total area of the country has been mapped.

Way Forward

The socio-economic development and economic growth, especially in drought prone and desert areas depends upon how wisely water resources are utilised. Water, being a finite resource, plays a key role especially in arid and semi-arid regions in restoring and sustaining the environment including flora and fauna. Its vitality for reducing the burden of disease and improving the health, welfare and productivity of human populations and keeping other life forms on earth possible cannot be underestimated or ignored. ❑

Views expressed here are personal.

Indigenous Bioresources of NER

Rajendra Aduk
Krishna Kant Pachauri
Dr Rakhi Chaturvedi

The Northeastern Region (NER) of India comprising of eight states (Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, and Sikkim) is blessed with smoky mountains, rivers, waterfalls, evergreen forests, valuable natural flora and fauna that should be protected, explored and used sustainably. NER shares both, Himalaya and Indo-Burma biodiversity hotspots that are the natural habitats of several endemic species, which are unexplored, untouched, and extremely beneficial. Its scenic beauty and exotic biodiversity have attracted scientists, policymakers and various stakeholders to work together as one coherent unit for overall wellness of the people of NER.

Landlocked by international borders, NER states are innately connected with nature and have a rich socio-economic and cultural heritage. The mighty Brahmaputra River and several affluents enrich soil fertility in an adjacent valley and support agriculture growth and allied sectors. Even though there is immense potential in agriculture, the majority of the tribal community from NER practices jhum/shifting cultivation, which accelerates habitat destruction, deforestation and environmental pollution. To curb self-sufficiency in agriculture, the policy makers are aiming for doubling of farmers' income by the introduction of high-yielding varieties and modern scientific farming strategies that improve productivity. Recent studies show that extensive urbanization, wild harvests of natural flora and changing environmental conditions become an adverse threat to NER. As a result, many medicinally and commercially important plant species are on the verge of extinction. In such a scenario, in vitro plant tissue culture techniques are a highly reliable approach for germplasm conservation, eco-restoration and phytopharmaceutical production, especially for several medicinally and commercially important plant species.

Qualitative Improvement of Genetic Resources of Indigenous Tea Species Camellia sp.

Tea plant (*Camellia* Jesian evergreen socio-economic crop species and belongs to the family "Theaceae". The

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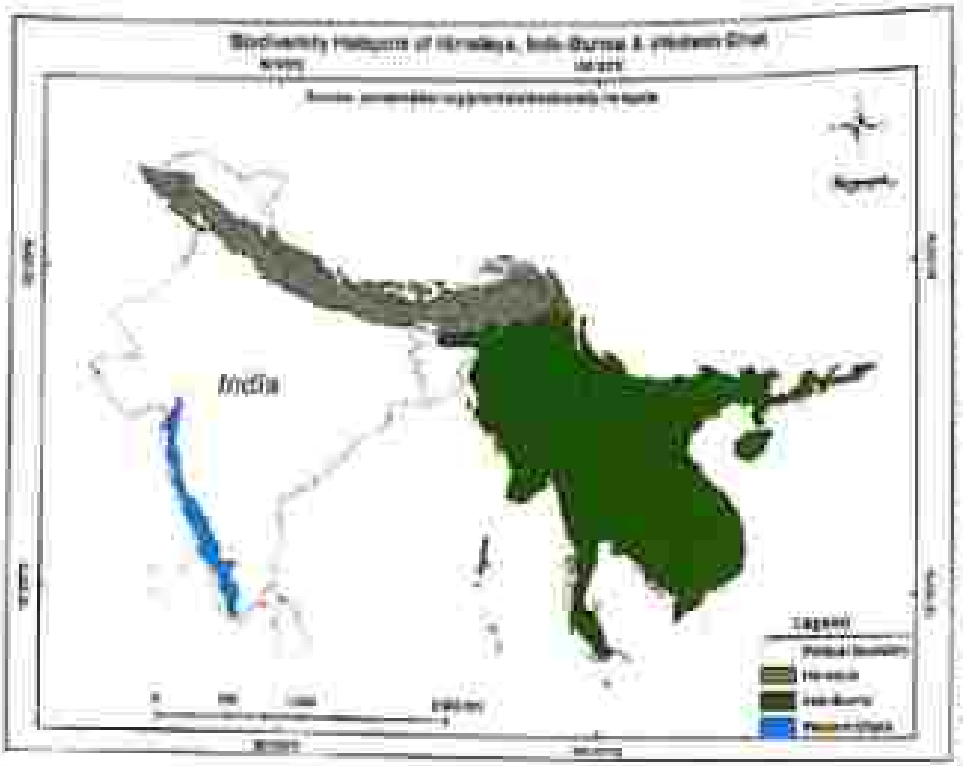

indigenous tea cultivar of Assam is named *Camellia sinensis* var. *assamica* (TV2)) having broad leaves and high content of catechins, dominates in black tea production as compared to China type tea (*Camellia sinensis*). The extreme cross-pollinating nature of tea plant results in high heterozygosity (high variability), which leads to inconsistent quantity and quality of phytochemicals. Conventional methods of plant propagation through seeds do not produce genetically uniform clones/identical plants and, on the other hand, stem-cutting and grafting have a poor survival rate and require adequate care to best suit the changing environmental conditions. Being a woody perennial, tea plant requires a longer time period to attain reproductive maturity, which causes less success rate of the development of superior clones/plants from existing parent plants following conventional farming strategies. Furthermore, improvement of genetic constituents and a further selection of superior varieties require several years in conventional breeding practices. In such scenario, in-vitro tissue culture method not only acts as a potential way of qualitative development of superior plants but can also produce large number of true-to-type (identical) plants in comparatively shorter duration. The in-vitro developed plants could serve as a potential source for the development of pure breeding plants and would also facilitate the consistent production of medicinally important bioactive metabolites, independent of seasonal variation.

Recent studies show that extensive urbanisation, wild harvests of natural flora and changing environmental conditions become an extreme threat to NER. As a result, many medicinally and commercially important plant species are on the verge of extinction.

