

INDIA'S ONLY POLAR THINK TANK



SaGAA | The Science and
Geopolitics of Arctic and
Antarctic

THE SAGAA VIII BOOK

Nov 24-25, 2025

NEW DELHI





Bharati, Antarctica



Himansh, Himalaya



Himadri, Arctic

NATIONAL CENTRE FOR POLAR AND OCEAN RESEARCH

*An Autonomous body under the Ministry of Earth Sciences,
Government of India*

NCPOR, Goa, under the aegis of the Ministry of Earth Sciences, Govt. of India is a nodal agency for India's expeditions to polar regions such as Antarctica, the Arctic, and the Southern Ocean.

Indian Gateway to Polar Regions

The institute also operates four stations throughout the year- Maitri and Bharati in Antarctica, Himadri in the Arctic, and Himansh in the Himalaya. NCPOR in Goa conducts R&D activities in key areas such as climate variability, oceanography, and cryospheric sciences. The institute is also involved in strategic marine geoscientific projects such as the Deep Ocean Mission, surveys of the Exclusive Economic Zone, the legal continental shelf, and the exploration of hydrothermal sulphide mineral deposits in the Indian Ocean.

44 Indian Scientific Expeditions to Antarctica

15 Indian Scientific Expedition to Arctic

12 Indian Southern Ocean Expedition

2010 Indian Expedition to the South Pole

2022 Indian Scientist Reached North Pole
Indian Antarctic Act, 2022

2005 India's Only Ice- Core Laboratory established at NCPOR, Goa.

Thrust Areas

Expedition & Operations
Antarctica, Arctic, Himalayas, Southern Ocean

Polar Sciences
Polar Cryosphere & Ice core studies; Past Climate Studies; Remote Sensing; Himalayan Cryosphere

Geoscientific Studies
Indian Ocean Discovery Program; Indian Ocean Geoid low; Extended Continental shelf Program

Deep Sea Exploration and Mapping
Mapping of the EEZ; Hydrothermal Mineralisation Studies; Cobalt Crust



National Centre for Polar and Ocean Research,
Ministry of Earth Sciences, Govt. of India
Headland Sada, Vasco-da-Gama,
Goa 403 804, India

+91-832-2525 511/600
director@ncpor.res.in;
info@ncpor.res.in

@ncaor_goa
@ncpor_goa/
@ncpor_goa/

@NCPORGoaVasco
www.ncpor.res.in

INDIA'S ONLY POLAR THINK TANK



SaGAA - The Science
and Geopolitics of Arctic
and Antarctic

THE SAGAA VIII BOOK

NEW DELHI



PRE-CONFERENCE MATERIAL

November 2025

Publication Details

Copyright: LIGHTS

Published by: IRIS Publication Pvt. Ltd.,
504, 5th Floor, Bhikaji Cama Bhawan,
R. K. Puram, New Delhi - 110066
www.geographyandyou.com
Phones: +91-11-40159058, +91-11-46014233

Cover Design and Illustration depicting the journey of a Wandering Albatross over
an imperfect world by Dhimaan Prasad and Layout by IRIS Publication Pvt. Ltd.

Disclaimer: This book is being published as Pre-Conference material for the benefit of
participants and speakers. It also consists of abstracts and talking points from various
speakers and panellists. We regret any inadvertent error in this publication.

Contents

5 Section A

Ideating the Conference

Efforts the organising committee to put together an event of national and international significance

13 Section B

The Context and Contemporary Relevance

Finding new pathways from a composite outlook of world politics, held through a national perspective

67 Section C

The SaGAA Speakers/Delegates

The change makers who are ushering nations into a new future of global friendship

127 Section D

The Discourse

Discussions on geopolitics; climate change and science of the polar regions

Section A

Ideating the Conference

SaGAA VIII 2025

Efforts the organising
committee to put
together an event
of national and
international significance

Ideating SaGAA 2025

In 2011, the first steps towards a civil society understanding of the Polar regions were taken with the launch of the Science and Geopolitics of Arctic and Antarctic (SaGAA) initiative. At a time when discussions about the Arctic and Antarctic were limited, SaGAA began as a biannual conference aimed at bridging science and policy. By 2015, it had been formalised as a think tank under LIGHTS, India's independent, not-for-profit organisation, and steadily evolved into the country's only institution dedicated exclusively to polar and cryospheric issues.

Over the past 15 years, SaGAA has organised seven major conferences, contributed to India's Arctic Policy, published three academic books, produced multiple special issues of Polar-themed Geography and You, launched a wide-ranging podcast series, and published a steady stream of newspaper articles to elevate Polar awareness in India's public sphere. Over the years, it has addressed the most pressing challenges facing the global community, such as the rapid melting of the Polar regions, the science behind it, and the evolving geopolitics that increasingly shape environmental decisions. Its mission has remained consistent and ambitious: to jointly undertake policy initiatives on all matters related to Polar science and Geopolitics; to act as an advocacy body for the Government of India; to forge alliances with national and international agencies to accelerate research capabilities; to serve the industry by strengthening globalisation efforts related to the Polar regions; to encourage universities, colleges, and schools to expand academic and policy research in Polar sciences; and to build platforms capable of influencing meaningful, long-term policy interventions.

The ideation of SaGAA VIII (2025) builds upon its rich legacy and marks the beginning of a new era. Ambassador Pankaj Saran, President of LIGHTS and Member of the National Security Advisory Board, joins this legacy as Chairman SaGAA VIII, bringing renewed strategic depth and coherence to the initiative. His leadership - supported by eminent patrons across India's scientific and diplomatic ecosystem re-energised the eighth edition. The consultations that shaped SaGAA VIII spanned an exceptional breadth of 55 institutions with an interest in the Polar regions. Senior leaders, Dr M Ravinchandran (Secretary, MoES), Ambassador Sibi George (Secretary, West, MEA), Dr V Narayan (Chairman, ISRO), Dr Shailesh Nayak (Director, NIAS), and Dr P S Goel (Honorary Distinguished Professor, Indian Space Research Organisation (ISRO) Headquarters; Professor, National Institute of Advanced Studies (NIAS)), helped distil the ideas for this eighth edition of SaGAA. Special mention must be made of Dr Thamban Meloth (Director, NCPOR) and Dr Acquino Vimal (JS [UNES], MEA) among many other leaders of various scientific forums and think tanks, who gave the SaGAA movement a fillip. The forum's institutional gravitas was elevated by the participation of senior government leaders and diplomatic representatives, including H.E. Benedikt Hoskuldsson, Ambassador of Iceland to India, H.E. May-Elin Stener, Ambassador of Norway to India and H.E. Rasmus Abildgaard Kristensen,

Ambassador of Denmark to India, firmly positioning SaGAA VIII at the intersection of science, strategy, and international cooperation.

An extraordinary level of commitment propelled the SaGAA VIII process. Steering this complex consultative journey, Dr Sulagna Chattopadhyay led sixty-five online and offline meetings, each ranging from thirty minutes to an hour. These interactions were intensive and purposeful, creating direct engagement with institutions and leaders across India's scientific and governance ecosystem.

Minutes were diligently recorded for every meeting, later forming the backbone of the conference's guidelines and thematic direction. The discussions - held primarily with Secretaries, Directors, Chairpersons, and Director Generals - centred on key research questions: understanding the institutional histories and mandates of participating organisations; identifying areas where Polar research could generate meaningful synergies; assessing their interest in strengthening Polar engagement; and emphasising why Polar science is indispensable to India's strategic future.

Advocacy for the Polar cause emerged as the unifying thread of the entire SaGAA VIII effort, and the depth of deliberation achieved was made possible only through this sustained, meticulous, and personally driven series of consultations.

Modern science - timeless in aspiration and universal in language - moves beyond the constraints of geography and politics. It seeks human well-being, extends its compassion to the non-human world, and thrives on shared learning. Science is not merely empirical thought elevated to innovation; it is a commitment to shared learning, a binding force that weaves together nations despite geopolitical turbulence. Human history has repeatedly shown that scientific cooperation can outlast conflict, the International Geophysical Year (IGY), the Antarctic Treaty forged at the height of the Cold War, the Montreal Protocol, which healed Earth's ozone layer, CERN, where scientists jointly explore the universe, and the global collaboration that produced COVID-19 vaccines. SaGAA VIII anchored itself as a multilateral knowledge platform designed to harmonise scientific priorities with geopolitical realities and emerging global partnerships. It aims to reinvigorate actionable collaboration and reconnect global and national scientific priorities at a time when geopolitical conflict has fractured global scientific cooperation and when resource density, strategic competition, and mistrust increasingly overshadow benign scientific agendas. SaGAA was among the earliest to insist that science and geopolitics must be viewed together, not in isolation, a principle that has now become indispensable in polar discourse.

As highlighted during SaGAA VII (2023), the organisers set out to broaden engagement with colleges, universities, and research institutions - a vision that came to life in SaGAA VIII (2025) with the launch of the SaGAA Future Leaders Programme. This annual competition is designed not just to encourage participation but to ignite curiosity and passion among students across a wide spectrum of interdisciplinary fields, nurturing the next generation of India's polar scholars and future leaders in science and policy. Designed as a national platform to identify emerging scholars working on India's scientific and strategic interests in the Arctic, Antarctic, and the Himalayas, the programme featured

an online paper presentation competition under the theme “Ice Work–Science and Livelihoods.” PhD and postdoctoral researchers submitted abstracts and university endorsements, after which shortlisted participants presented concise slides to an interdisciplinary jury of senior experts in polar science, oceanography, climate studies, and international relations. Three finalists were selected through online rounds held on 7 November 2025, and these winners were invited to deliver their final presentations during SaGAA VIII before leading scientists and policymakers. The winner is to receive a citation, an embossed plaque, a cash award of INR 25,000, and the opportunity to publish with Springer. Through this initiative, SaGAA strengthened its outreach to young researchers and created a meaningful platform for nurturing India’s next generation of Polar scholars and enthusing a gamut of young scholars present at the event.

SaGAA VIII is not merely a milestone; it is a declaration that India’s voice in polar science and policy is resolute, collaborative, and forward-looking - where science meets strategy, and where tomorrow’s leaders are forged today.

SaGAA VII (2023)

The ideation of SaGAA 7 began about 9 months ago, precisely in July, 2022 with the commencement of the LIGHTS governing body meeting with Dr Rasik Ravindra, Chairman, SaGAA and Senior Vice President, LIGHTS, at its helm. Professor NC Pant, Fmr Prof Geology, Delhi University, was invited to join the SaGAA organising committee as its Co-Chairman to help prepare the vision outline and contribute to the overall mission, goals, scope, and objectives of the SaGAA think tank. India’s new interest in the Arctic, partially due to the possibility of engaging beyond science with the Arctic nations and the increasing commercial viability of the Northern Sea Route, has contributed towards shaping the objectives of SaGAA 2023. The Conference being central to the activities of the think-tank, determined the nature of the seventh SaGAA event, and the platform was envisaged to throw up new ideas of collaborations.

With a resoundingly positive response from the Ministry of Earth Sciences, the National Security Council Secretariat, and the Ministry of External Affairs, SaGAA embarked on furthering the conference platform after a three-year hiatus since the pandemic. The organising committee upheld the dynamism and the urgent need to rebuild the SaGAA forum and engage in multifarious domains. The SaGAA 7 panel of patrons advised proactively through the ideation period and attended several online meetings. Members of the organising committee came together in several in-person meetings to build a methodology based on the advice of the patrons and identified key issues to be discussed during the SaGAA 7 conference. The members brought to focus various online and offline meetings, workshops and seminars that were organised between 2021-2022 related to the poles and the Southern Oceans. The topics from these events were curated, analysed and contextualised for contemporary and regional relevance. Thereafter a list was prepared with 35 topics. Armed with a list of topics, the patrons and organising committee attempted to put a face and name to each of these ideas. Thus emerged the list of identified experts who were to be invited for this special edition of SaGAA 7. The SaGAA secretariat then went on to write personalized letters to each of these invited speakers, outlining their areas of synergy with the topic selected for them. SaGAA 7 stands today with a total of 67 eminent speakers, including 6 secretary level officers, 17 Heads of the Departments from 7 nations

including India and representatives from more than 38 institutes, universities and organisations, working in the areas of geology, geography, climate science, technology, policy, security, exploration, geopolitics and environmental sciences.

However, the limitations of the SaGAA 7 two-day event, sans a parallel session format, imposed a time-constraint. All 35 topics were unable to be accommodated but a sizable number, 26, were addressed during the event. From the list of 26 topics, the majority (more than 24) of the papers were presented on the polar regions of the Arctic, Antarctic, and the Himalaya, primarily focusing on the issues of energy, climate change and disaster risk mitigation. In all 6 papers were presented on India's Deep Ocean Mission, and about the same number of speakers and panellists discussed topics pertaining to maritime security, Arctic-Indo-Pacific Connect, especially with regard to the narratives around Northern Sea Route and the Strait of Malacca. Deliberations on new areas of research in this sector pertained to indigenous communities in cryospheric realms, gender perspectives and youth participation in polar affairs. SaGAA 7's list of finalised talks were listed in this book of abstracts. It was decided that the future events of SaGAA would additionally focus on encompassing more papers, presentations and discussions on the topics of permafrost, blue and green economy, climate change and the disasters in the Arctic, Antarctic and Indian Himalayan region, and its impact on people's livelihood.

SaGAA VI (2020)

SaGAA VI, held on 28-29 September 2020, was a unique chapter in our history. It was the first time that the Webinar was organised as an end-to-end online event in multi-national dialogue mode. Day 1 recorded 532 registrations and 276 attendees, and Day 2 recorded 556 registrations and 184 attendees. These numbers speak for themselves, as such high registrations are rare for specialised events in the Polar regions. There was high audience engagement, with interesting questions posed in every discussion session. As SaGAA has been working for greater Indian involvement in the Polar Regions since 2011, its core competencies lie in facilitating high-level dialogues between the Indian scientific and social science communities and their international counterparts from the Polar Countries. The expert panel at SaGAA chose the theme "Managing the Polar Oceans Sustainably" to focus on for the SaGAA Webinar 2020, taking the cue from "2021-2030 to be the Decade of Ocean Science for Sustainable Development" declared by the United Nations. Devised to draw attention and accelerate scientific developments that will ensure the safety and sustainability of the vast oceans, the UN's initiative was a challenging milestone. In the context of the Polar oceans, this role's enormity magnifies. The Keynote addresses included 'Importance of the Southern Ocean for Global Climate' and 'Learning Sustainability from Whales'. Dr SWA Naqvi, Distinguished Scientist, CSIR, New Delhi and Dr Victor Smetacek, Professor Emeritus, Alfred Wegener Institute for Polar and Marine Research, Germany, delivered the keynote addresses. Four well-rounded panel sessions with eminent experts deliberated the impacts of the changing oceans on the different domains of science and policy over a period of two days: Polar oceans and their degradation; Pollution in the polar oceans; Microplastics and their impact; Biodiversity loss in the Polar oceans; Polar Oceans-Weather and Climate; Maritime Jurisprudence; and Blue Economy. Former Icelandic President His Excellency Ólafur Ragnar Grímsson was the Chief Guest for the Webinar, and the sessions were chaired by Dr P.S. Goel, Dr Shailesh Nayak, Dr M. N. Rajeevan

and Vice Admiral Pradeep Chauhan. The distinguished panellists included, Prof Katherine Richardson, Center for Macroecology, Evolution and Climate, University of Copenhagen, Denmark; Dr Ole Arve Misund, Director, Norwegian Polar Institute, Norway; Dr Pushp Bajaj, Associate Fellow, National Maritime Foundation, New Delhi; Dr M Ravichandran, Director, NCPOR, Goa; Dr Nalan Koc, Research Director, Norwegian Polar Institute, Norway; Dr Lasse Pettersson, Director, Nansen Environmental and Remote Sensing Centre, Norway; Dr. Asa Lindgren, Swedish Polar Research Secretariat, Sweden; Captain Sarabjeet Parmar, Executive Director, National Maritime Foundation; Dr Rasik Ravindra, Former Director of NCPOR and former Member, UN Commission on the Limits of the Continental Shelf; Dr Paula Kankaanpää, PAME Chair, SYKE, Finland; Dr M Sudhakar, Former Director, Centre for Marine Living Resources and Ecology, Kochi; Dr Atmanand, Director, NIOT, Chennai; H E Armstrong Changan, Ambassador of India to Iceland; Dr Sameer Guduru, Associate Fellow, National Maritime Foundation; Dr John Kurian, senior Scientist, National Centre for Polar and Ocean Research; and Dr Jan-Gunnar Winther, Centre for the Ocean and the Arctic, Norway.

SaGAA V (2019)

The international conference was held at the India International Centre, New Delhi, India, on November 26-27, 2019, with a focus on technological innovations and research expeditions. Various sessions were organised - current trends in polar sciences, ocean exploration, geopolitics, ice-class research vessels, technological innovation as an aid to scientific exploration in polar areas, building a new Maitri Station, an earth station, snow vehicles and ice runways, and manning expeditions were discussed. These sessions not only helped build a better understanding of geopolitics but also brought new research to the forefront, carried out around the globe to understand the dynamics and potential of these regions. SaGAA V was graced by the presence of dignitaries of great repute, including policymakers, scientists and students interested in Polar research from across the globe. The event was presided over by Dr M N Rajeevan, Secretary, MoES as honourable chief guest. Renowned scientists like Dr Rasik Ravindra, Dr P S Goel, Dr Nalan Koc, Dr B Meenakumari and many more attended the event. Mr Helge Tryti, Commercial Counsellor, Royal Norwegian Embassy and Director of Innovation Norway, India also attended the event. The Antarctic Station was also featured live during the proceedings and scientists manning the station interacted with the dignitaries present.

SaGAA IV (2017)

Science & Geopolitics of Arctic and Antarctic, an international conference was held at JNU Convention Centre, New Delhi, India during November 30 and December 1 of 2017 with a focus on climate change. Various sessions were organised - Climate change, health of Himalayan glaciers and its biodiversity, geopolitics of the poles, ocean research, and Arctic and Antarctic cryospheric research were discussed. Unprecedented changes in environment and morphology and emergence of political interventions is encouraging exploitation of Cryospheric areas laying a major stress and a rise in demand and conflict. Renowned international scientists such as Dr Walter R Roest, Dr Nalan Koc, Dr Arild along with H.E. Nils Ragnar Kamsvåg, Ambassador Norway and various other senior scientists and directors of Indian

institutions deliberated during the Conference. Dr M.N. Rajeevan, Secretary, Ministry of Earth Sciences was the chief guest with over 17 directors attending the two days of the SaGAA IV Conference, making it a resounding success.

SaGAA III (2015)

An international conference was held at India International Centre, New Delhi, India during 29-30 September, 2015. Continuing the practice of previous two SaGAA Conferences it again brought together; thoughts, experiences, researches and advocacies on cold regions. Various sessions were organised - Geopolitics of the Polar regions; Global climate change: Polar region and the third pole; living and non-living resources potential; marine protected areas and geopolitics; tourism industry and the Poles were discussed. Eminent scientists including scientists such as Dr. P.S. Goel, Dr. Shailesh Nayak, Dr. M. N. Rajeevan, Dr. Sanjay Chaturvedi, Dr. Uttam Kumar Sinha, Dr. R. Krishnan, Dr. Geir Moholdt, Dr. Anil V Kulkarni, Dr. M.R. Bhutyani, Dr. David E. Rheinheimer, Dr. Ravishankar, Dr. Rajan, Dr. Rasik Ravindra, H E Thórir Ibsen, Marcus Holknekt, HE Grahame Morton and HE Sergey A Borovik contributed to the conference. It was an interactive conference with more than 100 cold region enthusiasts attending the Conference.

SaGAA II (2012)

Held in continuation to SaGAA National 2011, an International Conference was held between March 9 and 11, 2012, successfully holding myriad sessions on geopolitics: UNCLOS and the global commons geopolitics of the global realms; biotechnology: microbial resources in Polar regions dynamics in Polar marine biodiversity (prokaryotes, vertebrates and invertebrates); information exchange and intellectual property rights; resources of the Southern Ocean; ice core for paleo climate; Southern Ocean and solar impact: sea ice melting; Polar atmospheric research: Ozone depletion; meteorological studies. Some of the senior scientists present were Dr. P S Goel, Dr. Shailesh Nayak, Dr. S.W.A. Naqvi, Prof. S. K. Tandon, Prof. John Turner, Dr. Timo Koivurova, Dr. Victor Smetacek, Dr. John P. Bowman, Prof. Nalan Koc, Prof. John M. Reynolds, Dr. George John, Dr. S. Shivaji, Dr. B. Meenakumari, Dr. S. Rajan, Dr. R. Ramesh, Dr. Rasik Ravindra apart from representatives from the countries such as United Kingdom, Finland, Germany, Australia, Norway and Chile. The participation of about 100 scientists was observed in the Conference.