Azadirachta indica

Azadirachta indica, commonly known as Neem plant, is native to the Indian subcontinent and Southeast Asia. All parts of the Neem tree, the leaves, stems, roots, flowers, fruits, and seeds contain medicinal metabolites and are used for household remedies against various diseases. Additionally, this magnificent tree is also renowned for its eco-friendly, insect-eliminating properties, thus regularly used in agriculture. The extreme cross-pollinating nature of Neem plant causes high variability in plants which leads to inconsistent quantity and quality of phytochemicals. To satisfy the growing demand and the vast use in pharmaceutical industries, attaining enhanced production of metabolic compounds should be our utmost priority. Neem tree is conventionally propagated through seeds. However, the low seed viability and seed-borne variability limit uniform and consistent metabolite production. In-vitro tissue culture methods would be the most suitable alternative strategy for the production of homozygous clones (pure breed plants) containing high amounts of metabolites compared to seed-borne trees. In the aseptic condition of the laboratory, pollen grains (male gametes) present in the male reproductive parts were successfully allowed to induce the haploid plants in suitable nutrient media. Haploid plants (sporophytes) are the product of meiosis and are the natural recombinants that carry the variable amount of metabolites in haploid plant lines. Haploids possess a single set of chromosomes (n) so they will not form the seeds but otherwise grow normally as a tall tree. Successful production of seeds requires an even number of chromosomes (2n) in parental lines. Therefore, the genome of these haploid plants was doubled to obtain seed-bearing doubled haploids plants that can be utilised as a pure breed variety. Screening and quantification of secondary metabolites (azadirachtin, salannin and nimbin) were analysed from these improved plants of the Neem plants. It has been observed that the newly developed haploid/doubled haploid plants contain higher azadirachtin, salannin and nimbin contents as compared to naturally grown parental diploid Neem plants. Despite these, overall methods have exploited the growth cycle with

added advantages of the production of genetically improved plant lines that are impossible to produce following conventional methods of breeding. Large-scale multiplication of plants requires many years and lakhs of plants are multiplied around the year. Now, the genetically improved variety is up for commercialisation and industry usage.

> In-vitro tissue culture methods would be the most suitable alternative strategy for the production of homozygous clones (pure breed plants) containing high amounts of metabolites compared to seed-borne trees.

Micropropagation and Biomass Resources Utilisation for High Value Metabolites Production

Lantana Camara

Lantana camara L. is an aromatic, evergreen shrub belonging to the family Verbenaceae. Each and every plant part is a natural reservoir of terpenoids, glycosides and flavonoids. Continual production of high-value metabolites at a commercial scale requires stable in-vitro elite cell lines. In this context, in-vitro culture from leaf explants was established in the laboratory to get a constant source of medicinally important compounds in higher amounts, all year round. Betulinic acid, oleanolic acid and ursolic acid are three pharmacologically active pentacyclic triterpenes that have been identified and quantified by various analytical methods. Moreover, the in-vitro derived cell extract exhibited cytotoxic activity in concanavalin HeLa cells.

Spilanthes Paniculata

Spilanthes paniculata Wall. ex DC. is a perennial herb belonging to Asteraceae family. The plant is commonly available in Northeastern India. It is a natural source of various important anti-malarial medicinal metabolites like N-alkylamides. Leaves and flowers are major edible portion of the plant, especially in Tripura and Arunachal Pradesh. The plant is known to possess anti-pyretic, anti-inflammatory, local anaesthetic, and anti-malarial properties. The primary active component is spilanthol, an isobutylamide mainly isolated from different parts of the plant, such as the flower and leaf. The high medicinal importance and increasing demand for plant-derived medicines lead to overharvesting of plants from natural habitats. In-vitro micropropagation is an excellent alternative to producing the plant at a large scale. It provides a rapid and constant supply of raw materials to produce important metabolites without seasonal and regional restrictions. Apart from micropropagation, elicitation and in suspension culture is also an important method of in-vitro biomass generation. This method can easily be scaled up from the flask to the bioreactor level for large-scale production of biomass as well as metabolites. In laboratory, we explore the alternate in-vitro approaches to biomass generation at a small scale level that can be further scaled up to a commercial level.

Stevia Rebaudiana

Stevia rebaudiana belonging to the family Asteraceae, is a medicinally important plant containing low-calorie sweeteners (steviol glycosides) in leaves. Health-conscious consumers around the world are recently looking for low-calorie artificial sweeteners as a substitution for sugar. Excess consumption of sucrose in the diet is associated with diabetes and cardiovascular diseases. Vegetative propagation of *Stevia rebaudiana* is limited by unfavourable climatic conditions, and seeds of the stevia plant show low viability in the field. However, in-vitro propagation is a rapid reliable system for the production of a large number of genetically uniform disease-free plantlets, irrespective of the seasonal variations. In this context, the accelerated in-vitro micropropagation protocol is established in the laboratory by nodal segments culture, followed by screening and quantification of steviol glycosides (stevioside and rebaudioside) from various plant parts.

Tinospora Cordifolia

Tinospora cordifolia or Giloy is a multipurpose woody liana that generally grows in tropical climates and is readily available in Northeast India. It is widely known for its immunomodulatory, hepatoprotective, anti-hypertensive, and antioxidant properties, hence called a rejuvenating herb. The antimicrobial features are also mainly due to the presence of high protein, carbohydrates, calcium, phosphorus, potassium, and iron. Recent studies show

Spilanthes Paniculata

Stevia Rebaudiana

Tinospora Cordifolia

that consumption of *T. cordifolia* has increased the recovery rate in dengue and SARS-CoV-2 patients. Therefore, the Government of India has included this plant in the 32 prioritised plant list for conservation and research. Giloy is mainly propagated through stem cuttings in the late spring, summer and autumn seasons. Another best-suited method for its propagation is using plant tissue culture technology, which uses micro-cuttings and grows them in controlled conditions. The quality control of *T. cordifolia* depends on its phytoconstituents content, which varies with geographical location. Chemical analyses of in-vitro regenerated plants showed higher alkaloid (berberine) content as compared to the stem and leaves of the mother plant. Additionally, inorganic nanoparticles were synthesised by utilising in-vitro cell cultures and further evaluated for biological applications.

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In-vitro Conservation and Nutraceuticals Production of Fruit Crops

Musa Balbisiana and Musa Paradisiaca

The *Musa* sp. commonly known as banana, belongs to the family Musaceae, and is one of the most widely distributed and consumed fruits with high content of minerals, vitamins, carbohydrates, flavonoids, and phenolic compounds. In Assam, farmers are growing bananas commercially due to high profitability. There are 15-20 different varieties of bananas available in Assam. In a seeded variety of bananas, non-viable seeds and long growth cycles limit plant propagation by the conventional method. Understanding this scenario, the laboratory is involved in micropropagation of large number of disease-free banana (*Musa* spp.) plants within a short period. Rutin, a flavonoid, naturally present in banana leaves has antioxidant properties and is beneficial to health. Extraction and quantification of rutin content were analysed in the laboratory from three different varieties of *Musa* sp., named Malbhog, Bhimkola and Chinichampa. The results indicated that banana leaves, a food industry by-product, and agricultural waste, have the potential for use as an inexpensive and new source of bioactive metabolites.

Oryza Sativa

In the Northeastern region of India, different black rice (*Oryza sativa*) varieties are grown in both the wetland and upland of Manipur and Tripura. The black rice varieties have got increasing attention due to their high nutritional, antioxidant and nutraceutical properties. The dark purple pigmentation is due to the presence of high anthocyanin (Cyanidin 3 O-glucoside) in the pericarp, which act as antioxidants and have vast applications in industries as a colorant, food supplements and nutraceuticals. Moreover, black rice is propagated through seeds and the availability of seeds is limited that restrict the farm growers to meet the high demand in the market. Thus, improved high-yielding black rice will encourage the farmers to cultivate them in field. Therefore, the laboratory has implemented in-vitro tissue culture techniques involving micropropagation and further analysis of bioactive metabolites from the cultured rice plants and cells. This process is serving a dual purpose, i.e., conservation of elite plants and to study their respective commercial values.

Conclusion

Biodiversity plays a pivotal role in maintaining the ecological balance in nature. Northeastern Region (NER) sharing Himalayan and Indo-Burma biodiversity hotspots, is one of the mega biodiversity centres in India and serves as the native habitat for valuable natural flora and fauna. Nowadays, indigenous bio-resources of NER have experienced a number of challenges, such as habitat destruction due to the ever-increasing human population, illegal mining, landslide, and overutilisation and illegal trading of medicinal plants. Considering the above alarming situations, ex-situ conservation and sustainable utilisation of indigenous bioresources of NER should be given top priorities. In this current scenario, in-vitro plant tissue culture techniques have added advantages in plant propagation, conservation, and improvement of medicinal and commercial plant species. The most important advantage of in-vitro technique is that it can further be used to produce bioactive medicinal metabolites in bulk, irrespective of geographical variations, seasonal variations, and also environmental factors. It offers a defined production system, continuous supply of products with uniform quality and yield. Novel compounds, which are not generally found in the parent plants, can be produced in the in-vitro grown plants through plant tissue culture. In addition, stereo- and regio-specific biotransformation of the plant cells can be performed for enhanced production of bioactive compounds from economical precursors. It is also independent of any political interference. Efficient downstream recovery of products and rapidity of production are its added advantages. Moreover, adoption of plant tissue culture techniques not only prevents extinction of germplasms but also makes NER self-reliant in modern agricultural practices.

Green Telecom

Sanjeev Bansal

With the advent of 5G technology, it is expected that there will be a significant rise in the towers, small cells, and BTS (or equivalent electronics) resulting in accelerating GHG and carbon emissions, and the resultant contribution in the overall global warming. To reduce the adverse effect on the overall ecosystem by the telecom sector, steps must be taken to lessen the energy consumption and migrate towards renewable sources of energy to mitigate the effects of global warming.

Ever since the start of industrialisation in the 18th century with steam power and mechanisation of production, the air and water pollution levels have been rising on Earth. Although pollution was present in the pre-industrialisation era also, it was negligible enough to be offset by the carbon dioxide stored and absorbed by the forests throughout the planet. However, in the 20th century, the pollution levels were more noticeable and the amount of Greenhouse Gases (GHGs) rising was giving effect to 'Global Warming.' The term 'Global Warming' refers to an unnatural increase in the average temperature of the planet as compared to pre-industrial levels. The various phenomena of global warming along with other natural calamities like typhoons, flash floods, melting of icebergs, etc., are collectively termed 'climate change.'

Climate Change is the biggest challenge the world is facing today. This requires all countries to come together and discuss measures to curtail the GHG emissions in the atmosphere. The respective sectors like Agriculture, Industry, Service sector, etc., have to take corrective steps in their area to mitigate the effects of climate change for a balanced ecological system.

Telecom services are an integral part of our lives, connecting people and things by the means of calls, messages, and the Internet. Telecom towers play a pivotal role in this process. The operations of these towers of telecommunication networks require electricity on a continuous basis for uninterruption-free telecom services. The electricity comes mainly from the power grid. However, when there are power cuts, these towers' electronics run on fossil fuels like Diesel Generator

Hybrid power supply on telecom towers

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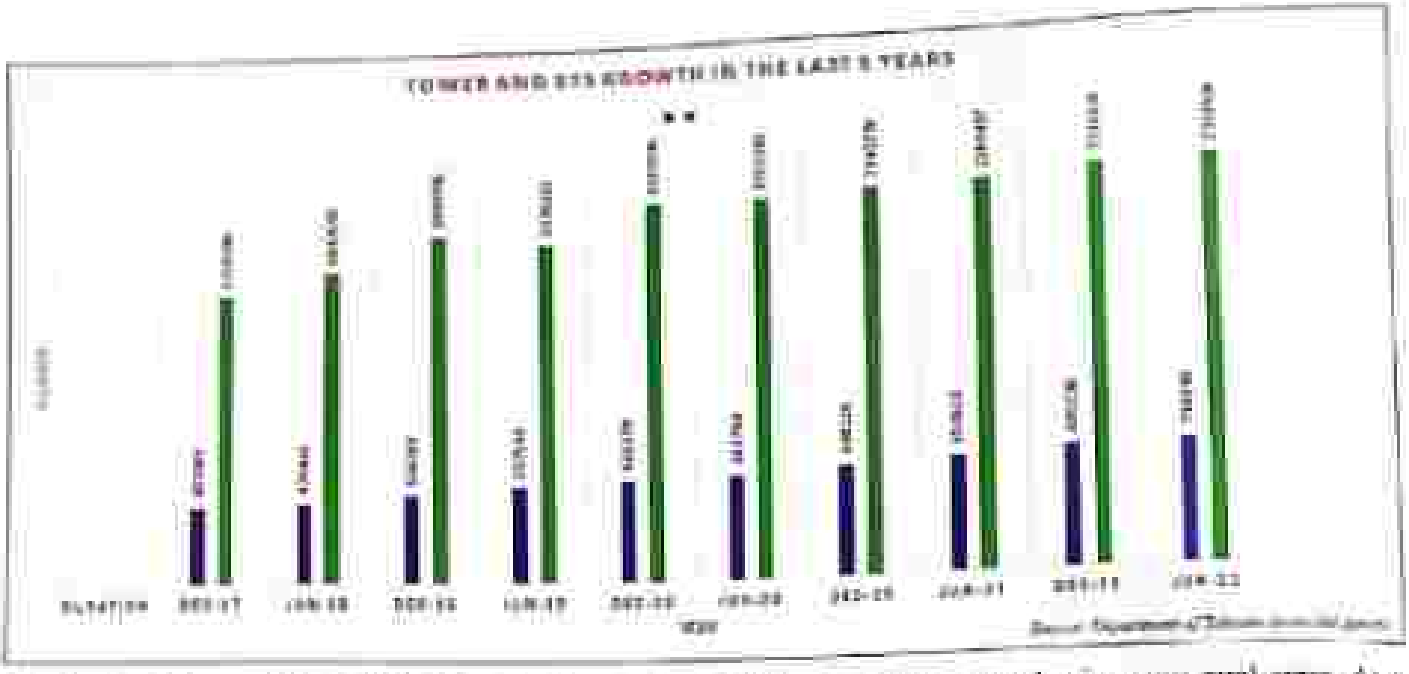


(DG) sets and battery backup. Both the grid energy and DG sets contribute to the emission of Green House Gases, thus increasing the carbon footprints, resulting in negative environmental effects like Global Warming. In addition, the energy consumption through these towers entails a significant amount of operational expenditure to the telecom service providers.