SaGAA I (2011)

The first National Conference on Science and Geopolitics of Arctic and Antarctic was held between January 14-15, 2011. Introducing India's Antarctic vision to the dignitaries present, Dr P C Pandey, set the framework of all future interactions and deliberations. Other sessions held discussed India's logistical needs in Antarctica and the policy foothold of the nation in the region. The sessions saw the gathering of eminent scientists such as Dr. Shailesh Nayak, Dr. Ajit Tyagi, Dr. N. C. Mehrotra, Dr. Anil K. Gupta, Dr. Rasik Ravindra, Dr. S. Shivaji, Dr. V.M. Tiwari, Dr. T. Meloth, Dr. Subba Rao, S. K. Mehta and many more. Dr S. K. Das and Dr. Ravindran and Dr. M. Sudhakar also attended the proceedings. It was an extremely successful event which paved the way for the following Conferences on the subject.

Section B

The Context and Contemporary Relevance

Confrontation to
Collaboration in a
Fractured World
Science-Business-Policy

Arctic Governance

The Arctic region is Earth's northernmost area centred on the North Pole, comprising the Arctic Ocean, adjacent seas, and parts of countries such as Canada, Denmark (Greenland), Russia, US (Alaska) and Norway. Its environment is largely ice-covered, with tundra and permafrost on land, and it contains critical glaciers and sea ice. Historically, the eight Arctic nations (Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden, and the US), along with Indigenous peoples, cooperated peacefully, focused on sustainable development and environmental protection. Governance issues intensified, especially after Russia's 2007 symbolic North Pole flag planting, the North Atlantic Treaty Organisation's (NATO) expansion, geopolitical tensions, and climate change opened new routes and resource competition in the Arctic.

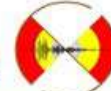
Cooperation with Russia in the Arctic has been strained since the Ukraine conflict, but some limited, technical engagement has resumed. From 2024 onward, the Arctic Council's working groups gradually restarted virtual meetings involving all eight Arctic states, including Russia, and by May 2025, Russia participated in the 14th Arctic Council ministerial held online.

However, high-level political dialogue remains minimal due to continued geopolitical tensions. Despite this, Norway and Russia have maintained their long-standing Barents Sea fisheries cooperation, one of the most resilient bilateral regimes in the region. This cooperation dates back to the mid-1970s, when Norway and the Soviet Union/Russia established the Joint Norwegian–Russian Fisheries Commission in 1976 to jointly manage major Barents Sea stocks such as cod, haddock, and capelin (Hønneland, 2014; Hammer & Hoel, 2012; Norwegian Government, 2012). At the same time, rising tensions - particularly since July 2025, when Norway aligned with EU sanctions to blacklist the Russian firms Norebo JSC and Murman Seafood for alleged state-sponsored intelligence activities - highlight how fragile this long science-based quota related cooperation has now become (The Barents Observer, 2025). The sanctions bar those companies' vessels from Norwegian ports and licensing in its EEZ, prompting retaliatory threats from Russia, including to close its exclusive economic zone to Norwegian fishing vessels.

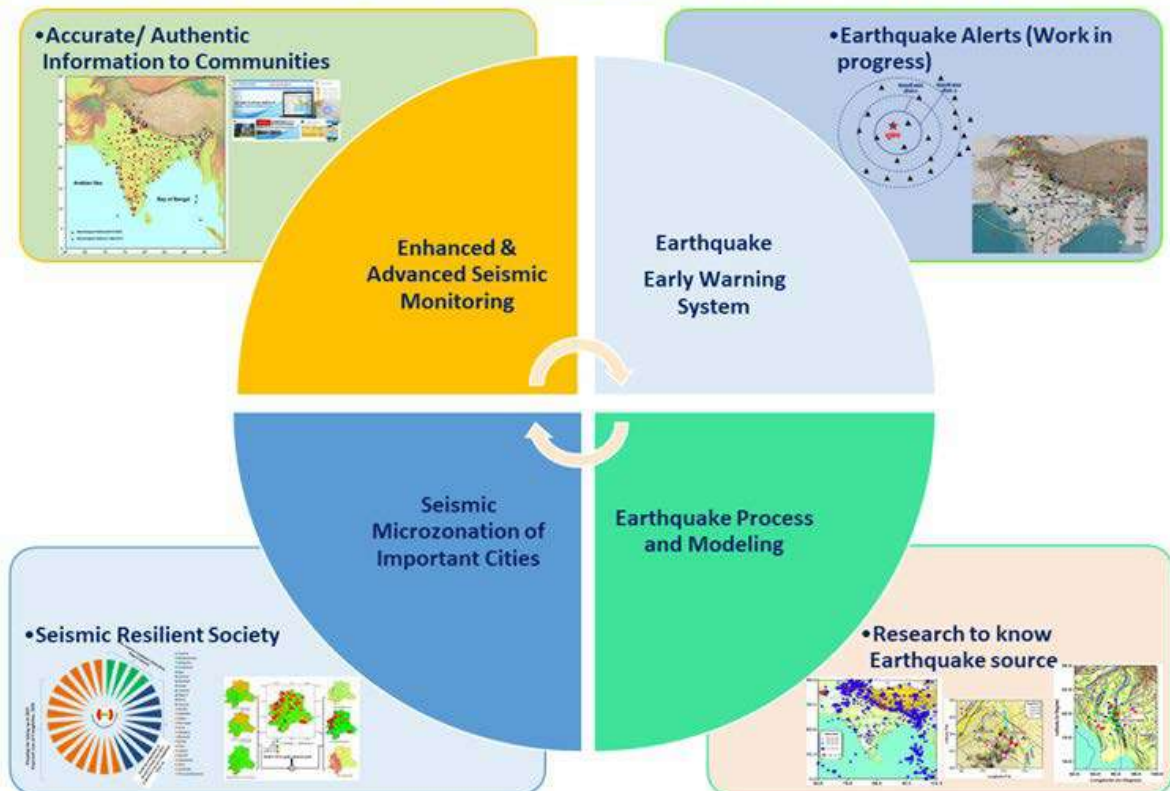
The Arctic Council began with the 1991 Arctic Environmental Protection Strategy by the Arctic states, formalised through the 1996 Ottawa Declaration, which established it as a high-level forum for cooperation among Arctic states and Indigenous groups on sustainable development and the environment in 1998. The Council has 8 member states, 6 Indigenous Permanent Participants, and multiple working groups addressing scientific, environmental, and search-and-rescue issues. Decisions require consensus, bringing diverse geopolitical actors together despite differences. Arctic governance is evolving within a complex geopolitical and environmental landscape. The Arctic Council remains the primary intergovernmental forum for non-military cooperation, focusing on science, indigenous participation, and environmental monitoring. However, its operations are strained by geopolitical tensions and the rise of minilateral initiatives, such as smaller coalitions addressing security, infrastructure, and shipping concerns. This hybrid governance model raises concerns about legitimacy, consensus decision-making, and the role of observers such as India in advancing from



NCS for Societal benefit



TO DEVELOP SEISMIC RESILIENCE, EARTHQUAKE PREPAREDNESS AND SCIENTIFIC UNDERSTANDING OF SEISMIC ACTIVITY



When Earth Vibrates, NCS Listens and Makes the People Awake
National Centre for Seismology (NCS)
Ministry of Earth Sciences (MoES)

scientific participation to strategic co-leadership.

Article 234 grants coastal states exceptional authority to adopt and enforce non-discriminatory pollution-prevention laws in ice-covered areas of their EEZs. This authority is an extension of jurisdiction in specific environmental conditions but does not supersede the broader sovereign rights exercised within the territorial sea. Like many coastal countries, Canada's Exclusive Economic Zone (EEZ) extends up to 200 nautical miles from its baselines, giving it sovereign rights over living and non-living resources within this zone. Beyond this limit, Canada has claimed an extended continental shelf (ECS) under UNCLOS and submitted its full claim to the Commission on the Limits of the Continental Shelf in 2019, granting it sovereign rights over the seabed and subsoil but not the water column. According to Section 17(1) of the Oceans Act, the continental shelf comprises "the seabed and subsoil of the submarine areas that extend beyond the territorial sea throughout the natural prolongation of the land territory of Canada to the outer edge of the continental margin, or to a distance of 200 nautical miles where the outer edge of the continental margin does not extend up to that distance (Oceans Act, S.C. 1996, c. 31). Similarly Russia has made submission to the CLCS for a large continental shelf beyond its EEZ in the Arctic ocean including the area around the Lomonosov Ridge which were approved in part of CLCS 2023 (United Nations, 2023).

Russia sent two mini-submarines to the Arctic seabed beneath the North Pole, where they planted a titanium flag on the Lomonosov Ridge and collected samples to support its claim that the ridge is geologically connected to its continental shelf. If proven, Russia could extend its Exclusive Economic Zone (EEZ) rights under UNCLOS, giving it access to significant oil and gas resources in the Arctic (Parfitt, 2017). The international legal framework for Arctic environmental protection rests on the United Nations Convention on the Law of the Sea (UNCLOS) and the Biodiversity Beyond National Jurisdiction (BBNJ) Agreement. While UNCLOS provides the foundation for ocean governance, its applicability, particularly under Article 234, remains contested, highlighting regulatory gaps specific to the Arctic's fragile ecosystem. The BBNJ Agreement complements, but does not fully address, these shortcomings. Strengthening guidance through international and regional mechanisms, including the IMO and the Arctic Council, could enhance coherence among the Polar Code, UNCLOS, and BBNJ frameworks.

National Institute of Ocean Technology
(Ministry of Earth Sciences, Government of India)

National Institute of Ocean Technology
(Ministry of Earth Sciences, Government of India)
Valecherry- Tambaram Main Road Pallikaranai,
Chennai – 600100 INDIA

Phone : +91-44-66783303, 66783304/ FAX : +91- 44-66783571
e-mail: director@niot.res.in/ web: <http://www.niot.res.in>

Phone : +91-44-66783303, 66783304/ FAX : +91-44-66783571
e-mail: director@niot.res.in/ web: <http://www.niot.res.in>



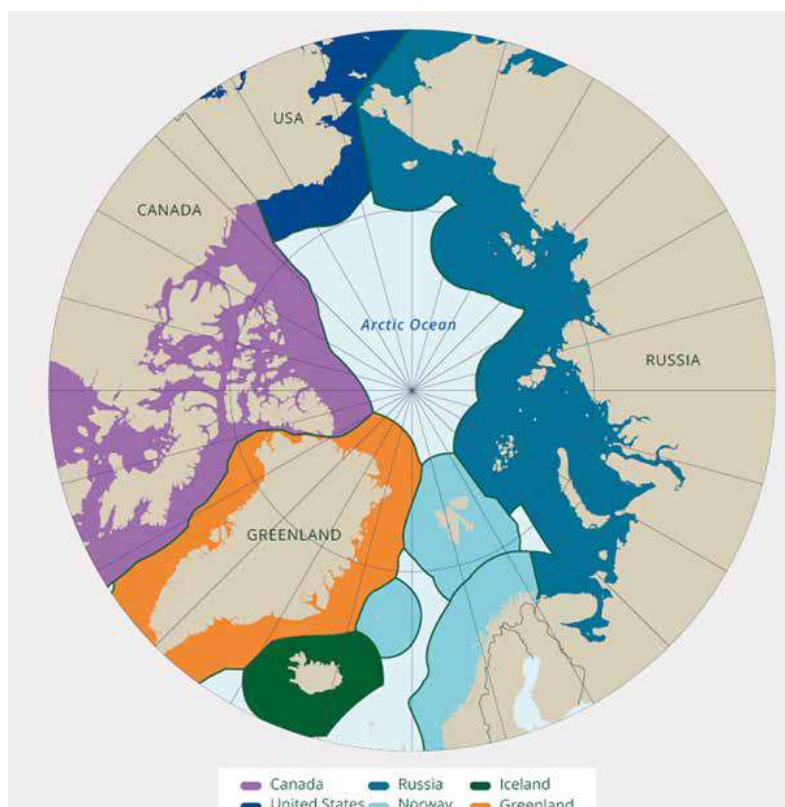


Fig description & source: Environmental Audit Committee, *The UK and the Arctic Environment (Sixth Report, Session 2022–23, HC 1141)* and Patricia Derepigny et al, 'Increased Transnational Sea Ice Transport Between Neighbouring Arctic States in the 21st Century', *Earth's Future*, vol 8(3), March 2020 (DeRepentignyn et al., 2020).

The Council consists of the 8 Arctic states with territorial claims above the Arctic Circle, 6 Indigenous Permanent Participants representing Arctic Indigenous peoples, and 38 observers, including NGOs and non-Arctic countries such as India. Working groups focus on sustainable development, contaminants, monitoring, conservation of flora and fauna, emergency preparedness, and protection of the marine environment. Most of the Council's work is scientific, but it also includes policy, environmental protection, and coordination of indigenous rights. By 2047, India aims to expand its strategic and scientific co-leadership through climate diplomacy and partnerships with Nordic countries and the European Union, contributing to sustainable Arctic governance and alignment with global ocean governance frameworks. India's Arctic engagement includes scientific research and diplomacy, marked by collaborations such as fieldwork in the Canadian High Arctic studying permafrost and climate impacts, joint feasibility studies on the Northern Sea Route with Russia, and cooperation with Nordic countries



पृथ्वी विज्ञान मंत्रालय

Ministry of Earth Sciences
Government of India (www.moes.gov.in)

Indian Institute of Tropical Meteorology (IITM)



IITM was formed on 17 November 1962, as The Institute of Tropical Meteorology (ITM). On 1st August 1971, it was transformed as an autonomous organization and named as the Indian Institute of Tropical Meteorology (IITM). Since July 2006, functioning under the Ministry of Earth Sciences (MoES), Government of India.

VISION:

"To Make IITM a World Centre of Excellence in Basic Research on the Ocean-Atmosphere Climate System required for improvement of Weather and Climate Forecasts"

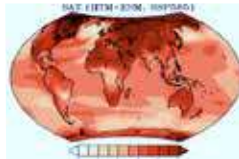
MANDATE:

- To conduct the R&D required to improve the skill of both Weather & Climate Forecasts & to make Indian forecasting system best in the world.
- To conduct regional climate change research to provide reliable projection of monsoon under climate change.

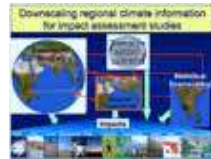
IITM Activities and Achievements:



High Performance Computing (HPC) System: HPC ARKA (11.77PF), HPC Pratyush (4PF) and HPC Aaditya (790TF) for enabling Research & Development work in Weather and Climate Science and Forecasting.



Centre for Climate Change Research (CCCR): IITM Earth System Model (IITM-ESM) - participated in CMIP6 & contributed to IPCC AR6.



High-resolution regional climate change projections over South Asia were generated & disseminated under Coordinated Regional Downscaling Experiment (CORDEX)



CCCR Observational Programs: FLUXNET- measurement of GHG fluxes, Kaziranga National Park, Sinhaad, Pichavaram mangroves, COSMOS-IITM for field-scale soil moisture measurements



Atmospheric Research Testbed Facility in Central India (ART-CI), Silkheda near Bhopal



High Altitude Cloud Physics Laboratory (HACPL), Mahabaleshwar Instrumental Setup



Lower Atmospheric Research Using Unmanned Aerial System Facility (LARUS) using Instrumented Unmanned Aerial Vehicle (UAV) system – first time in India



Cloud Aerosol Interaction and Precipitation Enhancement Experiment (CAIPEEX) Airborne Campaign



Winter Fog Field Experiment (WIFEX), New Delhi (since Dec. 2015)



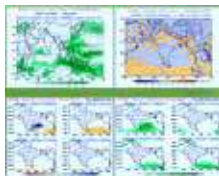
Air Quality Early Warning System: First of its kind a very high-resolution (400m) operational air quality prediction system. Dedicated Early Warning System provides daily air quality forecasts (72hrs in advance) for Delhi NCR.



SAFAR-India Program: launch & operationalization of SAFAR at Delhi, Pune, Mumbai and Ahmedabad MAPAN network



Lightning Location Network (LLN): Damini App: generates Lightning alerts



Monsoon Mission: Developed state-of-the-art coupled dynamical prediction systems for seasonal and extended range monsoon prediction and global highest resolution (12 km) ensemble forecast system for short and medium range (< 10 days) weather prediction, Lightning prediction system to predict lightning/thunderstorms, High Resolution Global Forecast Model (HGMF) TCO1534 forecast. IITM hosts an International Monsoon Project Office (IMPO)

IITM is implementing DESK programme for developing outstanding research talent capable of exploring & addressing unsolved science issues in weather and climate involving the ocean, the atmosphere and the biosphere. DESK executes MoES Research Fellowship Programme (MRFP) & short-term training programmes and workshops for capacity building of weather & climate science professionals/researchers at MoES institutions & other research/academic centres of the nation.



भारतीय उष्णदेशीय मौसम विज्ञान संस्थान
Indian Institute of Tropical Meteorology

<https://www.tropmet.res.in>

<https://www.facebook.com/iitmpuneofficial>

<https://twitter.com/iitmpune>



IITM
<http://www.tropmet.res.in>

such as Sweden and Iceland on oceanography and geothermal energy, respectively. India participates mainly in scientific and research domains and maintains observer status in the Arctic Council, reflecting its growing interest in Arctic science and policy.

NATO's expansion into the High North, marked by Finland's accession in April 2023 and Sweden's in March 2024, followed by large Nordic military exercises such as "Nordic Response" under the Steadfast Defender framework, has deepened defence integration across the region and accelerated the strategic militarisation of the Arctic. This shift, coupled with intensifying US–Russia rivalry, has pushed Arctic governance to a critical inflexion point: the region is moving away from consensus-based multilateral cooperation toward more transactional bilateralism, weakening the Arctic Council's traditional strengths in scientific diplomacy, environmental stewardship, and inclusive decision-making. As the Council lacks a mandate for security, has no permanent budget, and issues only non-binding recommendations, it is increasingly constrained at a time when climate change is transforming the Arctic through sea-ice loss, glacial retreat, and ecological "borealization," even as warming opens new sea routes and fuels a race for resources. Existing legal frameworks, UNCLOS, which does not explicitly address climate impacts, and the IMO Polar Code, which allows broad interpretive leeway and lacks strong environmental safeguards, are insufficient to manage the surge in shipping, the risks of black carbon emissions and oil spills, and the socioeconomic pressures on Indigenous communities. These geopolitical, environmental, and legal stresses are driving calls for governance reforms: strengthening and enforcing the Polar Code, updating UNCLOS to integrate climate obligations, and evolving or complementing the Arctic Council's mandate to address emerging environmental and security challenges. For India, these global shifts coincide with major domestic policy developments: the Department of Expenditure's approval of a revised INR 2329.40-crore cost for a Polar Research Vessel (PRV), renewed acquisition timelines for 2025–2026 to 2029–2030 (PIB Delhi, 2025) following earlier tender delays, and a newly signed MoU to build the first indigenous PRV an asset critical for sustaining future polar expeditions, expanding scientific research, and deepening international collaborations, including with partners such as the UAE.

References

1. Indian Council of World Affairs. (n.d.). Indian Council of World Affairs. <https://www.icwa.in/index.php>
2. Wu, F., & Li, T. (2025). International law concerning the environmental protection in Arctic: what is left behind UNCLOS and the BBNJ Agreement? *Frontiers in Marine Science*, 12. <https://doi.org/10.3389/fmars.2025.1680697>
3. Geostrata, T. (2024, December 21). Cool Diplomacy - India's emerging Role in Polar Diplomacy. *The Geostrata*. <https://www.thegeostrata.com/post/cool-diplomacy-india-s-emerging-role-in-polar-diplomacy>
4. Ministry of External Affairs. (2022, March 27). Union Minister Dr. Jitendra Singh releases India's Arctic Policy in New Delhi today. Ministry of External Affairs, Government of India. https://www.mea.gov.in/press-releases.htm?dtl%2F34983%2FUnion_Minister_Dr_Jitendra_Singh_releases_Indias_Arctic_Policy_in_New_Delhi_today



ONGC Videsh Limited
**Working
Relentlessly**

A VISION FOR THE NATION CANNOT BE LIMITED BY ITS BORDERS

Across 3 continents in 15 countries with 32 projects, ONGC Videsh reflects international integration and cooperation.

 /ONGCVideshLtd/

 /ongcvideshltd

 www.ongcvidesh.com

ONGC Videsh Ltd.

5th Floor, Tower B
Deendayal Urja Bhawan
5, Nelson Mandela Marg, Vasant Kunj
Delhi 110070, India
Tel: +91-11-26129344, 26753411 (EPBX)
Fax: +91-1126129345 (I), 011-26129346
CIN NO: U74899DL1965GOI004343

5. Dutta, A., & Banerjee, S. (2022). The Changing Arctic and India's Strategy for the Circumpolar North. In New Delhi paper: 11. Centre for Air Power Studies. https://capssindia.org/wp-content/uploads/2023/01/Stuti-Banerjee-Ankita-Dutta_The-Changing-Arctic-and-Indias-Strategy-2-1-23.pdf
6. Jakobson, L., & Melvin, N. (Eds.). (2016). The New Arctic Governance: SIPRI Research Report No. 25. Oxford University Press. https://www.sipri.org/sites/default/files/2021-09/no_25.pdf
7. National Wildlife Federation. (n.d.). The Arctic. National Wildlife Federation. Retrieved November 14, 2025, from <https://www.nwf.org/Educational-Resources/Wildlife-Guide/Wild-Places/Arctic>
8. Dutta, U. (2025, August 25). Arctic governance amid fragile geopolitics and climate change. Earth. Org. <https://earth.org/governing-the-melting-arctic-geopolitical-tensions-and-legal-gaps/>
9. Brimmer, E. (2023, July 18). Changing geopolitics in the Arctic. Council on Foreign Relations. <https://www.cfr.org/report/changing-geopolitics-arctic-0>
10. The Arctic Review. (n.d.). Structure of the Arctic Council. The Arctic Review. <https://arctic.review/arctic-council/members/>
11. Patel, A. (2025). How Modi's India Is Expanding Arctic Footprints? Cleaner Arctic. <https://cleanarctic.org/wp-content/uploads/2025/07/Explainer-Indias-Arctic-Footprint.pdf>
12. Arctic Portal. (n.d.). UNCLOS. <https://arcticportal.org/shipping-portlet/governance/unclos>
13. Government of Canada. (2024, November 27). Consolidated federal laws of Canada, Oceans Act. <https://laws-lois.justice.gc.ca/eng/acts/o-2.4/page-1.html>
14. Parfitt, T. (2017, April 12). Russia plants flag on North Pole seabed. The Guardian. <https://www.theguardian.com/world/2007/aug/02/russia.arctic>
15. Wolinski, S. J. (2025, October 14). The future of Arctic Governance in a fractured geopolitical landscape - Georgetown Journal of International Affairs. Georgetown Journal of International Affairs. <https://gjia.georgetown.edu/2025/10/14/the-future-of-arctic-governance-in-a-fractured-geopolitical-landscape/>
16. Dutta, U. (2025, August 25). Arctic governance amid fragile geopolitics and climate change. Earth. Org. <https://earth.org/governing-the-melting-arctic-geopolitical-tensions-and-legal-gaps/>
17. Jacobsen, V. a. P. B. E. (2025, August 29). Norwegian industry warns as Russia eases CoD rules. Fish Break. Retrieved November 18, 2025, from <https://fish-break.com/2025/08/29/norwegian-industry-warns-as-russia-eases-cod-rules/>
18. Nilsen, T. (2024, November 1). Cod quotas lowered for the fourth year in a row. The Barents Observer. <https://www.thebarentsobserver.com/news/cod-quotas-lowered-for-the-fourth-year-in-a-row/419770>
19. Quentin. (2024, November 1). FiskerForum. FiskerForum. <https://fiskerforum.com/norway-and-russia-strike-2025-fisheries-agreement/>
20. Arctic Council Secretariat. (2025a, April 8). The 14th meeting of the Arctic Council. Arctic Council. Retrieved November 18, 2025, from <https://arctic-council.org/news/14th-meeting-of-the-arctic-council/>
21. Arctic Council Secretariat. (2025b, May 12). Arctic states and Indigenous permanent participants convene for the 14th meeting of the Arctic Council and issue joint ROMSSA-Tromsø statement. Arctic Council. Retrieved November 18, 2025, from <https://arctic-council.org/news/press-release-14th-meeting-arctic-council-joint-romssa-tromso-statement/>
22. IZ.RU. (2025, January 24). Zakharova says Russia partially resumes work in the Arctic Council. Известия. Retrieved November 18, 2025, from <https://en.iz.ru/en/1827553/2025-01-24/zakharova-says-russia-partially-resumes-work-arctic-council>
23. 3. PIB Delhi. (2025, August 7). Parliament Question: Prv for Arctic Research. Ministry of Earth Sciences. Retrieved November 17, 2025, from [https://www.pib.gov.in/PressReleasePage.aspx?PRID=2153574#:~:text=The%20Department%20of%20Expenditure%20\(DoE,and%20specifications%20are%20already%20completed.](https://www.pib.gov.in/PressReleasePage.aspx?PRID=2153574#:~:text=The%20Department%20of%20Expenditure%20(DoE,and%20specifications%20are%20already%20completed.)

BRIC-Rajiv Gandhi Centre for Biotechnology (BRIC-RGCB), Thiruvananthapuram, under the Biotechnology Research and Innovation Council (BRIC) of Department of Biotechnology (DBT), Government of India, is dedicated to fostering a vibrant research environment that promotes academic excellence and scientific innovation.

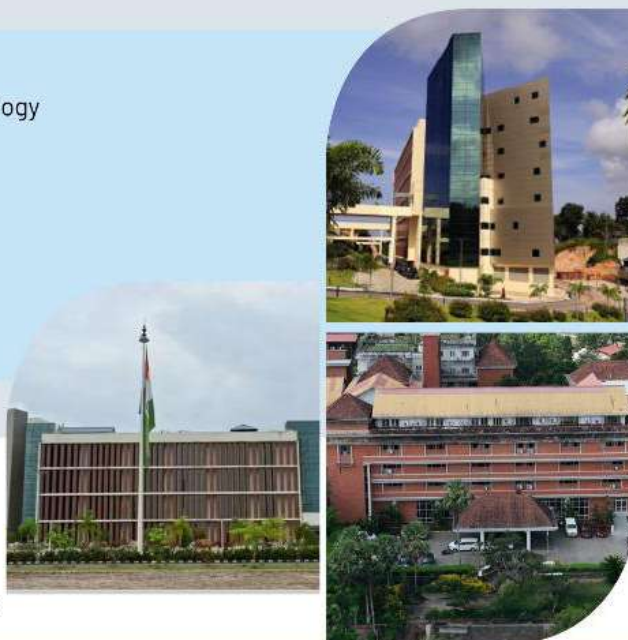
Located in Thiruvananthapuram, BRIC-RGCB is a leading institution in biotechnology research, well-regarded for its contributions to health biotechnology, genetic engineering, and disease diagnostics. The center emphasizes innovation and excellence in research and education.

Research Areas:

- Cancer Research
- Cardiovascular Disease & Diabetes Biology
- Pathogen Biology
- Regenerative Biology
- Plant Biotechnology
- Neurobiology
- Transdisciplinary Biology

Academic Programs

- PhD Programs
- MSc in Biotechnology
- Postdoctoral Training
- Short and Long-Term Training Programs:



Support Services:

- Research Consultancy Services
- Medical Laboratory Services
- Molecular Forensics & DNA Technologies
- Laboratory Medicine and Molecular diagnostics
- Bioinformatics Facility
- Research Infrastructure Support
- Entrepreneurship Initiatives

BRIC-Rajiv Gandhi Centre for Biotechnology,
Thycaud Post, Poojappura,
Thiruvananthapuram – 695 014, Kerala, India
+91-471-2529400 | 2347975 | 2348753

 info@rgcb.res.in

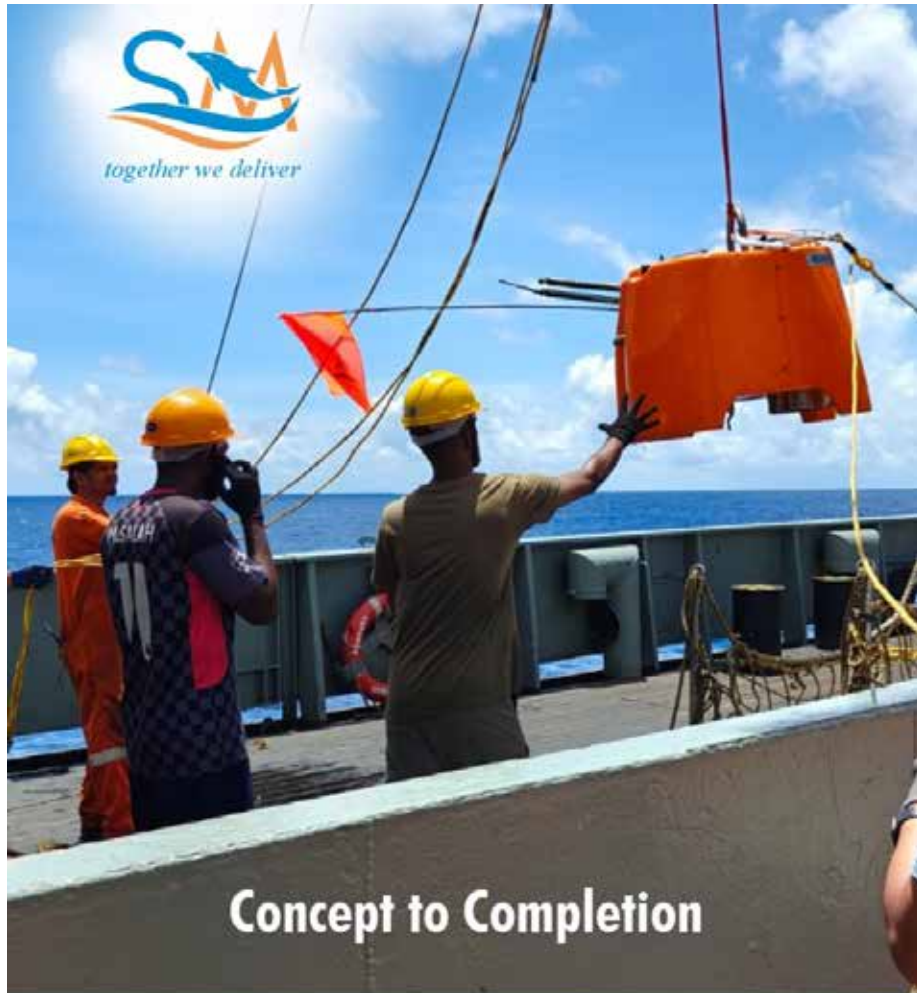


24. DeRepentigny, P., Jahn, A., Tremblay, L. B., Newton, R., & Pfirman, S. (2020). Increased transnational sea ice transport between neighboring Arctic states in the 21st century. *Earth's Future*, 8(3). <https://doi.org/10.1029/2019EF001284>
25. Arctic Council. (2025, April 24). The 14th Meeting of the Arctic Council. Retrieved from <https://arctic-council.org/news/14th-meeting-of-the-arctic-council/>
26. The Barents Observer. (2025, July 7). Norway kicks out Norebo and Murman Seafood in fear of intelligence gathering. The Barents Observer.
27. United Nations. (2023). Submission by the Russian Federation to the Commission on the Limits of the Continental Shelf (CLCS): Arctic Ocean. United Nations Division for Ocean Affairs and the Law of the Sea. https://www.un.org/depts/los/clcs_new/submissions_files/submission_rus_rev2.htm

Antarctic Governance

Antarctic governance is structured under the Antarctic Treaty System (ATS), which governs the entire region south of 60°S latitude, covering all longitudes and including the continent of Antarctica, its ice shelves, and surrounding Southern Ocean waters. ATS provides a unique model for international cooperation, science, and environmental protection in a region free from sovereignty disputes and military activity. The Antarctic Treaty was signed in 1959 by 12 countries involved in scientific activities during the International Geophysical Year (IGY) and entered into force in 1961. It covers all areas south of 60° South Latitude, freezes territorial claims, and provides consensus-based, peaceful administration focused on scientific research and environmental protection. The Treaty prohibits military activities, mineral mining, and nuclear testing, and regulates human impacts through a series of annexes covering environmental processes, including impact assessments, waste management, wildlife protection, and pollution prevention. Decision-making occurs at the annual Antarctic Treaty Consultative Meetings (ATCMs), with technical expert groups and environmental NGOs participating but not voting.

Antarctic governance under the Antarctic Treaty System (ATS) continues to prioritise scientific cooperation and environmental protection, even as pressures from tourism, fisheries management under CCAMLR, and the need for environmental modernisation intensify. According to IAATO reporting to ATCM 2025, a total of 118,491 visitors (vessel + deep-field) travelled to Antarctica during the 2024–2025 season, representing an approximate 5 per cent decrease from 2023–2024 - primarily due to one cruise-only operator not operating that season. Despite this decline in total visitors, the number of landed passengers remained virtually unchanged between 2023–2024 and 2024–2025, indicating a stable rise in the visitation at key Peninsula sites even as overall passenger volume fluctuated. Industry reflections from the 2025 IAATO Annual Meeting in Cascais, Portugal (14–17 April 2025) highlighted lessons learned from the season, with members approving 19 new guidelines aimed at strengthening visitor site management. IAATO also reviewed progress on its five-year strategic plan, *Embracing our Role as Stewards of Antarctica*, and adopted short-term goals for 2025–26 to further minimise environmental impact. These measures reinforce IAATO's mission to ensure that operator activities result in no more than a minor or transitory impact on Antarctica's fragile ecosystems. (International Association of Antarctica Tour Operators [IAATO], 2025)



Concept to Completion

Operations across the oceans | Custom Built Solutions
Professional turnkey Solutions & Services

ASSOCIATES, OUR IDENTITY



O&M of existing national networks, with experienced / trained operators

Deployment and retrieval, hands on experience

Solutions as "simple" as possible, yet strong and durable

samhithamarine.com

However - and here lies a governance blind spot - not all tourist activity is neatly captured by IAATO. According to IAATO itself, 4,088 passengers traveled aboard two non-IAATO operated vessels or aircraft, landing passengers in the Antarctic Peninsula area (International Association of Antarctica Tour Operators [IAATO], 2025) and there remain “unknown numbers” of private yachts whose operations are not fully tracked by IAATO or national authorities and travel on non-IAATO vessels or aircraft (International Association of Antarctica Tour Operators [IAATO], 2025). This highlights a deeper institutional challenge: self-regulation under IAATO, while valuable, may not fully account for the growing diversity of polar tourism actors, particularly small yachts and other non-commercial operators.



Polar Technologies/ CN Technologies (India)



Motto: Core Technologies Globally Connected, Locally Invested

CN Technologies and Polar Technologies, collectively, stand at the forefront of technological and scientific innovation in India. With a rich legacy spanning three decades, the companies have made significant contributions across various industries, particularly in extreme environments and complex engineering domains.

Core Areas of Focus:

1. Deep Sea Exploration & Mining
2. Oil & Gas Upstream
3. Land, Marine, and Airborne Geophysical Surveys
 - ROV (Remotely Operated Vehicle) Surveys
 - AUV (Autonomous Underwater Vehicle) Surveys
4. Environmental Sciences and Research
5. New Age Design & Construction of Research Stations
6. Logistic Support & Aviation Operations for Polar Regions
7. Nuclear Energy Applications
8. Inland Waterways Multimodal Engineering
9. End-to-End Project Solutions

Technology and Services - Technology Transfer: The companies excel in introducing advanced International technologies from jurisdictions such as Germany, the USA, the UK, France, Norway, and Canada into the Indian market. –

Support Services: They provide a comprehensive suite of support services designed to facilitate effective technology absorption, ensuring clients receive optimal assistance during implementation. –

****Local Expertise: **** Renowned for being a one-stop destination for timely Solutions, CN Technologies and Polar Technologies boast a team of OEM- trained engineers committed to delivering high-level technical support.

Notable Contributions –

****Indian Antarctic Programs: **** With over two decades of partnership in

Polar Sciences, the companies have played a pivotal role in fostering technological innovation within the domain. -

****Flagship Project:**** A highlight of their achievements includes the design and execution of the 3rd Indian Antarctic Research Station, “Bharati.”

This ambitious project was realized in collaboration with a consortium led by IMS Ingenieurgesellschaft MBH, BOP Architekten, and m+p consulting from Germany, successfully completed in 2011 under challenging Antarctic conditions.

Conclusion: CN Technologies and Polar Technologies have established themselves as Leaders in providing comprehensive scientific and technological solutions. Their unwavering commitment to quality, innovation, and localized support tailors their services to meet the specific needs of clients operating in extreme and complex environments, particularly in the Polar Regions.

The companies are poised for continued growth, leveraging expanded capabilities in inland waterways, multimodal engineering, and end-to-end project solutions to further enhance their market presence and impact.

At SaGAA VII (New Delhi, April 2023), India's experts reaffirmed its growing role in polar governance through science-based diplomacy, particularly in the Arctic and Antarctic. The conference underscored how climate change is rapidly reshaping both Poles and highlighted India's increasing institutional maturity from its Antarctic legislation to deeper engagement with bodies such as COMNAP and the ATS. SaGAA stressed that this leadership is dynamic rather than static: as environmental, strategic, and regulatory pressures evolve, India's polar governance strategy may require periodic reassessment, calling for adaptive policies, stronger capacity-building, and a forward-looking legislative and diplomatic framework. This becomes especially relevant as 2047 approaches the final year before the Antarctic Treaty's Environmental Protocol (Madrid Protocol, 1991), which prohibits mineral resource activities except scientific research, becomes eligible for formal review in 2048. Since the Protocol, in force since 1998, cannot be opened for review for its first 50 years (1998–2047), the post-2047 period marks a threshold when Consultative Parties may seek reassessment of environmental provisions, negotiate amendments, or even debate the future of the mining ban. India's deepening engagement in ATS and COMNAP processes is therefore strategically aligned with this impending phase of potential reassessment in Antarctic governance.

The broader Antarctic Treaty System (ATS) includes protocols on environmental protection and the regulation of marine living resources, reflecting a growing emphasis on conservation and sustainable use amid climate change, tourism growth, and bioprospecting. Antarctic governance is currently facing new challenges as global political tensions and climate pressures intensify. Japan will host the key Antarctic Treaty Consultative Meeting (ATCM) in 2026, focusing on critical issues such as tourism management, bioprospecting, and liability for environmental damage. Ongoing debates involve the creation of new marine protected areas, with consensus decision-making often stalled by opposition from parties such as China and Russia (Shibata, 2023). India has enacted the Indian Antarctic Act (2022) to implement the Treaty system domestically (Saha, n.d.), aligning national governance with international norms and actively participating in Treaty consultations and research.