India's telecom market is the second largest in the world in terms of subscriptions. This market is characterised by one of the lowest broadband rates in the world. As per the latest TRAI report, as on 31 May 2022, India had 1.15 billion mobile subscriptions and about 800 million broadband connections, most of which were on mobile devices and connected through telecom towers and small cells. There are more than 7 lakh telecom towers spread over the length and breadth of the country. These towers house mobile transmitters and receivers (called Base Trans-Receiver Systems or BTS) at their base and antennas are mounted over these towers to transmit and receive mobile signals for connectivity with mobile devices like handsets, iPad, laptops, etc.

Due to the pandemic, there has been a rapid growth in mobile broadband as people are using broadband for connecting through video-conferencing and using payment through applications like Unified Payment Interface (UPI). The proliferation of mobile and broadband has led to an increase in the number of towers, small cells, and BTSs. The diagram above reflects the growth of the telecom towers and BTSs in the last 5 years (half-yearly basis).

A significant number of these towers are in rural and hilly areas where the grid power supply is not very stable and there are power cuts also in many rural areas. As a result, these towers have to depend upon DG sets. With the advent of 5G technology, it is expected that there will be a significant rise in the towers, small cells, and BTS (or equivalent electronics) resulting in an acceleration in GHG and carbon emissions, and the resultant contribution to the overall global warming.

To reduce the adverse effect on the overall ecosystem by the telecom sector, steps must be taken now on the two main fronts:

1. Reducing the energy consumption of the electronics, designing eco-friendly electronics, buildings, consumables, and effective network planning with the overall aim to reduce power requirement; and
2. Migrating towards renewable sources of energy to mitigate the effects of global warming.

1. **Reducing the Energy Consumption:** There are ways to reduce the energy consumption of the electronics used in providing telecom services including those based on 5G technology. Some of these technologies are:

- **Use of 5G Technologies:** In the 5G technology, the energy issues are handled right from the design stage itself. Unlike earlier technological evolutions (2G, 3G, 4G) in this field, 5G technology takes care of network energy efficiency. The energy efficiency of future network like 5G is expected to be improved by a factor of twenty as compared to LTE/4G technology. 5G technology will also help in the most efficient and flexible allocation of resources for providing telecom and broadband services. It will help in power management at the equipment

The energy efficiency of future network like 5G is expected to be improved by a factor of twenty as compared to LTE/4G technology. 5G technology will also help in the most efficient and flexible allocation of resources for providing telecom and broadband services.

level itself, thus reducing not only power requirement but also the need for air conditioning. Further, 5G technology will allow flexible use of spectrum which is an essential element for wireless communications, which in turn will have a direct impact on energy consumption.

- **Efficient Use of Network Operations:** Traditional (4G and earlier) mobile networks spend only about 15% to 20% of overall power consumption on actual data transfer. The rest is wasted because of heat loss in power amplifiers, equipment kept running when no data is being transmitted, and inefficient rectifiers, cooling systems, and battery units. New approaches are needed to eliminate the energy wastage or harness that wasted power for other purposes by:

i. Cell switch-off techniques, i.e., by turning Radio-Frequency (RF) chains off when not in use and keeping only backhaul links alive, the base station is only changed to active mode when a signal is sensed. This can reduce base-station energy consumption by up to 40%.

ii. Introducing smart shutdown techniques using Artificial Intelligence (AI) across multiple sites and radio networks to reduce power consumption.

iii. Use of single Radio Access Network (RAN) platform, in which a single base station supports 2G, 3G, 4G, and 5G technologies, thus replacing multiple pieces of equipment and reducing total power consumption.

iv. Close or retract old 2G, 3G Technology-based systems

v. Use of Dynamic Spectrum Sharing (DSS), which allows new mobile technologies to make use of older networks' spectrum, sharing it on a dynamic basis.

vi. Installing Internet of Things (IoT) sensors on infrastructure to monitor energy usage and quality of service, in real-time.

> **Due to its favourable location in the solar belt (400 S to 400 N), India is one of the best recipients of solar energy with abundant availability. Compared to diesel, solar electricity offers a sustainable, cost-effective, and environment-friendly electricity supply for the growing telecommunication industry.**

vii. Use of AI & Machine Learning (ML) techniques to support network automation, and allocation of resources in an intelligent, proactive, and more power-efficient way.

viii. Use of Self-Organising Networks (SON) with AI capabilities to help make near real-time decisions to self-optimise the network with the aim to save power.

- **Use of end-to-end intelligent power systems:**

i. The combination of cloud infrastructure and AI in mobile networks can enable telecom service providers to move towards fully intelligent power systems.

ii. A cloud-based system can coordinate base stations, power supplies, edge infrastructure, backhaul units, and other equipment across multiple layers and domains so that power supplies become intelligent and efficiencies are made throughout the network.

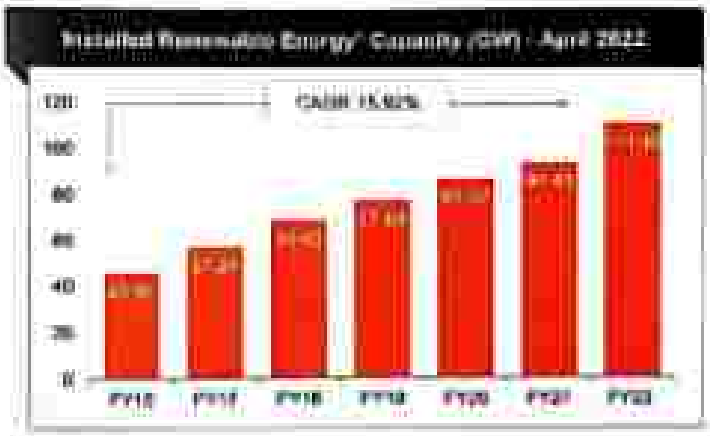
iii. In the future, full AI-based intelligent energy will emerge in which different levels of power are automatically made available depending on the time of day or applications.

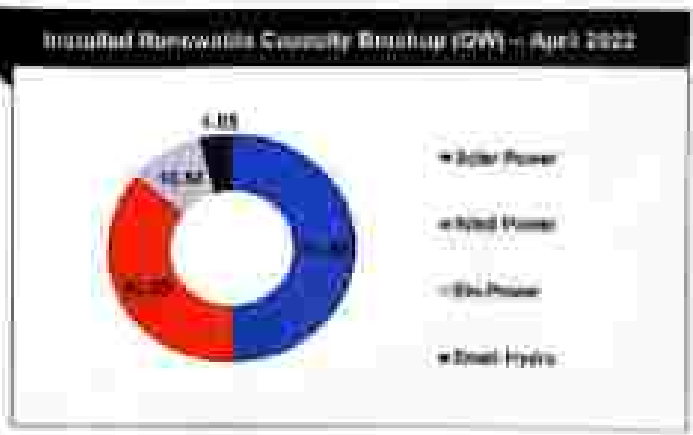
2. Migrate towards Renewable Sources of Energy

Telecom towers consume 65-70% of energy from the operations of telecom networks. In order to reduce the effect on the environment and ecology due to the energy needs of telecom equipment, there is an urgent need to move to renewable sources of energy for telecom towers, i.e., Green telecom towers for energy saving.

India was ranked fourth in wind power, fifth in solar power, and fourth in renewable power installed capacity, as of 2020. As per the Central Electricity Authority report, the total installed capacity increased by CAGR 15.92% between the Financial Years 2016-22.

For providing energy to the telecom towers, some of the following renewable sources can be used:





i. Solar Power

Due to its favourable location in the solar belt (400 S to 400 N), India is one of the best recipients of solar energy with abundant availability. Its generation has increased by more than 18 times from 2.63 GW in March 2014 to 49.3 GW at the end of 2021. Compared to diesel, solar electricity offers a sustainable, cost-effective, and environment-friendly electricity supply for the growing telecommunication industry. There are now hybrid models where power is drawn from both the grid and solar cells, thus reducing the dependence solely on grid and DG sets. In telecom towers, solar, grid, and DG-based power supply are increasingly being used in the field.

ii. Wind Power

Wind power is a clean, reliable, renewable, and cost-competitive source of renewable energy that has been used for decades. Wind power generation along with solar power generation (hybrid renewable power) is becoming quite popular now and many more wind turbines are getting installed. Conversion of wind energy has been expensive so far, along with the impact of a variable resource on the grid and siting. However, technology has advanced rapidly in recent years to accommodate these factors.

iii. Geothermal Power

Geothermal power is a renewable form of energy utilising underground hot water or steam created by the natural heat beneath the earth's surface. Low-temperature geothermal sources can be utilised to heat and cool by installing heat pump systems. Hot water or steam from high-temperature geothermal sources can be used to power turbines to produce, clean and renewable electrical energy.

iv. Fuel cell

Fuel cells are a promising technology for use as a source of heat and electricity. A fuel cell combines hydrogen and oxygen to produce electricity, heat and water. Fuel cells operate best on pure hydrogen. Fuels like natural gas, methanol or even gasoline can be reformed to produce the hydrogen required for fuel cells. Fuel cells are often compared to batteries. Both convert the energy produced by a chemical reaction into usable electric power. However, the fuel cell will produce electricity as long as fuel (hydrogen) is supplied, never losing its charge.

v. Other innovative solutions:

Wave power, tidal power, and ocean currents can also be used to drive turbines to generate electricity. Technologies to harness these forms of power are presently being developed to the stage of commercialisation.

Barriers to Renewable Energy Implementation

There are significant barriers to the implementation of renewable energy that need to be addressed. The key issues include the following:

1. Many renewable energy technologies remain expensive on account of higher capital costs, compared to conventional energy supplies for bulk energy supply to urban areas or major industries.

2. Implementation of renewable energy technologies needs significant initial investment and may need support for relatively long periods before reaching profitability.

3. There is still a lot to be done for consumer awareness of the benefits and opportunities of renewable energy.

4. Financial, legal, regulatory, and organisational barriers need to be overcome in order to implement renewable energy technologies and develop markets in India.

Conclusion

With the proliferation of broadband and mobile devices, there has been significant growth in the number of telecom towers and associated electronics at the Base-Stations (electronics below the telecom towers). It is expected that the 5G technologies-based mobile network will be rolled out and expanded quickly in India. This will increase the number of towers and small cells significantly. It is high time that we adopt the latest technologies to reduce the power requirement and move towards alternate sources of energy that are renewable and which in turn reduce the GHG and carbon emissions, thus helping in maintaining the ecological balance.

□

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Our Water Heroes

Dr V C Goyal
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Even though India suffered for 200 years under British colonial rule, its spirit to fight through difficult periods never wavered. Like a phoenix, India rose from its dark past to hold a prominent place in the world at present. Not only in the ancient Vedic and medieval periods, post-medieval era also witnessed pioneering works done on the development and conservation of water resources. Many water development and conservation works were carried out parallel with freedom struggle by Indian engineers, freedom fighters, rulers of the Princely States, and other unsung heroes, which have everlasting footprints in India.

Our ancestors had a rich knowledge of water conservation and management. For example, canal irrigation was not new to India as mentioned by Greek travellers and also mentioned in Arthashastra and not surprisingly, the Ahar-Pyne system of that period is still in use in the South Bihar region. Later, many princely States constructed tanks, lakes, reservoirs, dams, and other waterworks and services for irrigation and domestic purposes. History has innumerable contributions by many dignified Indian engineers, water warriors and unsung heroes, who have, for example, explored virgin areas and put them onto the map, discovered the origin of rivers, planned, designed, and implemented a variety of water structures, some of which are being utilised till now. Exploring the specific contributions during the British colonial period, we have come across the contributions of our Indian water heroes which may be categorised under three categories: "Jal Sarvagyahs," "Water Services," and "Water Structures."

Jal Sarvagyahs

Many persons were organised to document the scientific aspects of water for all sections of the society. Unquestionable issues imposed on the use of water also caused many lawsuits. Since lands and forests are intrinsically linked to water, and many protests were carried out on the theme of

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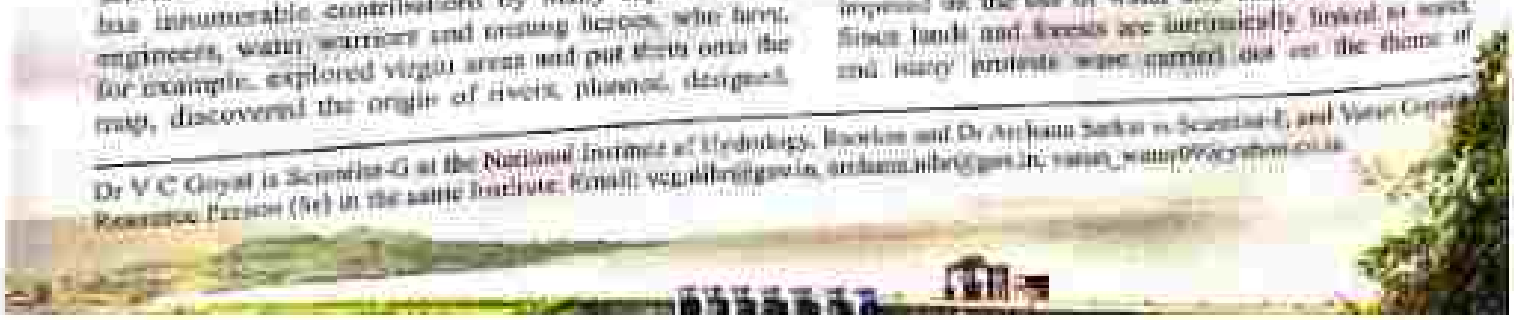