References

1. Unsold Antarctica. (2025, July 14). Antarctica Tourism numbers 2024-2025: The real data behind the headlines. <https://unsoldantarctica.com/latest/antarctica-tourism-numbers-2024-2025-the-real-data-behind-the-headlines>
2. Yves, F. (2025, January 5). The Antarctic Treaty: a unique governance for the environment and science - Encyclopedia of the Environment. Encyclopedia of the Environment. <https://www.encyclopedie-environnement.org/en/society/antarctic-treaty-unique-governance-for-environment-and-science-2/>
3. The Royal Geographical Society (with IBG). (2023, February 8). How is Antarctica governed? - Discovering Antarctica. Discovering Antarctica. <https://discoveringantarctica.org.uk/how-is-antarctica-governed/>
4. British Antarctic Survey (BAS). (2018, October 5). The Antarctic Treaty explained - British Antarctic Survey. British Antarctic Survey. <https://www.bas.ac.uk/about/antarctica/the-antarctic-treaty/the-antarctic-treaty-explained/>
5. Antarctic and Southern Ocean Coalition. (n.d.). Antarctic Governance - Antarctic and Southern



राष्ट्रीय वनस्पति अनुसंधान संस्थान लखनऊ (वैज्ञानिक एवं औद्योगिक अनुसंधान परिषद्, भारत सरकार)



परिचय एवं इतिहास



- राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ (सीएसआईआर-एनबीआरआई), वैज्ञानिक एवं औद्योगिक अनुसंधान परिषद्, नई दिल्ली के अंतर्गत एक प्रमुख पादप विज्ञान अनुसंधान केंद्र है। संस्थान को पादप जैव-विविधता, जैव-प्रौद्योगिकी, जैव-सूचना विज्ञान, पर्यावरणीय आकलन, पर्यावरणीय विष-विज्ञान, जैव-उपचार एवं फार्मास्यूटिकल शोध कार्य में दक्षता हासिल है।
- 1800 ईसा पूर्व, सिकंदरबाग के रॉयल गार्डन के नाम से प्रसिद्ध इस वनस्पति उद्यान को मुगल सल्तनत के नवाबों द्वारा स्थापित किया गया था। नवाब वाजिद अली शाह ने अपनी बेगम के नाम पर इस उद्यान का नाम सिकंदरबाग रखा था। ब्रिटिश शासन काल में इस उद्यान का नाम गवर्नमेंट हॉर्टिकल्चर गार्डन कर दिया गया।
- वर्ष 1932 में प्रसिद्ध वैज्ञानिक प्रो. बोरबल साहनी एवं डॉ. एस के चतुर्वेदी द्वारा इस सिकंदरबाग को वनस्पति उद्यान में तब्दील कर वर्ष 1948 में इसे नेशनल बोटैनिक गार्डन में परिवर्तित किया गया एवं 13 अप्रैल 1953 को वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्, नई दिल्ली (सीएसआईआर) द्वारा नेशनल बोटैनिक गार्डन को अंगीकृत कर 25 अक्टूबर 1978 में इसका नाम बदल कर राष्ट्रीय वनस्पति अनुसंधान संस्थान किया गया।



मुख्य शोध एवं विकास क्षेत्र



- पादप विविधता, वर्गिकी एवं निम्न तथा उच्च पादप समूहों के लिए डेटाबेस
- औषध विज्ञान, पादप रसायन एवं भेषज विज्ञान अध्ययन
- मानव स्वास्थ्य देखभाल हेतु हर्बल उत्पादों का विकास
- जलवायु परिवर्तन, सूक्ष्मजीवी एवं पर्यावरणीय प्रौद्योगिकियों पर अनुसंधान
- पारंपरिक एवं आधुनिक प्रजनन द्वारा पादप सुधार एवं आवुवांशिक अभियांत्रिकी
- वनस्पति उद्यान, पादप संरक्षण एवं पुष्प कृषि हेतु पौधों की नवीन किस्मों का विकास
- ऊसर एवं अन्य बंजर भूमि के सतत विकास हेतु कृषि-प्रौद्योगिकियाँ
- कौशल विकास कार्यक्रम एवं समाज कल्याण हेतु गतिविधियाँ

संस्थान की राष्ट्रीय सुविधाएँ एवं सेवाएँ



वनस्पति उद्यान

उद्यान में देश की दुर्लभ, संकटग्रस्त, सजावटी एवं वाणिज्यिक रूप से महत्वपूर्ण गैर-घसली पौधों की 5,000 से अधिक प्रजातियाँ संरक्षित हैं। वनस्पति उद्यान लखनऊवासियों में सुबह की सैर के लिए पसंदीदा स्थानों में एक है। प्रतिदिन 1000 से अधिक लखनऊवासी उद्यान के हरे और ताज़ा वातावरण से लाभान्वित होते हैं।



पादपालय

सीएसआईआर-एनबीआरआई में देश का तीसरा सबसे बड़ा पादपालय स्थित है जिसमें शीतल, ब्रायोफाइट्स, टैडिफोफाइट्स, शेक, जिमिनोसर्म्स और एजिनोसर्म्स के 2,50,000 से अधिक नमूने उपलब्ध हैं। यह राष्ट्रीय जैवविविधता प्राधिकरण द्वारा नामित एक राष्ट्रीय कोष है।



प्राकृतिक जड़ी बूटी/औषधि संग्रहालय

संग्रहालय में प्रमाणित औषधीयों के करीब 2000 नमूने प्रदर्शित किये गए हैं। इन औषधीय नमूनों को देश के सूखे भागों से एकत्रित कर इनके इस्तेमाल किये जाने वाले भागों जैसे स्ट्रुप्स, छाल ट्रुप्स, लीफ ट्रुप्स, स्टेम ट्रुप्स, बीज ट्रुप्स, असेरिड ट्रुप्स आदि के आधार पर आयुष प्रणाली के अनुसार वर्गीकृत किया गया है।



पर्यावरण सूचना, जागरूकता, क्षमता निर्माण और आजीविका कार्यक्रम केंद्र
पर्यावरण सूचना, जागरूकता, क्षमता निर्माण और आजीविका कार्यक्रम केंद्र (इंफोआईसीपी) पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय, भारत सरकार द्वारा पर्यावरण और वन क्षेत्रों के विषयों पर विशिष्ट कार्य करने हेतु स्थापित किया गया है। संस्थान में स्थित यह केंद्र हितधारकों के लिए 'पौधों एवं प्रदूषण' विषयक कार्यक्रमों एवं मिशन लाइफ के अंतर्गत विभिन्न कार्य रहा है।



कौशल विकास कार्यक्रम

संस्थान द्वारा विभिन्न कौशल विकास कार्यक्रम शुरू किए हैं जिनमें जैव-इन्वोक्यूमेंट प्रोडक्शन फॉर एग्रीकल्चरल एनोकिंग, कर्मसिंह प्लांट टिश्यू कल्चर, एनोकिंग एनोकिंग फॉर हर्बल इंडस्ट्री, जीनोमिक्स, इन-सिलिको एनोकिंग फॉर जीनोमिक्स एंड प्रोटीनोमिक्स एंड ग्रीन सिलिक डेनोमेट मुख्य हैं।



केंद्रीय उपकरण सुविधा

संस्थान की यह सुविधा पादप आधारित विश्लेषणात्मक परीक्षण सेवाएँ प्रदान करती है जिसके अंतर्गत पौधों से प्राप्त होने वाले आवश्यक तेलों के परीक्षण के साथ साथ प्रमाणित संदर्भ सामग्री (सीआरएम) का विकास भी किया जाता है। इस सुविधा को परीक्षण और अंशक प्रयोगशालाओं के लिए राष्ट्रीय प्रत्यायन बोर्ड (एनएपीएल) से मान्यता प्राप्त है।



संस्थान द्वारा विकसित हर्बल उत्पाद

संस्थान ने वैज्ञानिक रूप से मान्य हर्बल उत्पादों का भी विकास किया है जिनमें एनबीआरआई-डीबी: मधुमेह विरोधी हर्बल फार्मूलेट (BGR34), एनबीआरआई यूरो-05, ट्रांफ़ल हर्बल कैडिडा जेल, जोश: पारंपरिक कढ़ा, डेटो जेल: दंतदुर्द राहत जेल, क्रोमा -03: जैव उपलब्ध कर्कुरिन, न्यूट्रीनेस शामिल हैं।



संस्थान द्वारा कृषि प्रौद्योगिकियाँ

संस्थान द्वारा किसानों को लाभान्वित करने हेतु विभिन्न प्रौद्योगिकियाँ विकसित की गयी हैं जिनमें वमो: 108 कमल की किस्म, एनोकिंग निहार, असंक्रिय मूक धातु 'मुक्ताश्री', उत्तर भारत हेतु हल्दी की किस्म-केसरी, ससेन्ड, मक्खी प्रतिरोधी तकनीकी, बीटी कोटव तकनीकी, अनाकार्डिक एसिड आधारित ग्रोथ प्रमोटर, उच्च धीवर्धन युक्त ऑर्गैम पोषी लाइव, बायो-इलाक्यूलेट्स, जैव-उर्वरक एवं जैव-कीटाधी मुख्य हैं।

अधिक जानकारी के संपर्क करें:

निदेशक, वै.औ.अ.प.-राष्ट्रीय वनस्पति अनुसंधान संस्थान, लखनऊ
राणा प्रताप मार्ग, लखनऊ-226001; फ़ोन: 0522-2297804

हमारे सोशल मीडिया प्रोफाइल को फॉलो करें

✉ @csirnblko 📧 Csir Nbrl 📺 CSIR NBRI 📷 csirnbrofficial
वेबसाइट: www.nbrl.res.in

- Ocean Coalition. <https://www.asoc.org/learn/antarctic-governance/>
6. Shibata, A. (2023, April 20). The Future of International Governance in the Antarctic Ocean: The Lead Up to the 2026 Conference Hosted by Japan. The Sasakawa Peace Foundation. https://www.spf.org/opri/en/newsletter/545_2.html
 7. Saha, S. (n.d.). Gazette Notifications/Rules on Indian Antarctic Act, 2022. National Centre for Polar and Ocean Research (NCPOR). Retrieved November 14, 2025, from <https://ncpor.res.in/news/view/701>
 8. SaGAA. (2023). SaGAA VII: The Future of Arctic Ice – An Indo-Pacific Connect (Conference Report, April 27-28, 2023). New Delhi, India. https://www.saghaa.org/sagaa7_report.php
 9. Antarctic and Southern Ocean Coalition (ASOC). (n.d.). Antarctic governance. <https://www.asoc.org/learn/antarctic-governance/>
 10. International Association of Antarctica Tour Operators. (2025, May 23). Report of the International Association of Antarctica Tour Operators 2024-25 (Information Paper IP 31, ATCM 47). https://iaato.org/system/files?file=2025-07/ATCM47_ip031_e.pdf
 11. International Association of Antarctica Tour Operators. (2025, January). IAATO report to ATCM 28: Tourism statistics and environmental stewardship. IAATO. https://iaato.org/system/files/2025-01/ATCM28_ip082_e.pdf
 12. International Association of Antarctica Tour Operators. (2025, January). IAATO report to ATCM 28: Tourism statistics and environmental stewardship. IAATO. https://iaato.org/system/files/2025-01/ATCM28_ip082_e.pdf

India's Legislative Outlook for Polar Research

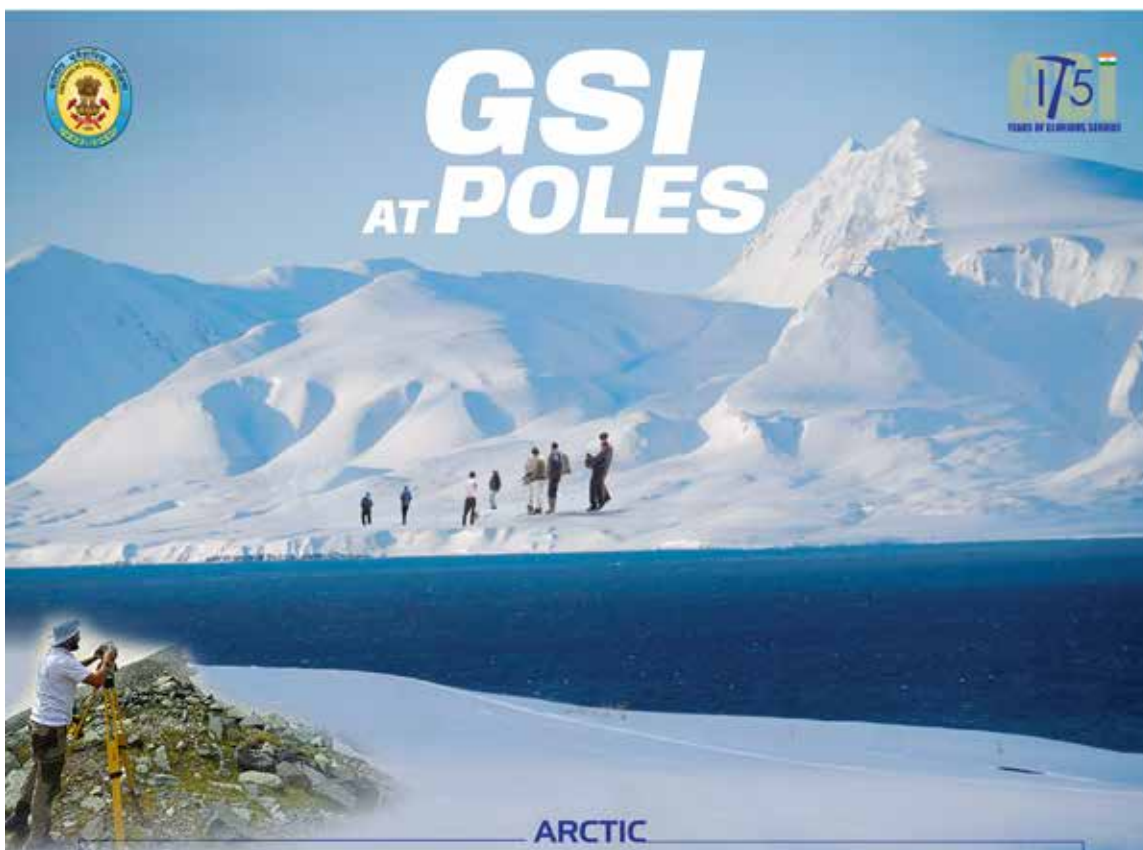
The Indian Parliament plays a crucial role in legislating foreign policy and scientific governance related to the Polar regions. Through parliamentary oversight, strategic priorities and budgets are defined for national programmes, enabling coordination among ministries and linking research outputs to foreign policy. A key example is the enactment of the India Antarctic Act (2022), which provides a legal framework for India's Antarctic activities. Similarly, the India Arctic Policy guides the country's strategic engagement in the Arctic, including its observer status in the Arctic Council and collaborative research initiatives with nations such as Russia, Norway, Canada, and Iceland.

India's National Centre for Polar and Ocean Research (NCPOR), under the Ministry of Earth Sciences (MoES), serves as the operational hub for polar research, coordinating scientific expeditions, data collection, and advanced research infrastructure. Parliamentary oversight supports resource allocation to national agencies like NCPOR and the Indian Meteorological Department (IMD) for enhanced climate services, forecasting, and strategic planning aligned with Vision 2047, which maps a pathway to a developed and climate-resilient India by the country's centenary of independence. Vision 2047 emphasizes integrated climate adaptation, innovation, and cross-sectoral resilience-building across sectors such as agriculture, water, energy, and transport.

To operationalize these goals, India is fostering multi-ministry coordination and funding frameworks, enabling institutions like NCPOR and other national research institutes to pursue large-scale polar and climate research projects. This approach mirrors international examples such as the UK's multi-year funding for the British Antarctic Survey and other environmental centers, which supports long-term environmental observation, modelling, and ecosystem research critical for



GSI AT POLES



ARCTIC

India's scientific endeavors in the Arctic began in 2007. Since 2008, GSI has been participating in the Indian Arctic Expeditions for systematic glaciological studies for the vestre Broggerbreen Glacier in the Ny-Alesund area of Svalbard, focusing on snow and ice chemistry, ice ablation, geomorphological mapping, glacier mass balance, snout monitoring, flow dynamics, and subsurface profiling using ground-penetrating radar.

HIMALAYA

GSI's glacier studies gained global significance as they integrated with international research initiatives. Building on this, the first training-cum-expedition to Gangotri Glacier in 1971 marked a major milestone, leading to the establishment of the Glaciology Division in 1974. From there, the division conducted detailed studies on glacier mass balance, hydrology, sediment load, and microclimate. Furthermore, the Inventory of Himalayan Glaciers positioned GSI as a key contributor to global Cryospheric research and monitoring efforts, thereby enhancing understanding of Himalayan glacier dynamics and their environmental implications.

ANTARCTICA

Through systematic geological mapping, isotopic dating, and petrological studies in East Antarctica, GSI elucidated the Proterozoic-Paleozoic evolution of the East Antarctic shield and linked it with India's tectonic history, thereby aiding global reconstructions of Rodinia and Gondwana. Notably, the identification of the Dakshin Gangotri Glacier in 1983 marked India's entry into Antarctic glaciology. Since then, GSI has monitored over 60,000 sq. km of the East Antarctic Ice Sheet, thus contributing critical insights into climate change and global sea-level rise.



understanding polar ecosystem responses and climate impacts. By linking legislative oversight, strategic policy, institutional capacity, Vision 2047, and coordinated funding, India positions itself not only as a scientific research player but also as a diplomatic actor balancing innovation with societal needs and national security.

India's emerging role in Polar diplomacy reflects its growing scientific, environmental, and geopolitical ambitions in both the Arctic and Antarctic. Although India holds no territorial claims, it recognizes the strategic value of Polar regions for climate research, energy security, trade routes, and global governance. In Antarctica, India has built a strong legacy since its first expedition in 1981, joining the Antarctic Treaty System in 1983, establishing two major research stations, and deepening cooperation through platforms like BRICS, the Asian Forum for Polar Sciences, ICAR, and bilateral partnerships with nations such as Argentina, Norway, and Sweden. Similarly, in the Arctic, India's involvement, rooted in the 1920 Svalbard Treaty, has expanded through scientific institutions and collaborations supported by over two dozen Indian universities conducting Arctic research. While geopolitical tensions, logistical challenges, and harsh polar environments constrain India's efforts, the country sees significant opportunities in scientific leadership, sustainable resource management, and future Arctic shipping routes. Through diplomacy, scientific cooperation, and environmental stewardship, India aims to position itself as an influential, responsible stakeholder in the rapidly changing Polar regions (Indian Council of World Affairs, n.d.).

References

1. Indian Council of World Affairs. (n.d.). India's emerging role in polar diplomacy - Indian Council of World Affairs (Government of India). https://icwa.in/show_content.php?lang=1&level=3&ls_id=10899&lid=6924

India's Polar Engagement in Arctic Oil Exploration

India's engagement with Arctic hydrocarbons has evolved significantly over the past two decades, shaped by energy security needs, geopolitical opportunities, and climate driven realities. In the early phase (2000s–mid-2010s) it was exploration oriented. India's initial interest in Arctic oil was scientific and exploratory, aligned with its broader polar research agenda. The main driver was the desire to understand Arctic geology, climate interactions, and potential resource distributions, not to enter commercial extraction. India engaged through scientific expeditions, participation in the Svalbard Treaty (1920) framework, and expanded polar research capabilities. The country's energy strategy at the time was dominated by Middle Eastern and African suppliers; Arctic resources were seen as a future diversification option, not an immediate necessity.

The transitional period was around the mid 2010s to 2020. As Arctic ice melt accelerates, the region is becoming increasingly accessible and Russia opens new investment windows, India's interest shifted (Ranjithkumar, 2021). India's oil companies, particularly ONGC Videsh Ltd (OVL) began strategic investments in Russian Arctic assets, notably the Sakhalin-1 project (Nanda & Observer Research Foundation, 2019), which provided early exposure to high-latitude extraction. This period marks the shift from pure exploration to strategic stakes in production assets, though not yet direct exploitation by India itself. Participation remained cautious due to harsh environment and infrastructure costs, international sanctions on Russia, technological



ICAR - CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY

ISO/IEC 17025:2017 NABL Accredited & ISO 9001: 2015 certified Institute

Founded in 1957, ICAR - CIFT has proven its excellence in the development of fishing and fish processing technologies. During the last 63 years, ICAR-CIFT has made commendable scientific contributions in the fields of fish harvesting, processing, packaging, seafood safety, aquaceuticals, biotechnological applications, engineering and policy interventions. The Institute is renowned for its high caliber and innovative research activities, trainings, partnerships and entrepreneurship promotion. It has vibrant research environment and is the only National Centre in the country where research in all disciplines relating to harvest and post-harvest is undertaken.

RANGE OF TECHNOLOGIES	SERVICES OFFERED
- Fishing Vessel / Gear Designs - Resource / Energy Optimisation - Processing / Preservation / Packaging techniques - Value added products / by-products - Cost effective processing machineries - Health Care / Aquaceuticals	- Novel technologies for harvest & post harvest sectors - New product formulation/ technology upscaling - Setting up of production lines/food processing units - Designing and equipping laboratories - NABL accreditation / HACCP Certification - Analytical services - Human resource development
JOIN THE AGRIBUSINESS INCUBATION CENTRE, ICAR - CIFT, Explore and choose from the wide range of technologies	

Get access to novel technologies and pro-active, value added business support services.

We handhold entrepreneurs to lay foundation for new technology based business enterprises

The Agri-Business Incubation Centre at ICAR-CIFT, Kochi provides an array of services to entrepreneurs, in the form of technology transfer / professional service functions, office space, certified state-of-the-art pilot level production facility, on-site guidance and specialized trainings to support and accelerate the growth of new businesses.

CONTACT US

The Director, ICAR - Central Institute of Fisheries Technology
 Willingdon Island, Matsyapuri P.O., Kochi-682 029, Kerala, India

CONTACT ZTM-ABI CENTRE / MATSYA FIC

Ph : 0484-2412414; Mobile: +91 97781 03137

Email : ciftitmu@gmail.com; cift.fic@gmail.com ; Website : www.cift.res.in



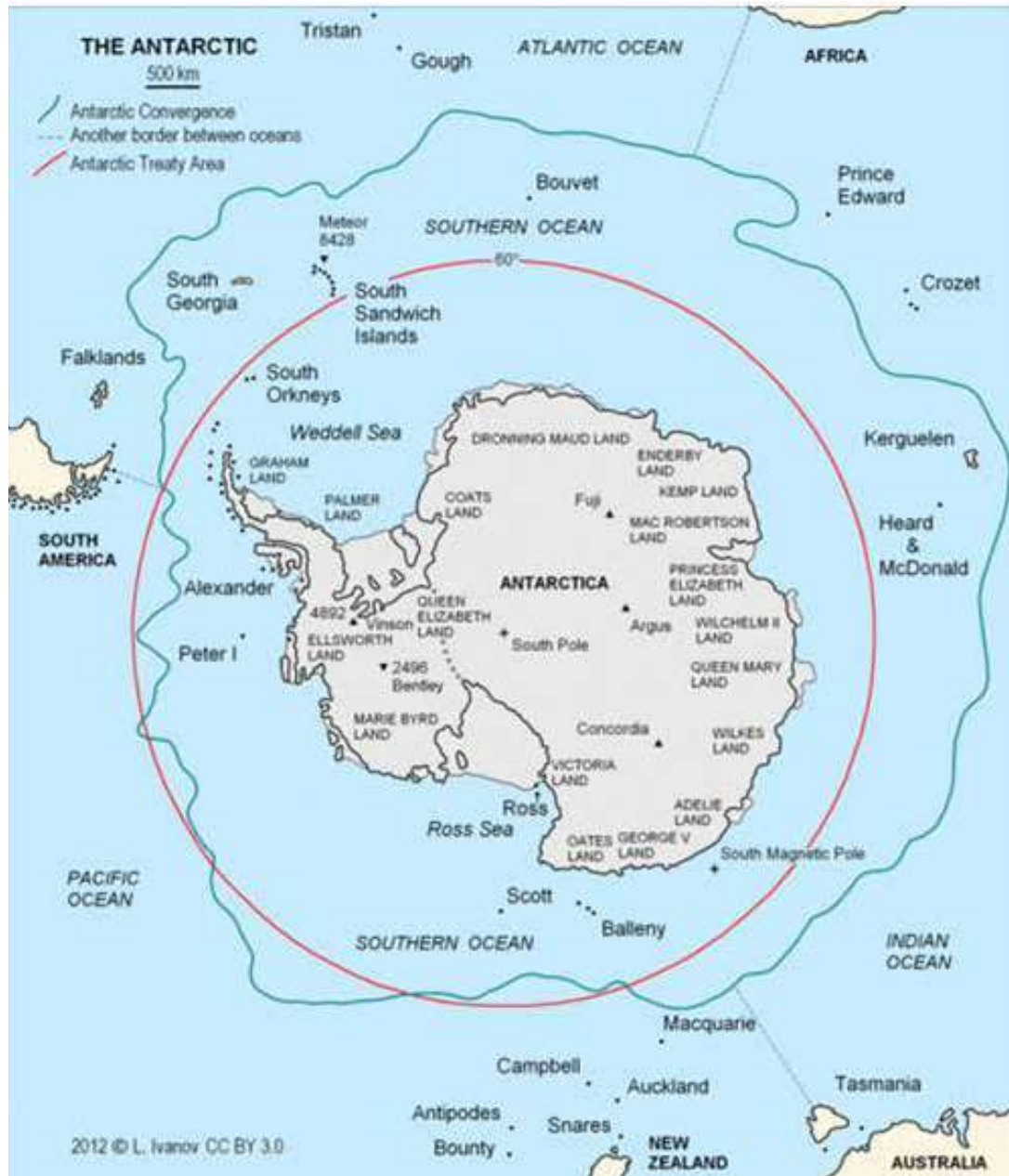


Fig description & source: The Antarctic Treaty was signed in Washington on 1 December 1959 by 12 nations: Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the USSR, the United Kingdom, and the United States. It entered into force in 1961 and applies to the area south of 60° South Latitude, including all ice shelves. The Treaty established Antarctica as a region free from military activity and encouraged cooperation, peaceful conflict resolution and the exchange of scientific information between nations. It ushered in an era of unprecedented international cooperation in both Antarctic science and governance. Antarctic and Southern Ocean Coalition (ASOC). (n.d.). Antarctic governance.



MORMUGAO PORT IS A MAJOR CONTRIBUTOR TO THE DEVELOPMENT OF THE STATE'S ECONOMY THROUGH PROMOTION OF MARITIME TRADE. AS AN IMPORTANT PORT OF CALL ON THE WEST COAST OF INDIA, IT PLAYS A CRUCIAL ROLE IN FACILITATING INTERNATIONAL TRADE, AS WELL AS COASTAL MOVEMENT OF GOODS.

FACILITIES & SERVICES

Mormugao Port Authority offers a comprehensive suite of modern facilities and services, designed to support diverse cargo types and ensure efficient maritime trade.



DRY BULK HANDLING

Dedicated berths, high capacity unloaders and extensive storage with dust suppression for coal, iron ore, and more.



BREAK BULK HANDLING

Multiple berths, mobile cranes, & transit sheds for break bulk cargo.



LIQUID BULK HANDLING

Dedicated Jetty with marine loading arm for petroleum, chemicals, and edible oils, ensuring safe and environmentally compliant handling.



CONTAINER HANDLING

Comprehensive infrastructure for seamless, secure, and efficient international containerized trade.



GATEWAY TO GLOBAL CRUISING

Step into Goa's upcoming premier International & Domestic cruise terminal a world class facility connecting visitors to vibrant culture and scenic coasts. With seamless passenger services, hospitality zones, and digital innovations.



SIGNALLING & TELECOMMUNICATION SYSTEM

Enables safe and efficient rake movements, centralized control, & dedicated telecommunication links for real time operations & coordination.



COVERED SHEDS

Spacious, weather protected storage for bulk cargo, preserving quality and ensuring uninterrupted operations.



INDIGENOUS VTMS

Real-time vessel monitoring for enhanced navigational safety, optimized traffic flow, and efficient scheduling.



RFID GATE ACCESS

Streamlined, contactless vehicle and personnel authentication for reduced wait times and enhanced security.

ADVANCING GREEN PORT INITIATIVES AT MORMUGAO

Harit Shrey: Green Ship Incentive

Encouraging vessels with superior environmental performance and those utilizing green fuels through specialized incentives.



Mechanized Cargo Handling

Automated bulk cargo handling systems with closed conveyors, integrated dry fog dust suppression, and efficient wagon loading systems.



3 MW Solar Power Plant

Mormugao Port operates on 100% renewable energy, achieving Green Port status through a significant solar installation.



100% Reduction in Groundwater usage for dust control measures

Transitioned entirely to recycled treated water for dust control, eliminating reliance on groundwater resources.



MORMUGAO PORT IS COMMITTED TO SETTING NEW BENCHMARKS IN ENVIRONMENTAL STEWARDSHIP WITHIN THE MARITIME INDUSTRY.

MORMUGAO PORT AUTHORITY HEADLAND SADA- MORMUGAO GOA

Website: <https://mptgoa.gov.in>

dependence on Western Arctic-capable firms.



Fig description & source: The Prirazlomnaya platform is the first Russian project for developing the Arctic shelf. (Humpert et al., 2011)

Post 2020 India's interest and engagement shifted towards resource security and exportations. Rising Indian energy demand and global supply disruptions (due to COVID-19, Ukraine conflict) pushed New Delhi to pursue long-term, diversified, and politically stable energy lines. Russia, seeking non-Western partners due to sanctions, encouraged deeper Indian participation in Arctic and High North hydrocarbons. India signaled willingness to consider greater upstream involvement moving closer to exploitation through additional stakes in Russian Arctic LNG (Tass, 2021; Bhaskar, 2022) and oil projects, discussions on transport corridors like INSTC for Arctic crude to India and interest in shipping cooperation via the Northern Sea Route.

India's Parliament, parliamentary committees and ministries increasingly shape the country's Arctic posture by authorising diplomatic engagement, energy deals, and scientific programmes. Legislative oversight matters for (a) approving or scrutinising bilateral energy agreements (notably with Russian producers supplying oil and LNG), (b) allocating funds for IMD-led climate services and polar science, and (c) setting national rules on expedition safety, liability and environmental safeguards for Indian actors operating in polar spaces. IMD's Vision 2047 now publicly released and tied to India's mission-led climate services and forecasting ambitions will influence how India sizes observational investments that support both climate diplomacy and operational planning connected to Arctic shipping and resource access (PIB Delhi, 2025).

Existing maritime law (UNCLOS) and technical boundary processes (CLCS) remain central to claims over seabed resources, but major powers are also reinterpreting or instrumentally using law to advance strategic interests. The Arctic's consensus-based institutions (notably the Arctic Council) have retained a science and environment focus,



CSIR
NPL
The International Physics of India

CSIR-NPL

National Metrology Institute of India

CSIR-NPL is the custodian of National Standards and maintains the Indian Standard Time (IST). It is mandated to be India's National Measurement Institute (NMI) by an act of Parliament. CSIR-NPL disseminates precision measurements that are needed for the growth of Indian science and industry as well as for the legal metrology needs of the nation.

- 1 Calibration and testing
- 2 Consultancy and technical services
- 3 Industrial training
- 4 Academic activities
- 5 Focused R&D in frontline S&T areas
- 6 Bharatiya Nirdeshak Dravya (BND)



For details, please visit:
www.nplindia.org

but geopolitical pressures have narrowed cooperation and encouraged pragmatic minilateral groupings. For India, an Arctic Council Observer, the shifting architecture suggests pragmatic coalitions will increasingly determine access and norm-setting, rather than broad UN-centered solutions alone. Indian legislative strategy must therefore plan for flexible diplomacy and legal preparedness, including contingency approaches to contested supply chains (Kumar, 2025).

India's Polar engagement, especially under the subcategory of Arctic oil exploration, sits at the intersection of governance, legislative policy making, international collaboration, and scientific cooperation. Despite the shift in interest, India balances Arctic energy ambitions with its climate diplomacy identity. India today can be described as not a primary exploiter, but no longer purely exploratory.

References

1. PIB Delhi. (2025, January 13). PM to participate in celebrations of 150th Foundation Day of India Meteorological Department on 14th January: PM to launch 'Mission Mausam' and release IMD Vision-2047 document. Press Information Bureau, Government of India. Retrieved November 14, 2025, from <https://www.pib.gov.in/PressReleaseDetailm.aspx?PRID=2092386&utm>
2. Kumar, V. (2025, November 3). Observer Activity Report - Republic of India - 2025. Arctic Council. <https://oaarchive.arctic-council.org/items/b28a9430-237a-4320-8df3-55adc863ebd3>
3. Nanda, D. & Observer Research Foundation. (2019). India's Arctic potential. In ORF Occasional Paper. Retrieved November 19, 2025, from https://www.orfonline.org/wp-content/uploads/2019/02/ORF_Occasional_Paper_186_Arctic.pdf
4. Tass. (2021, September 6). ONGC Videsh, Petronet LNG to purchase 9.9% in Arctic LNG-2 from Novatek, says source. TASS. <https://tass.com/economy/1334459>
5. Bhaskar, U. (2022, February 25). No immediate plans to invest in energy assets in Russia: OIL. Mint. Retrieved November 19, 2025, from <https://www.livemint.com/industry/energy/no-immediate-plans-to-invest-in-energy-assets-in-russia-oil-11645729871207.html>
6. PTI Mumbai. (2023, May 29). ONGC Videsh has less than \$100 mn stuck in Russia, says official. The Indian Express. Retrieved November 19, 2025, from <https://indianexpress.com/article/business/companies/ongc-videsh-money-stuck-russia-8634920/>
7. Ranjithkumar. (2021, November 23). Indian companies looking to invest in Vostok oil project in Russia. NS Energy. Retrieved November 19, 2025, from <https://www.nsenergybusiness.com/news/indian-consortium-vostok-oil-russia/>
8. Humpert, M., et al. (2011, August 31). ExxonMobil gains access to Arctic oil and gas reserves in deal with Rosneft. The Arctic Institute. <https://www.thearcticinstitute.org/exxonmobil-gains-access-arctic-oil/>

Indigenous people of the High-North

Indigenous peoples of the High North including Sámi, Inuit (Kalaallit), Nenets and other communities are central actors in Arctic governance. Their livelihoods, languages and knowledge systems are tightly coupled to ice, sea-ice, permafrost and migratory species; climate change, expanding extractive activity, and increased tourism are rapidly transforming those ecological foundations. Indigenous organizations hold formal roles in Arctic governance as Permanent Participants of the Arctic Council and are increasingly asserting rights-based, knowledge-based and co-management claims in domestic and international fora. These dynamics position Indigenous communities as both knowledge-holders crucial to climate adaptation

and as rights-bearing stakeholders whose consent and participation are pivotal to legitimate, effective governance in the High North (Arctic Council, n.d.).

Climate driven livelihood pressures such as warmer winters, rain-on-snow events, and rapidly shifting forage conditions are undermining reindeer herding and other traditional subsistence economies, forcing Indigenous communities to rethink mobility and co-design adaptive strategies with scientists (WWF Arctic, 2025). At the same time, the accelerating global demand for rare earths, lithium, and other minerals essential to the green transition is pushing new extractive projects into Indigenous territories, generating sharp conflicts between European/Arctic supply-security priorities and the land, food, and cultural security of local communities (Dazio & Haarala, 2025). Sweden's Sápmi region, rare-earth and mineral mining proposals reported throughout 2025 have raised serious social and environmental concerns, with Sámi reindeer herders warning that Europe's push for strategic minerals threatens their traditional livelihoods. These pressures are compounded by long-standing problems in developer agreements especially in sectors like wind energy, mining, and forestry where confidentiality clauses, limited protections, and land-access loss have prompted calls for stricter rules on consultation and consent. Similar tensions persist in Norway, where Sámi communities continue to protest and legally challenge power-line and infrastructure projects that, while promoted as essential for national climate goals, risk fragmenting grazing routes and disrupting sensitive calving grounds (Fouche, 2024).

In response, Indigenous organizations are increasingly turning to domestic courts, human-rights mechanisms, and Arctic Council processes to contest mining, energy, and infrastructure projects, seeking stronger consent procedures, equitable benefit-sharing, and long-term territorial protections (Bryant, 2024). Parallel to this legal and political pushback, Indigenous knowledge is gaining greater recognition, with co-production of climate and biodiversity monitoring through digital mapping, seasonal observations, and community-based monitoring becoming standard practice in adaptation policy (Weichenrieder et al., 2024). Meanwhile, the surge in Polar tourism introduces both opportunities and vulnerabilities: while promising income diversification, it also heightens risks of cultural commodification, ecological disturbance, and pressure on seasonal resources, prompting growing calls for Indigenous-led tourism governance models that safeguard cultural integrity and environmental sustainability (Okoli, 2024). Recent developments across the Arctic highlight growing tensions between climate transition imperatives and Indigenous rights. At the Arctic Council meeting in Romssa-Tromsø in May 2025, Arctic States and Indigenous Permanent Participants jointly reaffirmed the need for stronger Indigenous engagement in governance, science, and policy as Denmark assumed the Council chairmanship (Arctic Council Secretariat, 2025).

References

1. Arctic Council. (n.d.). Permanent Participants. Arctic Council. Retrieved November 15, 2025, from <https://arctic-council.org/about/permanent-participants/>
2. WWF Arctic. (2025, October 23). Sámi Reindeer Herders Map Climate Change - WWF Arctic. Retrieved November 15, 2025, from <https://www.arcticwwf.org/the-circle/stories/sami-reindeer-herders->

map-climate-change/

3. Dazio, S., & Haarala, M. (2025, September 7). Sweden's plans to mine rare-earth minerals could ruin the lives of Indigenous Sami reindeer herders. AP News. Retrieved November 15, 2025, from <https://apnews.com/article/sweden-reindeer-sami-indigenous-people-climate-change-82bd86af6b29bf395bb698b8bdf282c9>
4. Bryant, M. (2024, March 14). Developer contracts with Sámi reindeer herders 'harmful' to Indigenous people. The Guardian. Retrieved November 15, 2025, from <https://www.theguardian.com/world/2024/mar/14/agreements-between-sami-reindeer-herders-and-developers-do-more-harm-than-good>
5. Weichenrieder, S., Carvalho, V. N., & De Cuyper, F. (2024, August 27). Leveraging Indigenous Knowledge for Effective Nature-Based Solutions in the Arctic. The Arctic Institute. Retrieved November 15, 2025, from <https://www.thearcticinstitute.org/leveraging-indigenous-knowledge-effective-nature-based-solutions-arctic/>
6. Okoli, M. (2024, October 2). Arctic Indigenous People, Traditional Culture: Potentials for Tourism Development. IDN-InDepthNews. Retrieved November 15, 2025, from <https://indepthnews.net/arctic-indigenous-people-traditional-culture-potentials-for-tourism-development/>
7. Arctic Council Secretariat. (2025, May 12). Arctic states and Indigenous permanent participants convene for the 14th meeting of the Arctic Council and issue joint ROMSSA-Tromsø statement. Arctic Council. Retrieved November 15, 2025, from <https://arctic-council.org/news/press-release-14th-meeting-arctic-council-joint-romssa-tromso-statement/>
8. Fouche, G. (2024). Reindeer herders battle power line needed for Norway's climate goal. In Reuters. Retrieved November 15, 2025, from <https://www.reuters.com/investigates/special-report/arctic-reindeer-norway-power/>

International Relationship in Polar and Maritime Domains

India's Arctic policy emphasizes strengthening scientific research, particularly in climate change, cryosphere studies, and glacial monitoring, while fostering international collaboration. India has developed substantial research capacity in polar and Himalayan regions, as highlighted by initiatives under the National Centre for Polar and Ocean Research.

The United States and India have developed a robust partnership in scientific research, technology, and polar studies, with cooperation spanning the Arctic, Himalayas, and cryosphere monitoring. A flagship example of this collaboration is the NASA-ISRO Synthetic Aperture Radar (NISAR) satellite mission, jointly developed by NASA and the Indian Space Research Organisation (ISRO), which aims to monitor the Earth's changing frozen regions, including glaciers, ice sheets, and permafrost, with unprecedented precision. Beyond space technology, U.S.–India cooperation also extends deeply into climate technology through the U.S.–India Strategic Clean Energy Partnership (SCEP) on 22 April 2021. This high-level partnership, launched under the broader U.S.–India Climate & Clean Energy Agenda 2030, advances clean-energy innovation across five pillars: power & energy efficiency, renewable energy, responsible oil and gas, emerging fuels and technologies, and sustainable growth (U.S. Department of Energy [DOE], 2021a, 2021b). Studies have highlighted the teleconnection between the Arctic and the “Third Pole” in the Himalayas, emphasizing the need for coordinated monitoring of glacier retreat, snow cover, and monsoon variability. This partnership is supported by India's Arctic Policy,



Centre for Marine Living Resources and Ecology (CMLRE)
Ministry of Earth Sciences (MoES)

Mandate

To lead India's scientific efforts on the assessment, sustainable utilization, and management of Marine Living Resources (MLR) by undertaking long-term ecosystem monitoring, resource evaluation, and biodiversity studies to support evidence-based fisheries management and national blue economy priorities.

Vision

To advance scientific understanding and sustainable management of India's Marine Living Resources for the long-term health of ocean ecosystems and the prosperity of coastal communities.

Implementing Programmes

1. Prithvi Vigyan
2. Deep Ocean Mission
3. Mission Mausam



FORV Sagar Sampada

Area of Focus

1. Biodiversity and Ecology
2. Fishery Resources and Habitat Assessment
3. Societal Services through MLR Enhancement
4. Marine Biodiversity Governing Cell
5. Southern Ocean Resource Management
6. Deep-sea Biodiversity Exploration through Technological Innovations

International Cooperation:

As an attached office of the Ministry of Earth Sciences, CMLRE functions as the National Focal Point for India's international engagements related to Marine Living Resources such as Biodiversity Beyond National Jurisdiction (BBNJ), Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), and Indian Ocean Biodiversity Information System (IndOBIS).