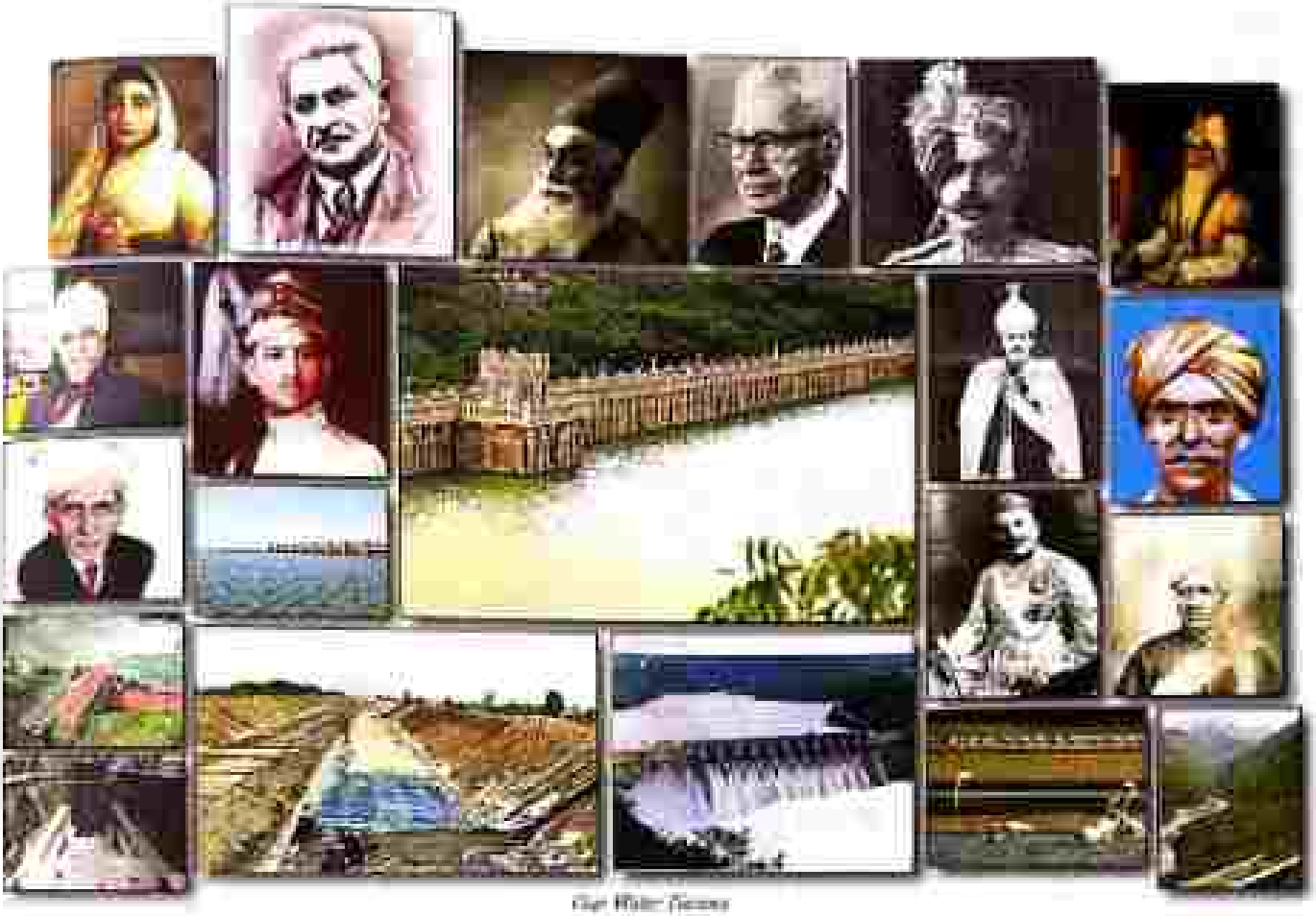

Our Water Heroes

Jal-Jungle-Jameen, especially in the tribal areas.

The Koya Revolt (1862) started against the 'Mutadars' (zamindars) who formed a chain of rent collectors from the colonial rulers in the year 1862. The rebels attacked the authorities under the leadership of Tammanna Dora in 1879. In 1922-24, this movement got revitalised with the Non Cooperation and Civil Disobedience Movement under the leadership of Alluri Sitharama Raju in West Godavari district. Kumuram Bheem (1901-40), a revolutionary leader in Hyderabad State from the Gond tribes, is credited for coining the slogan Jal, Jangal, Jameen (translated as Water, Forest, Land), which symbolised a seamless rights management and exploitation.

Water Services

Besides water-related protests and building water structures, another category of efforts made by our water warriors and unsung heroes includes activities like exploring virgin areas to identify water sources, carrying out surveys and investigations for planning of water schemes, establishing institutions, etc.

We come across an interesting story of a community managing their water needs by practising various traditional water harvesting and conservation techniques in Amarkot (now in Pakistan). Akin to the present-day water-supply mission, various piped-water supply schemes were implemented by Sood community during 1860 to 1920 in Shikhe, Garli, and Garh villages of Kangra Region and adjoining areas of undivided Punjab.

Maharaja Ranjit Singh was the first ruler in Punjab who thought of large-scale utilisation of canal water for irrigation of crops. Both the perennial and inundation canals were excavated and expanded in the early nineteenth century. Under the Kingdom of Lahore, inundation canals were excavated particularly in the southwest, in Multan and Derajat, and took their supply from the rivers Sutlej, Chenab, and Indus.

Maharaja Ranjit Singh was the first ruler in Punjab who thought of large-scale utilisation of canal water for irrigation of crops. Both the perennial and inundation canals were excavated and expanded in the early nineteenth century.

Nain Singh Rawat (1830-82) was one of the first 19th century Indian explorers who explored the Himalayan region. His accolades consist of putting Tibet on the map and accurately locating the source of the Brahmaputra River.

An illustrious alumnus of Thomason College of Engineering, Roorkee, Ex Ganga Ram converted 20,000 hectares of barren, unirrigated land

in Montgomery District into smiling fields, irrigated by water lifted by a hydroelectric plant and running through a thousand miles of irrigation channels, all constructed at his own cost. This was the biggest private enterprise of the kind, unknown and unimaginable in the country before.

After the catastrophic floods of 1908 from rivers Mula and Mul, Hyderabad's Nizam Mahboob Ali Khan engaged Sir M Visvesvaraya to prepare a comprehensive plan for the flood protection of the city. Khadakwasla Dam on the Mutha river near Pune and the associated reservoir known as Khadakwasla lake were also constructed by Sir Visvesvaraya. This is the main source of water for Pune and its suburbs even today.