CMLRE, ATAL BHAVAN
LNG Road, Puthuvypin South, Ochanthuruthu PO, Kochi-682508



www.cmlre.gov.in



[cmlre_kochi](https://www.youtube.com/cmlre_kochi)



[cmlre_kochi](https://www.telegram.com/cmlre_kochi)



[cmlrekochi/](https://www.facebook.com/cmlrekochi/)

41

Book of Abstracts

which emphasises scientific diplomacy, teleconnections between the Arctic and Himalayas, and enhanced capacity through the National Centre for Polar and Ocean Research (NCPOR) (MP-IDSA, 2023; India's Arctic Policy, 2022). India also leverages this collaboration to strengthen its scientific institutions, such as the National Centre for Polar and Ocean Research (NCPOR), enabling joint research on climate change impacts, glacial hazards, and polar oceanography.

Alongside science and technology, the U.S – India relationship also encompasses economic dimensions, including trade and tariffs, which indirectly support scientific and technological collaboration. Recent agreements and negotiations on reducing trade barriers and harmonizing tariffs have facilitated the import of scientific instruments, satellite components, and research equipment, enabling smoother execution of joint missions like NISAR and other technology-intensive projects. Such economic engagement complements science diplomacy, creating a multi-dimensional partnership where technology, research, and trade jointly strengthen India–U.S. ties and advance climate, polar, and Himalayan studies.

India and China share a complex relationship in the context of polar and Himalayan science, encompassing scientific cooperation, environmental monitoring, and geopolitical considerations. Both countries face shared environmental risks in the Himalaya, including glacier retreat, black-carbon deposition, and water security challenges, which present opportunities for scientific cooperation. While their ecological stakes in the Himalayas could warrant deep scientific cooperation, formal India–China collaborations remain very limited. For example, hydrological data sharing from China to India has historically been constrained, and there is no transparent, dedicated MOU for joint glacier monitoring (Mizo, 2023; The Wire Science). Some related research on black carbon and pollutant transport in the Tibetan Plateau and Himalayas is conducted through third-country platforms (such as Nepal via ICIMOD), rather than direct India–China bilateral programmes. This limited cooperation underscores how political tensions complicate potentially beneficial shared scientific endeavors. Overall, the India–China nexus in the polar and Himalayan domains is shaped by the convergence of scientific priorities, environmental imperatives, and broader political considerations, suggesting that science diplomacy can serve as a platform for collaboration even amid complex bilateral dynamics.

India's relationship with the Nordic countries (Norway, Sweden, Denmark, Finland, Iceland) in the Polar domain is becoming increasingly strategic, especially in science, sustainability, and Arctic governance. In 2019, India signed an MoU with Sweden on polar-science cooperation, enabling joint research and exchange of expertise. On the policy front, India's 2022 Arctic policy underscores its scientific ambitions and envisages partnerships with Nordic countries for research, green technology, and sustainable development. Moreover, in 2024, New Delhi and Nordic partners held a workshop under the University of the Arctic (UArctic) network, emphasizing science diplomacy, environmental monitoring, and policy capacity-building. This cooperative framework not only strengthens India's scientific footprint in the High North but also helps build a more rules-based, sustainable Arctic governance architecture, leveraging the Nordic countries' expertise and shared climate-governance norms. In 2025, India proposed a joint feasibility study with Norway for operationalising the Northern Sea Route (Arctic) with collaboration in Arctic Navigation, research and development in Arctic shipping

and the design of ice-class vessel, signalling not just scientific but strategic economic and infrastructural collaboration (ET EnergyWorld, 2025; India Briefing, 2025).

India's growing interest in the Arctic's untapped reserves of hydrocarbons and minerals is deeply intertwined with its partnership with Russia. India's investment in Russian oil and gas projects highlight the growing opportunities in Arctic nations. The investment ensures India's economic and strategic foothold in a region that is becoming increasingly critical for future resource security. At the 22nd Indo-Russia Summit, both nations expressed a commitment to intensify trade and investment cooperation, particularly in the Russian Far East and Arctic zones. This includes establishing a joint working body within India-Russia Intergovernmental Commission on Trade, Economic, Scientific, Technological, and Cultural Cooperation (IRIGC-TEC) for NSR collaboration, demonstrating India's ambitions to actively participate in Arctic shipping and energy development and signaling a strategic commitment beyond economic interests. Scientifically, the two countries collaborate under institutional frameworks like the Integrated Long-Term Programme (ILTP) and a Working Group on Science and Technology, facilitating joint research in frontier domains such as deep-sea exploration, submersible development, and polar science. In the Polar domain, in 2025, India's National Centre for Polar and Ocean Research (NCPOR) signed a memorandum of understanding (MoU) with Russia's Arctic and Antarctic Research Institute (AARI) to strengthen scientific cooperation and logistical support in the polar regions, including joint expeditions and use of Russian ice-capable platforms (Sputnik News, 2024). However, work is yet to commence. Notably, the INDARC mooring is functioning perfectly, and the new buoy has been retrieved for factory calibration of sensors; it will be redeployed with the original configuration upon completion.

Despite suspended cooperation following the Ukraine invasion, Russian specialists have continued collaborating with observer states like India on renewable energy projects, such as the Snezhinka Arctic station in the Yamal-Nenets Autonomous Area (Manini, 2025). In parallel, India has increased its imports of Russian crude oil, including lighter grades from the Arctic like ARCO and Novy Port, while enhancing commercial shipping ties. In September 2021, Mazagon Dock Shipbuilders, an Indian government-owned company, signed an agreement with Zvezda, Russia's largest shipyard, for commercial shipping and shipbuilding. On the geopolitical front, such scientific collaboration is aligned with India's strategic aim to balance its Arctic engagement: while New Delhi seeks to diversify its partnerships, the deep technical and logistical ties with Russia remain a core pillar of its polar strategy.

References

1. NASA. (2025). This US-Indian satellite will monitor Earth's changing frozen regions. NASA. Retrieved from <https://www.nasa.gov/missions/nisar/this-us-indian-satellite-will-monitor-earths-changing-frozen-regions>
2. Down to Earth. (2025). Indo-US satellite NISAR to study Earth's cryospheric changes will help in natural resource & hazard management. Retrieved from <https://www.downtoearth.org.in/science-technology/indo-us-satellite-nisar-to-study-earth-s-cryospheric-changes-will-help-in-natural-resource-hazard-management-93853>
3. U.S. Department of Energy. (2021a, September). U.S.-India Strategic Clean Energy Partnership: Pillars and accomplishments. <https://www.energy.gov/sites/default/files/2021-09/SCEP%20>

Pillars_Accomplishments.pdf

4. Ministry of Earth Sciences (MoES), Government of India. (2022). India's Arctic Policy. Retrieved from <https://www.moes.gov.in/sites/default/files/2022-03/compressed-SINGLE-PAGE-ENGLISH.pdf>
5. Institute for Defence Studies and Analyses (IDSA). (2025). India's Arctic Endeavours: Capacity Building and Capability Enhancement. Retrieved from <https://www.idsa.in/publisher/policybrief/indias-arctic-endeavours-capacity-building-and-capability-enhancement>
6. Press Information Bureau (PIB), Government of India. (2025). Polar research and institutional initiatives. Retrieved from <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2102740>
7. Cryosphere Research: Indian Perspective. (2012). Proceedings of the Indian National Science Academy. Rasik Ravindra & Laluraj C. M. Retrieved from file:///C:/Users/user/Downloads/CryosphereResearchIndianPerspective.pdf
8. United States Trade Representative (USTR). (2025). India – U.S. Trade Relations. Retrieved from <https://ustr.gov/countries-regions/south-central-asia/india>
9. Ministry of Commerce, Government of India. (2025). India – U.S. Trade Agreements and Tariffs. Retrieved from <https://commerce.gov.in>
10. Ministry of Earth Sciences. (2022). India and the Arctic: Building a partnership for sustainable development. Government of India. <https://www.moes.gov.in/sites/default/files/2022-03/compressed-SINGLE-PAGE-ENGLISH.pdf?>
11. ISDP. (2021). The Himalayas are heating up: Can China and India cool their climate rivalry? Institute for Security & Development Policy. <https://www.isdp.eu/publication/the-himalayas-are-heating-up-can-china-and-india-cool-their-climate-rivalry/>
12. Shi, Y., et al. (2021). Characteristics and changes of the Himalayan glacial area: Remote sensing and modelling. *Journal of Glaciology and Geoscience*, 42(7), 1123–1140. <https://link.springer.com/article/10.1007/s11629-021-7024-8?>
13. The Wire. (2024). India, China, Himalaya: Glacier melt and energy transition. <https://science.thewire.in/economy/energy/india-china-himalaya-glacier-melt-energy-transition/>
14. PreventionWeb. (2024). Cooperation is key as Himalayan nations deal with glacial floods. <https://www.preventionweb.net/news/opinion-cooperation-key-himalayan-nations-deal-glacial-floods?>
15. Granthaalayah. (2024). China's near-Arctic ambitions and India's scientific diplomacy. *ShodhKosh, Arts Journal*. <https://www.granthaalayahpublication.org/Arts-Journal/ShodhKosh/article/view/6317?>
16. ORF. (2025). India's strategic engagement in the Arctic. Observer Research Foundation. <https://www.orfonline.org/public/uploads/upload/20251029084410.pdf?>
17. The Arctic Institute. (2025). India, Arctic: Advancing a path for strategic autonomy beyond Russia. <https://www.thearcticinstitute.org/india-arctic-advancing-path-strategic-autonomy-beyond-russia/?>
18. National Centre for Polar and Ocean Research (NCPOR). (n.d.). India in Arctic. Ministry of Earth Sciences, Government of India. Retrieved from <https://www.ncaor.gov.in/arctics>
19. Niti Tantra. (n.d.). India's Arctic Policy: Building a partnership with sustainable development. Niti Tantra. Retrieved from <https://nititantra.com/indias-arctic-policy-building-a-partnership-with-sustainable-development/>
20. University of the Arctic. (2024, March 13). International workshop on India's polar region policy: Towards building partnerships for sustainable development. <https://www.uarctic.org/news/2024/3/international-workshop-on-india-s-polar-region-policy-towards-building-partnership-with-sustainable-approach/>
21. Menon, N. (2025, June 5). India, Norway to collaborate on green maritime tech and Arctic shipping. *ESG Times*. <https://www.esgimes.in/climate/supply-chain/india-norway-to-collaborate-on-green->



गार्डन रीच शिपबिल्डर्स एण्ड इंजीनियर्स लिमिटेड Garden Reach Shipbuilders & Engineers Ltd.

(A Government of India Undertaking, Ministry of Defence
61, Garden Reach Road, Kolkata-700 024
Tel: +91-33-2469 8101

BUILDERS OF 100+ WARSHIPS



65 GLORIOUS YEARS OF SHIPBUILDING

Delivered 803 Vessels including 114 Warships to Armed Forces of India & Friendly Foreign Countries



PROJECT 17A FRIGATE

NEXT GENERATION
OFFSHORE PATROL VESSEL

SURVEY VESSEL (LARGE)

ANTI SUBMARINE WARFARE
SHALLOW WATER CRAFT

ACOUSTIC RESEARCH SHIP

OCEAN RESEARCH VESSEL

COASTAL RESEARCH VESSEL

MULTI-PURPOSE VESSEL

TSH DREDGER

HYBRID FERRY

• WE SERVE THE NATION • WE BUILD WARSHIPS • WE BUILD BRIDGES

WARSHIPS & COMMERCIAL VESSELS

Frigates | ASW Corvettes | Missile Corvettes | Landing Ship Tanks (Large) | MPV | ORV
Offshore Patrol Vessels | Survey Vessels (L) | Next Generation Offshore Patrol Vessels |
Landing Craft Utility Ships | ASWSWCs | FACs | ARV | Other Vessels



ENGINEERING PRODUCTS

Pre-Fabricated Steel Bridges | Railless Helo Traversing System | Deck Machinery Items |
Assembly/Testing/Overhauling of Marine Diesel Engines | 30MM Naval Surface Guns |



Scan the QR Code
for the latest updates
on GRSE



For any query please contact:
✉ marketing@grse.co.in

Follow us : grsekolkata

officialgrse

OfficialGRSE

garden-reach-shipbuilders-&-engineers

www.grse.in

In Pursuit of Excellence & Quality in Shipbuilding

- maritime-tech-and-arctic-shipping/
22. Varshney, S., & Kumar, R. (2020). Science & Technology: Epitome of India-Russia Cooperation. Embassy of India, Moscow. https://www.indianembassy-moscow.gov.in/pdf/snt/Indo-Russia%20S%20and%20T%20Cooperation%20Article_2020.pdf
 23. Embassy of India, Moscow. (n.d.). Indo-Russian S&T cooperation. <https://www.indianembassy-moscow.gov.in/indo-russian-s-t-cooperation.php>
 24. Sputnik India. (2024, April 28). India, Russia in talks for Arctic project comparable to International Space Station: Scientist. Sputnik India. <https://sputniknews.in/20240428/india-russia-in-talks-for-arctic-project-comparable-to-international-space-station-scientist-7238069.html>
 25. Manini. (2025, March 10). Introducing the Arctic as a strategic geopolitical pillar for India (ORF Occasional Paper No. 467). Observer Research Foundation. <https://www.orfonline.org/research/introducing-the-arctic-as-a-strategic-geopolitical-pillar-for-india>
 26. MP-IDSA. (2022). India's Arctic Policy: Building a Partnership for Sustainable Development. <https://www.idsa.in/publisher/issuebrief/indias-arctic-policy-building-a-partnership-for-sustainable-development>
 27. Mizo, R. (2023). Border disputes threaten climate science in the Himalaya. The Wire Science. Retrieved from <https://science.thewire.in/external-affairs/south-asia/border-disputes-threaten-climate-science-in-the-himalayas/>
 28. ET EnergyWorld. (2025, May 12). India, Norway discuss deeper maritime ties, joint focus on green technologies, electric ferries, shipbuilding collaboration. Economic Times. <https://energy.economictimes.indiatimes.com/news/power/india-norway-discuss-deeper-maritime-ties-joint-focus-on-green-technologies-electric-ferries-shipbuilding-collaboration/121637404>
 29. India Briefing. (2025, May 15). India's 2025 maritime push with US\$20 billion investment and global ties. <https://www.india-briefing.com/news/indias-2025-maritime-push-with-us20-billion-investment-and-global-ties-38114.html>
 30. Sputnik News. (2024, July 29). India may join research on Russia's North Pole platform. <https://sputniknews.in/20240729/india-may-join-research-on-russias-north-pole-platform-7928872.html>

Fishing Resources in Polar

Arctic and sub-polar fisheries are undergoing rapid reconfiguration as warming waters and shifting species ranges challenge long-standing quota regimes, including the Norway–Russia framework in the Barents Sea (Welling, 2024). Although both countries agreed to sharply reduced quotas for 2025 with steep cuts to cod and continued capelin closures, sanctions, geopolitical frictions, and ecological uncertainty have made the 2024–2025 period one of the most volatile in recent Barents-Sea management history.

In the Southern Ocean, fisheries, especially krill remain at the centre of contentious CCAMLR negotiations (Kessler, 2025). The 2025 CCAMLR meeting again ended without consensus on proposed Marine Protected Areas or strengthened krill-harvest rules, prompting warnings from conservation groups and fuelling calls for precautionary closures or moratoria to protect dependent Antarctic food webs.

Against this backdrop, the polar regions are becoming increasingly important to the global seafood supply as other oceans face declines driven by overfishing and climate stress. Emerging trends include ecosystem-based fisheries management, advanced satellite enabled stock monitoring, real-time fisheries data systems, and

growth in blue-economy (Global Agriculture, 2025) models that promote circular, zero-waste processing. India has aligned with these developments: its fisheries policy is shifting from nearshore to deep-sea and distant-water operations including activity within CCAMLR frameworks while expanding bilateral blue-economy cooperation with partners such as Iceland. India–Iceland collaboration on sustainable aquaculture, zero-waste fish processing, technology transfer, and cluster-based value-chain development offers a timely model for resilient and resource efficient seafood systems.

References

1. Welling, D. (2024, November 1). Norway, Russia reach deal on Barents Sea cod quota for 2025. *intrafish.com*. <https://www.intrafish.com/whitefish/norway-russia-reach-deal-on-barents-sea-cod-quota-for-2025/2-1-1721989>
2. Kessler, R. (2025, November 4). Antarctic conservation summit closes with stalemate on MPAs & krill fishing rules. *Mongabay Environmental News*. <https://news.mongabay.com/2025/11/antarctic-conservation-summit-closes-with-stalemate-on-mpas-krill-fishing-rules/>
3. Global Agriculture. (2025, September 15). India Strengthens Fisheries and Aquaculture Cooperation with Iceland for Blue Economy Development. *Global Agriculture*. <https://www.global-agriculture.com/india-region/india-strengthens-fisheries-and-aquaculture-cooperation-with-iceland-for-blue-economy-development/>

Minerals under the sea

The Arctic is emerging as strategic frontiers in the global race for critical minerals essential to the clean-energy transition. The Arctic holds substantial shares of rare earth elements (Gupta, 2025), nickel, cobalt, magnesium and other CRMs, drawing renewed investor and government attention through 2024–25 reports and forums such as Arctic Frontiers. Melting sea ice is opening geographies previously inaccessible for exploration, intensifying interest but also raising concerns over Indigenous rights, climate risks, and fragile polar ecosystems. Greenland (Discovery Alert, 2025) and northern jurisdictions are advancing new extraction and processing projects, including low-carbon and low-waste methods aimed at reshaping upstream value chains. Notably, Norway has entered into a cooperation agreement with Greenland and Denmark on seabed minerals, formalized through an MoU to build a joint knowledge base for mineral activity in the Arctic region (Norwegian Offshore Directorate, 2024). Exploration companies in Greenland are also drilling for rare earth elements; for instance, Amaroq Ltd. launched a major 2025 exploration campaign targeting REEs in South Greenland (Amaroq Ltd., 2025; Amaroq Minerals, 2025).

Similarly, there is growing speculation about Antarctica's hydrocarbon potential, especially after Russian geophysical surveys by Rosgeo identified major sedimentary basins (Rosgeo, 2024). Russian media and other reports claim discoveries equivalent to 511 billion barrels of oil, although these are based on surveys rather than confirmed drilling (Offshore Magazine, 2025; Science Times, 2025). Current news highlights pilot-scale seabed exploration missions and rising debates at the International Seabed Authority regarding technology transfer, equitable mineral allocation, and environmental safeguards especially near hydrothermal vents and sensitive benthic habitats. India, working through global governance platforms and in alignment with

sustainability standards, is prioritizing innovation in minimally invasive deep-sea mining technologies while calling for fair access, responsible sourcing, and strong environmental protections. For India, the implications are clear: diversify and secure supply chains; invest in recycling, refining partnerships, and advanced geological surveys; and pursue strategic international collaborations for upstream processing.

References

1. Gupta, C. (2025, October 30). Critical Minerals explained: why they matter for geopolitics, clean energy & tech. The Belfer Center for Science and International Affairs. Retrieved November 18, 2025, from <https://www.belfercenter.org/explainer-what-are-critical-minerals>
2. Arctic Frontiers. (2025, August 29). Accessing critical minerals for accelerating the green transition - ArcticFrontiers.com. Retrieved November 18, 2025, from <https://arcticfrontiers.com/abroad/kiruna/>
3. Discovery Alert. (2025, November 17). Greenland Magnesium extraction: Arctic Mining Revolution. Retrieved November 18, 2025, from <https://discoveryalert.com.au/arctic-critical-mineral-revolution-european-independence-2025/>
4. Thorsson, E. (2024, October 4). Arctic could be vital supplier of critical minerals for global green transition. ArcticToday. <https://www.arctictoday.com/new-report-arctic-could-be-vital-supplier-of-critical-minerals-for-global-green-transition/>
5. Norwegian Offshore Directorate. (2024). Entering into cooperation with Greenland and Denmark on seabed minerals. <https://www.sodir.no/en/whats-new/news/general-news/2024/entering-into-cooperation-with-greenland-and-denmark-on-seabed-minerals/>
6. Amaroq Ltd. (2025, July 21). Commencement of 2025 exploration campaign. <https://www.greenlandherald.com/article/832585506-commencement-of-2025-exploration-campaign>
7. Amaroq Minerals. (2025, November 4). Discovery of rare earth elements in South Greenland. <https://www.globenewswire.com/news-release/2025/11/04/3179980/0/en/Discovery-of-Rare-Earth-Elements-in-South-Greenland-in-surface-grab-samples.html>
8. Rosgeo. (2024). Rosgeo conducts geophysical surveys in Antarctica's shelf seas: Identifying sedimentary basins and hydrocarbon potential. <https://rusgeology.ru/en/press/news/rosgeologiya-vypolnila-issledovaniya-geologicheskogo-stroeniya-i-neftegazovogo-potentsiala-shelfa-an/>
9. Offshore Magazine. (2025, May 10). Russia reportedly finds vast oil and gas reserves in British Antarctic territory. <https://www.offshore-mag.com/geosciences/article/55039736/russia-reportedly-finds-vast-oil-and-gas-reserves-in-british-antarctic-territory>
10. Science Times. (2025, May 21). Russia claims massive Antarctic oil reserves. <https://www.sciencetimes.com/articles/50278/20240521/russia-oil-reserve-gas-reserve-antarctica.htm>

Oil Exploration as Resources

The Arctic remains a politically sensitive frontier for hydrocarbon exploration, where climate and conservation pressures increasingly collide with strategic interests of several states. In contrast, the Southern Ocean is a governance-sensitive zone rather than an extraction frontier - mineral resource activities, including hydrocarbon exploration, are currently prohibited under the Madrid Protocol. While CCAMLR has flagged long-term concerns about potential Antarctic oil activity, global reporting in 2024–2025 shows a mixed picture in the Arctic such as tanker flows have declined from earlier expectations, yet repair and maintenance often in EU shipyards has kept parts of Russia's LNG fleet operational despite sanctions. At the same time, Russia,



CSIR-NORTH EAST INSTITUTE OF SCIENCE AND TECHNOLOGY

JORHAT, ASSAM



A constituent multidisciplinary research laboratory under CSIR, dedicating for Industrial development and societal upliftment of NER India by nurturing basic and applied research for developing technologies with sustainable development goals to improve quality of life in the region.

64 celebrating
years of
glorious
existence

Some Major Technology Recipients & Collaborators

- M/s Kudos Laboratories, New Delhi
- M/s Acinom Aromatics Pvt.Ltd, Guwahati
- M/s Mphinite Solutions Pvt.Ltd, Bangalore
- Sigma Aldrich Co., LLC, USA
- Eco Friendly Foundation, Gultekadi, Pune
- Oil India Limited, Duliajan, Assam
- Numaligarh Refinery Ltd, Golaghat, Assam
- Assam Petrochemical Limited, Namrup, Assam
- Arunachal Pradesh State Council for S & T

Major Testing and Analytical Facilities Available

- 500 MHz NMR, GC-MS, LCMS, FTIR, CHN & Sulphur Analyser
- Confocal Microscope
- Ion Chromatography System
- Fluorescence Activated Cell Sorter & Flow Cytometre
- Universal Testing Machine
- High Pressure Reactor
- Ultra High Performance Liquid Chromatography
- X-Ray Photoelectron Spectrometer
- High Resolution Mass Spectrometer (HRMS)
- Thermal Analyser for DTA, TGA & DSC
- Atomic Emission Spectrophotometer (ICP-AES)
- High Resolution Transmission Electron Microscope
- Scanning Electron Microscope
- Isotope Ratio Mass Spectrometer (IRMS)
- Nuclear Magnetic Resonance (NMR)

More than 70 ongoing research projects

CSIR-Aroma Mission, CSIR-Floriculture Mission, Millets Mission, Agro-mission, API Mission, CSIR-Safe and Sustainable Climate Resilient Building for India etc.

PhD programmes for Research Scholars

- Skill Development under CSIR Interagted Skill Facilities
- Testing and Analytical Services
- CSIR-Jigyasa: Student-Scientists Connect Programme

NEIST making Impact in NER through

- Basic, exploratory, and applied research
- Survey, exploration & utilization of medicinal, aromatic and spice plants, social microbes, minerals etc.
- Seismicity Studies
- MSME Scale Technologies



More than 130 Technologies Developed

www.neist.res.in

(0376) 2370086

ps@neist.res.in

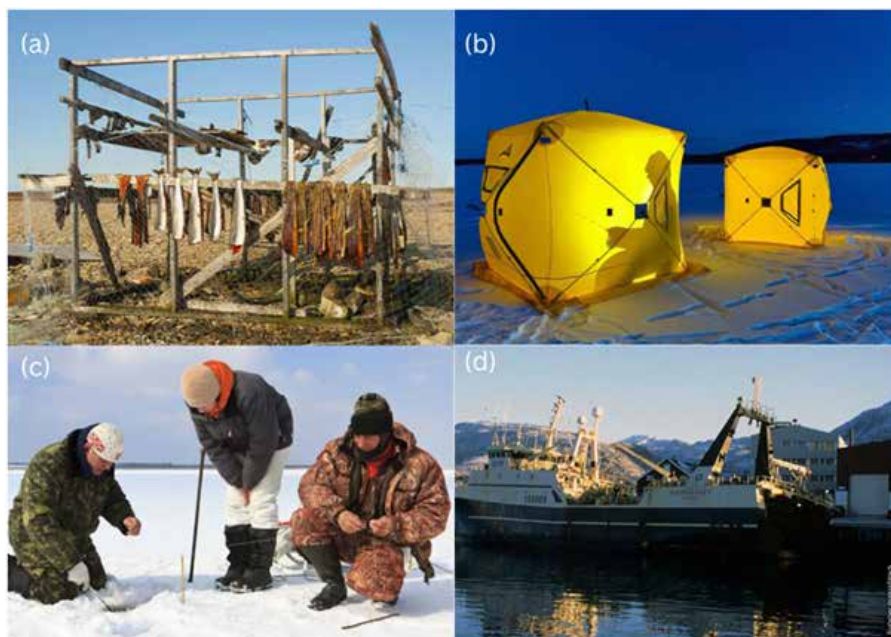


Fig description & source: (a) Fish drying on an Arctic beach; (b) Ice fishing in tents at night; (c) Ice fishing; (d) Commercial Fishing, Large industrial trawler, Nuuk, Greenland. (Discovering the Arctic, n.d.)

Norway, and the United States have accelerated drilling initiatives in the Barents, Kara (Russia's Pivot to Asia, 2025), and Chukchi seas, even as environmental opposition and stricter EU- and investor-driven climate policies slow or challenge specific projects. These dynamics continue to shape the economics and geopolitics of new Arctic hydrocarbon ventures.

References

1. Russia's Pivot to Asia. (2025, October 20). China-Russia Northern Sea route traffic doubled during 2025. Retrieved November 18, 2025, from <https://russiaspivottoasia.com/china-russia-northern-sea-route-traffic-doubled-during-2025/>
2. Staalesen, A. (2025, November 13). "Shadow ships" take pole position on Northern Sea Route. Thebarentsobserver. <https://www.thebarentsobserver.com/news/shadow-ships-take-pole-position-on-northern-sea-route/440360>
3. Gibson, J. (2025, November 2). Australia criticises "lost opportunity" for strengthened Antarctic conservation. ABC News. Retrieved November 18, 2025, from <https://www.abc.net.au/news/2025-11-01/antarctic-conservation-krill-fishing-ccamlr/105958414>
4. Kubny, H., et al. (2023, April 19). Oil tanker to China via Northeast Passage. Polar Journal. <https://polarjournal.net/oil-tanker-to-china-via-northeast-passage/>

Northern Sea Route

The governance challenge around oceans is based on the ambiguity and conflicting nature of international laws and treaties that govern the part of oceans beyond national jurisdiction. Strategically and economically important global maritime routes such as the Suez/Strait of Malacca and the NSR are realigning in the backdrop of climate change. UNCLOS, being an important legal international instrument, can address



National Centre for Medium Range Weather Forecasting Ministry of Earth Sciences, Govt. of India



The National Centre for Medium Range Weather Forecasting (NCMRWF), under the Ministry of Earth Sciences is a Centre of Excellence for weather and climate modelling. Its primary goal is to enhance the accuracy and reliability of Numerical Weather Prediction (NWP) systems for India through continuous research, technological advancement, and innovation.

Vision and Mandate

NCMRWF aims to provide accurate medium-range weather forecasts through advancements in numerical modelling, data assimilation, and Earth-system science.

The mandate includes improving forecast skill over India and neighboring regions, strengthening observational networks, and supporting national agencies with reliable weather and climate information.



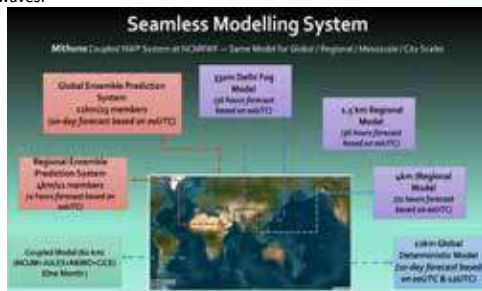
Core Capabilities

The centre's core strengths span high-resolution modelling, satellite data assimilation, supercomputing, forecast verification, and sector-specific services. NCMRWF integrates coupled atmosphere-land-ocean systems, AI/ML techniques, and advanced observational processing to ensure robust and reliable predictions.



Seamless Modelling Framework

A unified coupled modelling suite enables seamless prediction across global, regional, and city-scale domains. The system supports medium-range forecasts, subseasonal outlooks, ocean-atmosphere coupling, and hazard-specific modelling for extreme events such as cyclones, heavy rainfall, and heatwaves.



Integrated Remote Sensing & Coupled Data Assimilation



NCMRWF ingests advanced observations—Satellites, buoy networks, and other modern platforms—into a hybrid variational-Kalman filter coupled data assimilation system (atmosphere, ocean, land, and sea-ice).

A hybrid assimilation framework—combining variational and Kalman filter methods—ingests multi-sphere observations (atmosphere, ocean, land, sea-ice).



Forecast Products and Applications

NCMRWF provides a suite of operational products supporting agriculture, aviation, renewable energy, hydrology, disaster management, and urban forecasting.

Outputs include high-resolution gridded forecasts, severe weather guidance, probabilistic products, and city-scale prediction services.



High-Performance Computing Growth at NCMRWF

Advances in HPC—from megaflop to teraflop and now petaflop systems—have enabled major upgrades in NWP resolution and complexity.



BIMSTEC Centre for Weather and Climate



The centre also provides a wide range of NWP products and guidance to BIMSTEC countries.

NCMRWF serves as the BIMSTEC Centre for Weather and Climate (BCWC), supporting member nations through weather and climate modelling, data assimilation, application development, and capacity building.

some of the maritime security challenges. However, the issues related to energy exploration, trade and transportation require a more focused attention. The NSR is likely to become commercially viable in the coming years, and India's involvement needs to be enhanced to help develop multi-stakeholder collaborations with several nations in the region. MEA, MoPSW and MoPN need to review and take action. The Russian plan to establish a year-round navigation system in the NSR by the 2030s could greatly benefit exploration efforts in the Arctic region leading to a significant increase in marine traffic, which would require the development of infrastructure such as ports, railways, roads, and pipelines. Areas such as Murmansk, Novaya Zemlya, Taymyr Peninsula, and Yamal Peninsula in Russia are likely to see significant development in this regard. The development of this route could also have broader strategic implications, as it would provide a shorter and more economical alternative to the existing Indian and Pacific Ocean marine traffic routes. The legal framework of the UNCLOS is also important for the Strait of Malacca and the NSR, two of the most important routes that relate to the fate of the Indo-Pacific region, from the perspective of maritime security, especially bearing in mind the consequences of climate change. Various debates have emerged regarding the dynamic relationship between both the routes and its importance for the Indo-Pacific region, and by extension, for India.

Climate change driven sea-ice loss has intensified global focus on the Northern Sea Route, which can potentially halve transit times between Europe and Asia and reshape trade architecture. Seasonal navigability has improved as states expand meteorological stations, ice-class fleets, and port infrastructure along the NSR. Yet traffic growth remains uneven despite Russia promoting "record highs" in 2025, year-to-date figures indicate declines relative to 2024, affected by sanctions, geopolitical misalignment, opaque "shadow ship" (Staalesen, 2025) activity, and insurance and logistics constraints. For India, the NSR offers long-term strategic value reduced freight times, diversified sea lanes, and stronger Arctic partnerships but current risks mean it should adopt a calibrated approach centred on pilot voyages, research logistics, and bilateral mechanisms with Russia rather than treating the NSR as an immediate alternative to Suez. At the same time, increased Arctic shipping raises serious environmental risks black carbon from vessels accelerates ice melt, oil-spill response capacity remains limited, and fragile ecosystems face rising stress. Regulatory debates at the Arctic Council and IMO showcase diverging priorities but growing calls for greener fuels, low-impact routing, and strengthened search-and-rescue systems. The global critical minerals race is accelerating, from Arctic mining initiatives to the U.S. or EU reshoring efforts. As demand for rare earths, battery metals, and high-purity industrial minerals grows, Indigenous rights concerns and environmental impacts are intensifying. Expect more export controls, tighter sourcing standards, and an expansion of "clean-supply" financing tools.

Recent global climate change issues have impacted the Malacca Strait region, as shown by increased sea surface temperature and level trends. In terms of sea level change in the Malacca Strait, many reports demonstrating the increasing trend in sea level have been established, whereby based on the latest records, the rate of sea level change has reached 0.46 cm/year (Wisha, Wijaya, & Hisaki, 2023). There has been speculation that the NSR can dilute the importance of the Strait of Malacca (Sharma, 2023). The Strait connects all the emerging economies of the world and China's reliance on crude oil is being fulfilled via the Malacca Strait. Meanwhile, China's control over Africa also makes the Strait crucial for the country. The number of ships sailing via Malacca and the NSR vary widely. Less than 100 vessels pass through NSR within a year, while about 80,000 vessels pass through the Strait every

year (Ibid.). The global bulk carriers of oil and gas as well as coal mainly pass through the Strait. Fossil fuel is not likely to disappear from usage anytime soon and hence, the energy transition to clean energy is also distant, which makes the Malacca even more critical to the world energy map. Moreover, there are infrastructural disadvantages of the NSR. For instance, ice-breaker vessels are necessary to navigate through the NSR, however, such vessels are expensive and limited (Ibid.). The geopolitical tension between Russia and the West is also likely to create an obstacle for the viability of the NSR in the future. The Ukraine war has elevated tensions between Russia and the West (Ibid.).

There may be efforts in the future where more vessels will try to access the NSR for cargo transportation because of its shorter route. Yet, the NSR will not be able to reduce the paramount importance of Malacca, from both the economic and security perspective. After the then USSR President M Gorbachev declared NSR open for the first time, non Russian ships were able to access these waters, although they had to be, till date, escorted (Chattopadhyay, 2023). In theory, NSR reduces 40 per cent of the sailing distance. Yet, the route is only navigable for some parts of the year, and commercially navigable for only 1.5 months annually (Ibid.). This is one of the biggest challenges of the NSR and it also serves as a strong argument against NSR becoming an alternative to the Strait of Malacca in the near future (Ibid.). The problem of licensing to navigate via the route is also a challenge for the NSR, along with the tonnage of commercial vessel containers and ships. Only small ships can navigate through the NSR which reduces their efficiency and increases the cost due to the prolonged time due navigating through variable sea ice extent (Ibid.). Looking from the Indian point of view, NSR is one of the primary areas for its economy and diplomacy.

NSR is believed to be ice-free by 2050, and it will bring both opportunities and challenges. The INSTC is an important proposition for India if NSR becomes viable for navigation (Pradhan, 2023). Moreover, NSR can open opportunities for exploration of the Arctic energy resources. From Saint Petersburg, to the Kara and the Barents Sea, and the Mormons are some of the important regions where energy resource exploration is possible. Russia is the biggest claimant into the area and it calls the Mormons port the NSR Western gateway (Baveja, 2023). Therefore, NSR has strategic importance, even if it is not commercially viable as of now. Other regions that the NSR can open up for energy exploration are the Beaufort Sea (North Slope, Alaska and Mackenzie Delta, Canada), Northwest part of the Russian Arctic (Barents Sea and West-Siberia), and the Canadian Arctic Archipelago (Nunavut) (Ibid.). It is estimated that the recoverable reserves in the Arctic amount to 150 billion barrels of oil and natural gas liquids and 1700 trillion cubic feet of natural gas. These resources account for about 22 per cent of the undiscovered, technically recoverable resources in the world. About 84 per cent of the estimated resources are expected to occur offshore. Receding sea ice cover and permafrost thaw will influence accessibility to mineral and energy in the Arctic and opening of the NSR in the future (Ibid.). The cargo load in 2019 carried via the Yokohama, Japan to Rotterdam, Netherlands route was 26 million tonnes. Therefore, there are future prospects for energy transportation and exploration via the NSR, even if it cannot replace the Strait of Malacca in terms of strategic and economic significance (Chattopadhyay, 2023).

India and Norway are conducting a feasibility study on operationalizing the Northern Sea Route (NSR). The Ministry of Ports, Shipping & Waterways (MoPSW) of India is involved: in their "International Cooperation" page, they mention the "9th India-

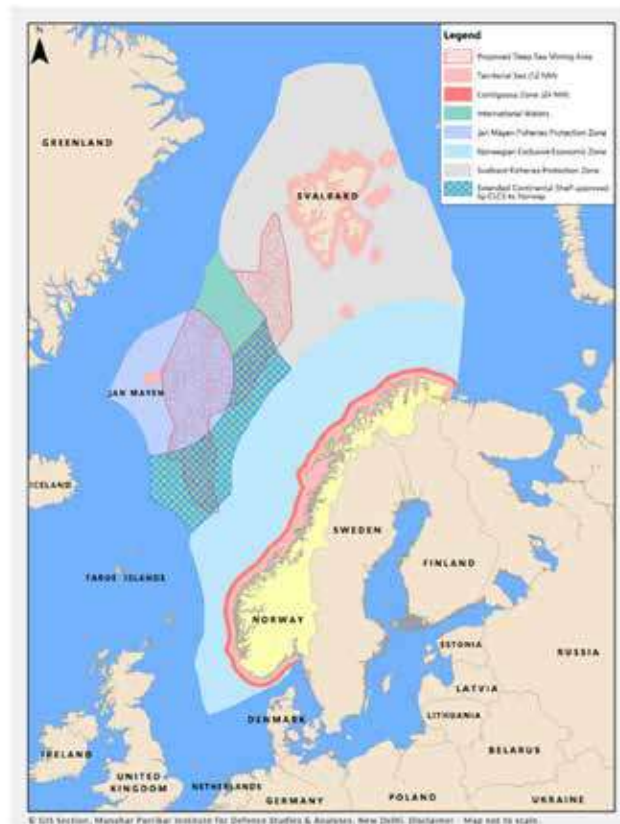


Fig description & source: Map showing deep seabed mining activity area approved by Norwegian parliament in the Arctic Fourth, most of the Arctic states have made their formal submissions before Commission on the Limits of Continental Shelf (CLCS) for claiming extended continental shelves in the Arctic. Some of these claims have been granted by CLCS to the respective states while the decision on others remains pending. Despite CLCS decision making, there exists challenges with regard to overlapping claims of states of their extended continental shelf in the Arctic. Norway's call for exploiting REEs in its extended continental shelf would make the competition between these states over their extended continental shelf claims fiercer. Further, any new discoveries of REEs in these overlapping areas would leave little scope for cooperation between states and would rather result in competition among states to dominate these resources.

Norway Joint Working Group (JWG)" meeting (May 2024), where joint feasibility of the NSR was discussed. This includes research on ice-class vessel design, navigation safety, and sustainable shipping technologies, positioning India to engage with new maritime opportunities emerging in a changing Arctic (Ministry of Ports, Shipping and Waterways, n.d.).