Another alumnus of Thomson College of Engineering, Roorkee, Er Ajudhiya Nath Khosla conducted surveys and investigations of the Bhakra Dam Project. Er Khosla applied his methods to the design of the Trimmu Barrage on the river Chenab in Jhang District of Punjab province and constructed it within two years (1937–1939) to pass the excess flows during high floods. Er Kanwar Sain Gupta, also known as father of Indira Gandhi Canal (IGC), gave a vision to build this canal in 1940. IGC is the longest canal in India and the largest irrigation project in the world. Raja Jwala Prasad, an illustrious alumnus of Thomson College prepared the Ganga Canal Grid Scheme in 1924.

Water Structures

Many water harvesting and water conservation structures were built by the Princely States' rulers. Since nineteenth century, major demographic and economic changes started happening. This was the period when many famines occurred in India. In order to tackle famine and recurring droughts, large-scale construction of canals and wells was taken up. Artificial lakes and tanks were mainly constructed in southern India. Just before freedom, many "multi-purpose reservoir" projects were conceived.

Ranjya Kaul (1800) irrigation system was re-constructed by Rani of Kittoor. In addition to providing irrigation water, Kulls used to meet all the water needs of the villages they flowed through. Sukhai Bagicha at Howdi Indore was got made by Devi Ahilya Bai Holkar in around 1833 at the time of construction of Omeshwar temple.

Sathachi Iyer was responsible for initiating the first hydro-electric project in Asia, at Shivanasamudra in the Mandya district of Karnataka, which began generating power in 1902 for the Kolar gold fields and for Bangalore in 1905.

Thol Lake Sanctuary near Ahmedabad is made up of a reservoir that was created in 1912 as an irrigation

Nizam Sagar is the oldest dam built in 1931 over Manjira River which is the tributary of the Godavari River, and flows between the villages Achampet and Banjapalle of the Kamareddy district in Telangana.

tank, when the Sayajirao Gaekwad of Baroda Kingdom ruled the region. Rankala lake in Kolhapur city was constructed by Chhatrapati Shahu Maharaj in 1890s. Envisioned by Jamsetji Tata, Valvan dam near Lonavala, Pune was constructed in 1916 to be used for Khopoli hydro-electricity plant, and is a source of water supply for Lonavla, Khandala and nearby villages.

Nizam Sagar is the oldest dam in Telangana which was built by 7th Nizam of Hyderabad, Mir Osman Ali Khan and designed by famed engineer Alj Nawaz Jung Bahadur. It was built in 1931 over Manjira River, which is the tributary of the Godavari River and flows between the villages Achampet and Banjapalle of the Kamareddy district in Telangana.

Mulshi dam on Mula River in Mulshi Taluk of Pune district was constructed by the Tata Industries in 1927 for hydroelectricity generation. Water stored in the reservoir is used for irrigation and also provided to the reservoir is used for irrigation and also provided to Bhira hydroelectric project, operated by the Tata Power company. This project was the main subject of the Mulshi Satyagraha led by Senahati Bapat, a Gandhian revolutionary.

Maharaja Ganga Singh conceived the idea of bringing area of Bikaner State under irrigation from Sutlej Waters. Foundation stone of the Canal Head Works at Ferozepur was laid on 5 December 1925, and the construction of 89 miles of head canal was completed in 1927.

Thippagondanahalli Reservoir (1930-34) was constructed by King Chamaraja Wodeyar VIII of Mysore, at the confluence of Arkavathi and Kumudavathi rivers. It is used by the Bangalore Water Supply and Sewerage Board as a major source of drinking water.

The first hydro-electric project in Kerala was established at Pallivasal during the reign of Maharaja Sri Chithira Thirunal Balarama Varma. It was commissioned during 1940-42 in three stages. Bhakra dam was built on Sutlej river in Bhakra village near Bilaspur in Himachal Pradesh. The agreement for project had been signed by the then Punjab Revenue Minister, Sir Chhotu Ram in November 1944 with Raja of Bilaspur and finalised the project plan on 8 January 1945. Construction of the dam started in 1948 and was completed under the guidance of Er Kanwar Sain Gupta.

This instills a feeling of pride to learn how devoted kings and queens, talented engineers, patriotic freedom fighters and unsung heroes have made enormous contribution in developing and conserving water resources while fighting for the freedom of India.

Bhakti & Nationalist Movement

Dr Moloy Rakshit

The song, Vande Mataram, written originally in 1875, was used by Bankim Chandra in his novel, Anand Math, in 1882. Bankim believed that this song could cause waves across the entirety of India and it came to be ranked almost as the national anthem since 1905 when it was provided a melody by Rabindranath Tagore. Through this novel, for the first time in the canon of Bengali novels, an 'all-encompassing and active nationalism' appeared in a very distinct and more intense form through bhakti and shakti, the freedom movement.

The rise of nationalist sentiment in Bengal revolved around Chaitra Mela, established in 1867. Educated Bengalis sought nationalistic inspiration from the glorious chapters of ancient Indian scriptures and started celebrating the staging of Sanskrit dramas in Bengali translation in their theatres instead of Shakespearean plays.

Rajnarayan Basu had first attempted to theorise this newborn nationalistic passion and brought it under an organisational framework. The most significant of Rajnarayan's proposals was the introduction of a unified education system of imparting of moral lessons, the inculcation of benevolence for the nation, and promoting mutual love, all through supernatural means.

It is significant that in the last two decades of the nineteenth century, the Bhakti cult of Hindu nationalism was far more influential than the political cult of neo-nationalism. Though Bankim's *Anand Math* talked about the militant form of nationalism, the root of that nationalism lies in Bhaktism. To understand its real nature, we will have to evaluate how much influence this novel had on our national movement.

Bankim has given the national struggle a well-organised orderly form. It could have been easily left unsaid that amidst a dense and impenetrable forest, situated 'in a large chunk of land surrounded by broken rocks', *Anand Math* was a Hindu abbey. Brahmananda took Mahendra to the temple located at the heart of the abbey and showed him the incarnations of the goddess. Despite ample evidence of the idol of the goddess, it can be said that it was neither any temple of a Hindu deity nor a religious locale. In fact, it was the secret base of revolutionaries, a central office, and an organised centre from which their operations could be carried out in secret. Only those who organised the movement, or who were in charge of different tasks, lived there. There was a constitution of the organisation along with rules and regulations as well, all of which had to be strictly followed. In the second volume, Satyananda made Mahendra and a disciplined Khanta take an oath regarding some unbreakable 'rules' and responsibilities before their initiation programme. That oath pledged that until the native land was recovered, they were to give up domestic matters, relations, servants, wealth as well as sensual pleasures, to submit all earned wealth to the treasury of the abbey and to take hold of arms and fight

Anand Math

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the Santans Dharma. All kinds of physical training, mental training, rigorous practices, corporal privation were part and parcel of the routine works of the abbey in order to prepare for the upcoming battle. When the regimented and trained Santans attacked the enemy, it became evident that it was a planned and skillfully led attack. Moreover, they chose hostility (looting and robbery) as a way to solve the financial crisis for conducting warfare and collecting arms. The Santans arranged their own arsenal and treasury to fight against the powerful enemy. After his initiation to the Santans group, Mahendra was instructed to go back to the village of Pirbitchhera to build a fortress out of his mansion which was supposed to be a refuge for the army, and a treasury and factory to manufacture arms. Arms and ammunition were to be manufactured in a domestic fashion and stored. From this perspective, the nature of the nationalism portrayed in *Anand Math* can be called 'militant nationalism.'

Bankim Chandra Chatterjee

The second section of the functional approaches was Bhakti. The Bhakti cult preached by Ramakrishna had taken the milieu of Bengal by storm. Staged in 1881, *Ravana Badha* by Girish Chandra had left the audience overwhelmed with the Bhakti Rasa. In the 1880s and 90s, Girish Chandra kept Bengalis imbued in the Bhakti Rasa by writing and performing plays like *Chaitanya Leela*, *Prahlad Charitra*, *Nimaimangal Thakur*, *Jana*, etc. Since Bankim comprehended the relevance of the Bhakti Rasa in *Anand Math*, he directed extremist armed revolution hand-in-hand with the drills of Bhaktism and the devotional pursuit of an all-sacrificing monk. Above all, he tried to represent this paragon of Bhaktism in a devotional song. In the first volume of the novel, the song sung through Bhavananda's voice: "Vande Mataram/ Sujalam Suphalam Malayaja Shitalam/ Shashyashyamalam Mataram" was an attempt to worship the motherland, as the "Mother and the Motherland (that) was greater than Heaven itself." On the other hand, the key chant of this song was 'Vande Mataram', which had become the group identity, the great hymn of liberation, the reverberation of their devotion, strength and courage for the Santans.

The Santans group and their activities in *Anand Math* were actually comparable to the arrangements for a revolutionary upheaval. The last two decades of the nineteenth century were the age of Bhaktism. There was no ground of possibility for a political movement against the British. Rather, the middle class Bengalis had dedicated themselves to the devotional plays of Rajkrishna, the *kirtana* marches filled with Bhakti ideals led by the men of the epoch Keshav Chandra Sen, and to the pursuit of recasting the woman in the model of *Sati-Savitri* irrespective of their groupism and ideological conflicts. *Anand Math* was received by middle class Bengalis as a paragon of Bhakti only. The extremist and active nationalism closely intertwined with every bit of the novel did not seem to have much relevance in the national life of the Bengalis in that period. Its necessity emerged with the advent of a new century, secret arrangements for revolutionism were being made and the Partition of Bengal caused an unprecedented stir in the national life. Revolution against the state began, along with which continued the mainstream swadeshi movement and secret terrorist missions of the revolutionary movement. *Anand Math* became an acceptable 'model' for the revolutionary organizations.

> The Bhakti cult preached by Ramakrishna had taken the milieu of Bengal by storm. Staged in 1881, Ravana Badha by Girish Chandra had left the audience overwhelmed with the Bhakti Rasa.

Setting ground for revolutionary movements in Bengal had started as far back as in 1902. Aurobindo Ghosh penned the idea of creating 'secret societies' to enlighten youth. A small booklet was published with the same intent, namely, 'Bhawani Mandir'. The book conveyed that there would be a temple of Bhawani among the mountains, where a capable one would succeed in his devotional pursuit and under the guise of Bhawani, would preach the principles of freedom to the nation. Hemchandra Kanungo in his famous autobiography 'Revolutionary Attempts in Bengal', has written – "The idea of a temple of Bhawani as an imitation of *Anand Math* first occurred

to Debabrata Babu. This Debabrata Babu is the revolutionary Debabrata Basu."[1] However, Natarajan in his book, 'Biplabeshwar' wrote— "Aurobindo published a booklet expatiating on the topic of the Bhavani temple. Hundreds of books like this were circulated within the country. The whole country was shaken to realise the contents of these books. The revolutionary community was built. It was like a real life representation of Bankim's *Anand Math*."[2]

Revolution against the state began, along with which continued the mainstream swadeshi movement and secret terrorist missions of the revolutionary movement. Anand Math became an acceptable 'model' for the revolutionary organisations.

There were two basic models for revolutionary struggle in Bengal— one, the secret revolutionary attempts of the Santanas and two, the Carbonari revolutionary group of Italy which Mazzini incorporated in his struggle and achieved independence for Italy. Hemchandra Kanungo mentions that during the first decade of the twentieth century, from 1902 to 1908, the map of secret revolutionary movement/upheaval in Bengal was drawn following no other model but *Anand Math*. He refers to *Anand Math* and says that the so-called revolutionists of Bengal were in fact acting towards the novel through their revolutionary activities. Afterwards, in his book, he shows how each scene was being acted out as an imitation of the Santanas of *Anand Math*. He says that the way Bankim depicted women was that "Shanti, despite being one of the Bengali women, could effortlessly snatch away the rifle from the British captain's grasp and knowing him full of love for humans, could throw it away with utter despise, then what was it that we, the men of Bengal, could not do!" The widely accepted notion regarding the history of the revolutionary movements during the 'Agniyug' of Bengal has been changed by Hemchandra Kanungo in order to present us with an alternative history. These narratives reveal to us the flaws of our patriotism as well as those of militant nationalism or armed revolutionism, and points at the greed and lust, the contradictions and hypocrisies within its corpus.

Hemchandra writes that the model of nation-salvation through religion too was actually taken from *Anand Math*. It was possible to acquire divine powers only through religious practices. Therefore, it was considered possible for a revolution to succeed if it happened in the likeness of *Anand Math*.

A secret society used to have a room for *akhadas* in Medinipur. Hemchandra mentions that this room was "Pathghar" and renamed *Anand Math* and an idol of Goddess Kali was established there. The revolutionaries were made to participate in various spiritual like worshipping Shakti or becoming a devotee of Kali. To become spiritually sound, they had to read Gita and reach the state of "Nistraigunya Bhavarjuna," mentioned in the twelfth chapter. Those who used to progress in these matters were the ones considered revolutionaries of a higher level, and the others of a lower one.[3]

Apart from its dignity as a song, 'Vande Mataram' had become the only slogan for the mainstream national movements of Bengal as well as India, right since the time of the Partition of Bengal. Among the protest movements, on the day the Partition of Bengal came into effect, there was one happening on the 30[th] of the Bengali month of Aswin in 1905, where the banks of Ganga were reverberating with the repeated chants of 'Vande Mataram'. Savarkar was arrested in 1906 under charges of sedition for writing an essay on 'Vande Mataram.' It slowly became an acceptable mantra for protesting and rousing patriotism even at the pan national level. ❑

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