References

1. Staalesen, A. (2025, November 13). "Shadow ships" take pole position on Northern Sea Route. Thebarentsobserver. Retrieved November 19, 2025, from <https://www.thebarentsobserver.com/news/shadow-ships-take-pole-position-on-northern-sea-route/440360>
2. Wong, E. (2025, November 15). The Arctic this Week Take five: Week of 10 November, 2025. The Arctic Institute - Center for Circumpolar Security Studies. Retrieved November 19, 2025, from <https://www.thearcticinstitute.org/arctic-week-take-five-week-10-november-2025/>
3. Ministry of Ports, Shipping and Waterways. (n.d.). International Cooperation | Ministry of Ports, Shipping and Waterways. Retrieved November 19, 2025, from <https://www.shipmin.gov.in/division/international-cooperation>
4. Wisha, U. J., Wijaya, Y. J., & Hisaki, Y. (2023). Sea level variability in the equatorial Malacca Strait: The influence of climatic-oceanographic factors and its implications for tidal properties in the estuarine zone. *Climate*, 11(3), 70. <https://doi.org/10.3390/cli11030070>
5. Sharma, B.K. (2023). Discussion Panel 2 of the 7th Conference of Science and Geopolitics of Arctic and Antarctic. Retrieved November 19, 2025, from <https://www.saghaa.org/SaGAASchedule.pdf>
6. Chattopadhyay, S. (2023). Discussion Panel 2, the myth of the Northern Sea Route offsetting the Malacca. Retrieved November 19, 2025, from https://www.saghaa.org/assets_new/files/schedule_day2.pdf
7. Pradhan, RP. (2023). Arctic Melting Ice: Examining NSR-Indo-Pacific Circular Transport Corridor Prospect. Retrieved November 19, 2025, from https://www.saghaa.org/assets_new/files/schedule_day2.pdf
8. Baveja, S. (2023). Exploring oil opportunities in the Arctic. Retrieved November 19, 2025, from <https://www.saghaa.org/speaker.php?name=sanjay-baveja>
9. Humpert, M., et al. (2011, September 15). The future of the Northern Sea Route: A "Golden Waterway" or a niche trade route. The Arctic Institute from <https://www.thearcticinstitute.org/future-northern-sea-route-golden-waterway-niche/>

Himalayan glacier loss

The Himalaya or Hindu Kush Himalaya region, often referred to as the 'Third Pole', is home to the world's largest mountain ranges and is facing significant challenges due to climate change. As the climate warms, it diminishes the seasonal meltwater from glaciers and snowpacks, which has historically sustained local communities and farms. This poses a severe risk to water security, especially during drought years. It could lead to increased competition for water, forced migration and even conflict between water rivals. The loss of snow and ice in these mountains is directly affecting nearly a billion people who rely on this water resource for agriculture, hydropower and their day-to-day water needs (World Economic Forum, 2024). Rapid warming, atmospheric pollution, and rising emissions are accelerating glacier retreat, permafrost degradation, and changing hydrological cycles. These changes increase hazard risks like Glacial Lake Outburst Floods, landslides and threaten downstream water security, agriculture, hydropower, and livelihoods. Importantly, the Himalaya is not isolated as it is atmospheric such as Aerosols. Aerosols are small particles suspended in the atmosphere. They are often not or barely visible to the human eye, yet their impact on climate, weather, health, and ecology are significant. As well as hydrological, and cryospheric processes are deeply connected to global climate systems, making it a vital node for international research and cooperation.



Fig description & source: The Russian nuclear icebreakers “Yamal”, “Arktika” and “50 Let Pobedy” are ready to escort oil tankers on the Northern Sea Route. (Kubny et al., 2023)

According to a rough estimate, the water that flows from the Third Pole directly supports 120 million people through irrigation systems. About 1.3 billion (one-fifth of the world’s population) people indirectly benefit through river basins in China, India, Nepal, Pakistan and Afghanistan. Arctic and Antarctic, the Third Pole is also sensitive to global warming. According to Qin Xiang, one of the first scientists to gather data from this region, the rate at which the glaciers are melting has almost doubled since 2005. His research reveals that over 509 small glaciers disappeared in the past 50 years and even the biggest ones are shrinking rapidly. According to Xiang, 226 glaciers in China’s Tiger Valley region have lost 27 sq km of ice in the past 48 years. In the wider area of the Qilian Mountains home to 2,684 glaciers the impact has been catastrophic (DTE, 2016).

Glaciers in the HKH could lose up to 80% of their current volume by the end of the century, on current emissions trajectories. Across the Hindu Kush Himalaya (HKH), glaciers melted 65% faster between 2011 and 2020 compared to the previous decade, placing nearly two billion people in South and Southeast Asia at heightened risk as their primary water towers destabilize. (2023, November 27). Scientific projections warn that if global temperatures rise beyond 1.5°C–2°C, the region could lose up to 50% of its glacier volume by 2100, with losses reaching 75% in some basins under >3°C warming scenarios. The drivers are intensifying: new research shows that black carbon deposition has increased surface snow temperatures by over 4°C in two decades, accelerating melt rates, while NCPOR observations recorded a more than 50% decline in snow depth within a single year on a western Himalayan glacier evidence of rapidly shifting accumulation dynamics. Iconic glaciers like Nepal’s Yala Glacier, already reduced by ~36% in area and retreated 680 m since the 1970s, are projected to vanish entirely by the 2040s. These changes heighten the risk of glacial lake outburst floods (GLOFs), landslides, and cascading hydrological hazards.

References

1. Sharma, K. (2025, February 12). Addressing the impacts of climate and environmental risks on water, and air pollution - ICIMOD. ICIMOD - International Centre for Integrated Mountain Development. Retrieved November 15, 2025, from <https://www.icimod.org/climate-environment-risks/>
2. Manish. (2023, November 27). Landmark report on impacts of disappearing snow and ice in the Hindu Kush Himalaya – current emissions path. ICIMOD - International Centre for Integrated Mountain Development. Retrieved November 15, 2025, from <https://www.icimod.org/press-release/landmark-report-on-impacts-of-disappearing-snow-and-ice-in-the-hindu-kush-himalaya-current-emissions-path-threatens-two-billion-people-and-is-accelerating-species-extinction/>
3. Pandey, K. (2025, May 31). Glaciers melting faster as black carbon heats Himalayas by 4°C in 2 decades: study. ABP Live. <https://news.abplive.com/science/himalaya-glaciers-melting-fast-black-carbon-global-warming-climate-change-1776324>
4. Ray, A. (2025, March 29). Nepal's glaciers are retreating faster than ever. The Kathmandu Post. <https://kathmandupost.com/climate-environment/2025/03/29/nepal-s-glaciers-are-retreating-faster-than-ever>
5. The Economic Times. (2023, June 20). Himalayan glaciers risk losing 75% of their volume by 2100 due to global warming. The Economic Times. <https://economictimes.indiatimes.com/news/new-updates/himalayan-glaciers-risk-losing-75-of-their-volume-by-2100-due-to-global-warming/articleshow/101130703.cms>
6. Sequeira, N. (2025, January 11). Over 50% reduction in snow depth on Himalayan glacier raises risk of floods, shows study by Goa-based NCPOR. The Times of India. <https://timesofindia.indiatimes.com/city/goa/over-50-reduction-in-snow-depth-on-himalayan-glacier-raises-risk-of-floods-shows-study-by-go-a-based-ncpor/articleshow/117157903.cms>
7. Talwar, G. (2025, January 17). Nepal's Yala glacier shrinking, may vanish by 2040s: Scientists. The Times of India. <https://timesofindia.indiatimes.com/city/dehradun/nepals-yala-glacier-predicted-to-vanish-by-2040s/articleshow/117337941.cms>
8. World Economic Forum. (2024, December 13). Why you should care about the Third Pole and its crucial role as a global water resource. Retrieved November 17, 2025, from <https://www.weforum.org/stories/2024/12/care-the-third-pole-crucial-role-global-water-resource/>
9. Goddard Earth Sciences Division Project. (n.d.). Aerosols and their importance. NASA, Earth Sciences. Retrieved November 17, 2025, from <https://earth.gsfc.nasa.gov/climate/data/deep-blue/aerosols#:~:text=What%20are%20aerosols?,ash%20are%20all%20primary%20aerosols.>
10. DTE. (2016, August 19). 509 glaciers in 'Third Pole' disappeared in last 50 years. Down to Earth. Retrieved November 17, 2025, from <https://www.downtoearth.org.in/climate-change/509-small-glaciers-in-third-pole-disappeared-in-last-50-years-55345>
11. Asharq Al-Awsat. (2023, June 20). Report: Himalayan glaciers on track to lose up to 75% of ice by 2100. English Aawsat. https://english.aawsat.com/varieties/4391566-report-himalayan-glaciers-track-lose-75-ice-2100%C2%A0?_wrapper_format=html&page=3

Himalayan Water Security and Transboundary Treaties

Accelerating glacier melt and permafrost degradation across the Himalaya are driving a phenomenon known as “hazard amplification,” where glacial lake outburst floods (GLOFs), landslides, debris flows, and extreme weather events increasingly occur as cascading, interconnected disasters. These risks are further compounded by transboundary atmospheric pollutants, especially black carbon which not only hasten cryospheric melt but also disrupt monsoon circulation and precipitation patterns, directly linking Himalayan glacier health to regional air quality. Climate-induced environmental stress is already displacing vulnerable mountain communities,

exemplified by the relocation of Samjung village in Nepal's Upper Mustang due to water scarcity and flooding.

Despite mounting threats, many high-risk glacial lakes remain under-monitored, and the region still lacks comprehensive, integrated early warning systems (EWS) capable of linking cryosphere dynamics with downstream hydrological and hazard risks. Given the Himalaya's fragmented topography and shared river basins across India, Nepal, Bhutan, China, and Pakistan, the establishment of robust,

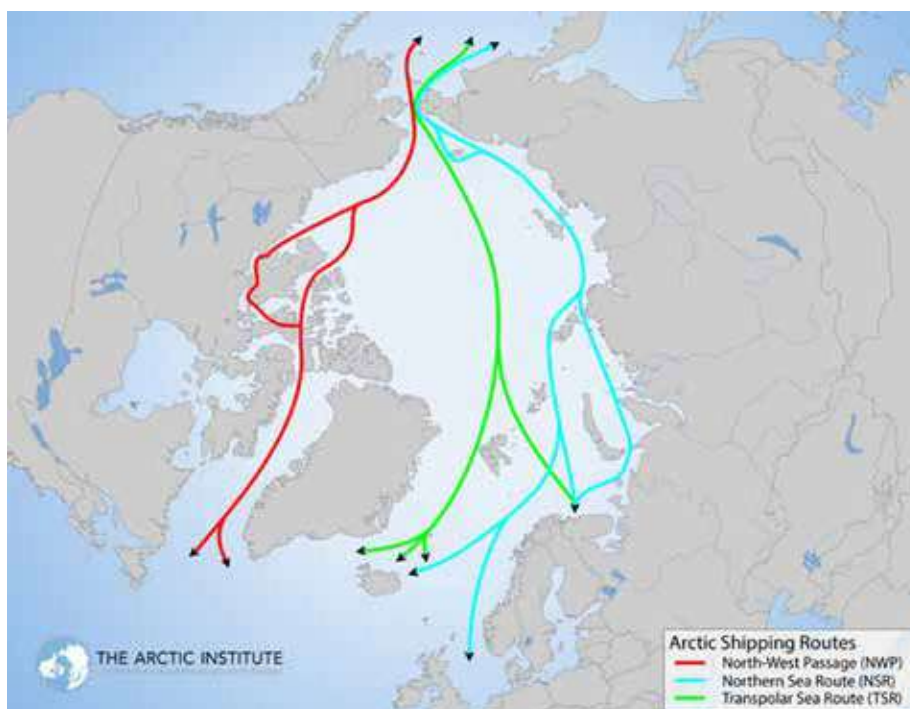


Fig description & source: Map showing the Northern Sea Route, the Northwest Passage and the Transpolar Sea Route. The Arctic Institute. Humpert, M., et al. (2011, September 15).

transboundary EWS is critical.

This urgency is particularly evident in the Indus River Basin, one of the world's most climate-sensitive and geopolitically complex transboundary watersheds. The Indus river system, originating in the Himalaya, is governed by the 1960 Indus Waters Treaty (IWT) between India and Pakistan, brokered by the World Bank. Under this treaty, India controls the eastern rivers (Ravi, Beas, Sutlej), while Pakistan controls the western ones (Indus, Jhelum, Chenab). In April 2025, India announced it would hold the IWT "in abeyance" following a deadly terror attack in Pahalgam, citing Pakistan's support for cross-border terrorism as a core reason (India Today, 2025). The Cabinet Committee on Security (CCS) formalized this decision, stating that the treaty would remain suspended until Pakistan "credibly and irrevocably abjures" support for terrorism.

However, on 27 June 2025, a Court of Arbitration established under the IWT ruled that unilateral "abeyance" or suspension is not permissible, and the treaty

continues in force until mutually terminated. India, however, strongly rejected this ruling, claiming that the very constitution of the arbitral body is in breach of the treaty. These tensions underscore how hydropolitics can disrupt or weaken long-established cooperative mechanisms. A deeper challenge is that climate change is altering Himalayan hydrology faster than existing treaties or bilateral institutions can adapt. Designed in the 1950s, the IWT did not account for glacier retreat, permafrost thaw, shifting river seasonality, or cryosphere-driven flood pulses. There is also a strong Indian view that provisions for climate change and reduced contributions from glaciers were not contemplated at the time of framing the IWT, and that the entire pattern of the hydrological system has drastically changed since then.

Another pressing transboundary water infrastructure issue is the Farakka Barrage on the Ganges, which significantly affects downstream hydrology and livelihoods in Bangladesh (Kawser et al., 2016; Mia et al., 2014; Observer BD, 2025). Critics argue that, along with the Indus Water Treaty, the barrage places India in an uncomfortable position — amplifying calls for a re-examination of these arrangements in light of evolving water realities. Under the 1996 Ganga Water Treaty, India and Bangladesh agreed on a water-sharing formula based on 10-day periods during the dry season (1 January to 31 May), with allocations depending on the flow at Farakka. However, India is now seeking to amend the treaty to secure an additional 30,000–35,000 cusecs during the lean season, citing growing demands for irrigation, port maintenance, and power. Critics in Bangladesh warn that the diversion of water via the barrage is already causing acute scarcity: impacting up to 60 million people through reduced river flows, groundwater depletion, and soil salinity in regions such as Barendra, Khulna, and Satkhira. Meanwhile, the Indian Ministry of External Affairs maintains that data-sharing continues through the Joint River Commission and denies that barrage operations alone are responsible for flooding in Bangladesh.

References

1. HHN. (n.d.). Himalayan Glacier Melt and Rising Mountaineering Risks Claim Lives Amid Climate Change. Himalayan News Network. <https://himalayannewsnetwork.com/earth/himalayan-glacier-melt-and-rising-mountaineering-risks-claim-lives-amid-climate-change/>
2. Ghosal, A., & Shrestha, N. (2025, July 1). An ancient village in the Himalayas ran out of water. Then, it moved and started over. AP News. Retrieved November 17, 2025, from <https://apnews.com/article/nepal-himalaya-climate-water-a68c96a65463b677f30af99737b7977a>
3. Climate Action Network South Asia. (2024). Adaptation in the Himalayas. Retrieved November 15, 2025, from <https://cansouthasia.net/adaptation-in-the-himalayas/>
4. India Today. (2025, May 13). Indus treaty to remain paused until Pak abjures support for terrorism: India. India Today. Retrieved November 20, 2025, from <https://www.indiatoday.in/india/story/indus-waters-treaty-suspended-pakistan-abjures-support-for-terrorism-india-2724203-2025-05-13>
5. Chakraborty, P. (2025, May 19). India to not consider Pak's request to reinstate Indus Waters Treaty: Sources. India Today. <https://www.indiatoday.in/india/story/india-pakistan-request-indus-waters-treaty-government-sources-amend-agreement-2727294-2025-05-19>
6. Library of Congress. (2025, August 13). India – Pakistan: Court confirms competence to arbitrate Indus Waters Treaty case. Global Legal Monitor. <https://www.loc.gov/item/>

- global-legal-monitor/2025-08-13/india-pakistan-court-confirms-competence-to-arbitrate-indus-waters-treaty-case/
7. NDTV. (2024, August 27). Explained: The Farakka Barrage agreement amid 'fake news' on Bangladesh floods. <https://www.ndtv.com/india-news/explained-the-farakka-barrage-agreement-amid-fake-news-on-bangladesh-floods-6427801>
8. Bangladesh Post. (2025). Farakka Barrage affects 60 m people in Bangladesh. <https://bangladeshpost.net/posts/farakka-barrage-affects-60m-people-in-bangladesh-152147>
9. The Economic Times. (2025, June 14). India now looking to amend Ganges treaty with Bangladesh. https://economictimes.indiatimes.com/news/india/india-now-looking-to-amend-ganges-treaty-with-bangladesh/articleshow/122097774.cms?UTM_Campaign=RSS_Feed&UTM_Medium=Referral&UTM_Source=Google_Newsstand&from=mdr&utm
10. Asian Development Bank. (1996). Ganges water-sharing treaty between the Government of the Republic of India and the Government of the People's Republic of Bangladesh. <https://lpr.adb.org/sites/default/files/resource/1610/ganges-water-sharing-treaty-1996.pdf>
11. Shrestha, U. B., & Aryal, S. (2022). Challenges in understanding the variability of the cryosphere in the Himalaya and its impact on regional water resources. *Water*, 14(3), 1–17. <https://doi.org/10.3390/w14030319>
12. The Observer. (2025, May 14). Farakka Barrage causes ecocide. The Observer (Bangladesh). <https://www.observerbd.com/news/524314>

Biodiversity loss in the Himalaya

The Himalaya is a global biodiversity hotspot known for its diverse ecosystems, from subtropical forests to alpine meadows, which are home to thousands of plants and animal species, many of which are endemic. This region is under threat from habitat loss due to factors like agriculture, climate change and urbanization.

The Himalayan ecosystem is one of the world's richest biodiversity hotspots and is undergoing rapid ecological transformation as rising temperatures push snowlines and vegetation zones uphill. These shifts endanger specialized alpine species such as the snow leopard, red panda, Himalayan musk deer, and numerous high-altitude medicinal and aromatic plants that thrive within narrow altitudinal bands. The shrinking habitat of these bio-resources threatens not only biodiversity but also the traditional knowledge systems, cultural practices, and livelihoods of mountain communities that depend on them. ICIMOD's HI-WISE report warns that the accelerating loss of ice and snow is already driving species range shifts, ecosystem degradation, and heightened extinction risks. Cryosphere changes are also reshaping high-altitude agriculture: communities are increasingly abandoning traditional subsistence crops like barley in favor of cash crops, a trend that may undermine long-term food security, nutrition, and local health.

Amid these challenges, new opportunities are emerging. Technology-driven biodiversity monitoring such as AI and CNN based mobile applications used to identify Himalayan herb species offers powerful tools for conservation and documentation of indigenous botanical knowledge. At the same time, holistic ecosystem-based adaptation (EBA) strategies are becoming essential. These

approaches integrate scientific conservation methods with indigenous knowledge, emphasizing habitat protection, slope and watershed restoration using native species, bioshield development, and community-led stewardship of fragile mountain landscapes. Given that ecological degradation, water stress, and soil erosion transcend national boundaries, inclusive models of cross-border collaboration are critical. Regional cooperation on biodiversity conservation, equitable benefit-sharing, and biotechnology innovation will be vital to sustaining the Himalayan ecosystem and securing the well-being of its communities in a rapidly changing climate.

References

1. Mowbray, S., & Scherer, G. (2025, March 21). With climate change, cryosphere melt scales up as a threat to planetary health. Mongabay. Retrieved November 15, 2025, from <https://news.mongabay.com/2025/03/with-climate-change-cryosphere-melt-scales-up-as-a-threat-to-planetary-health/>
2. Thapa, P., Sharma, M., Nyachhyon, J., & Pandeya, Y. R. (2025, May 4). Local Herb Identification using Transfer Learning: a CNN-Powered mobile application for Nepalese flora. arXiv.org. Retrieved November 15, 2025, from <https://arxiv.org/abs/2505.02147>
3. Tomar, D. S. (2025, February 24). Climate change in the Himalayan region: susceptible impacts on environment and human settlements. Frontiers. Retrieved November 15, 2025, from <https://www.frontiersin.org/journals/environmental-science/articles/10.3389/fenvs.2025.1550843/full>
4. GRID-Arendal. (n.d.). The Hindu Kush Himalayan region (Resource #12806). <https://www.grida.no/resources/12806>

Polar Industries

The Arctic is warming far above the global average, triggering sea-ice loss, permafrost thaw, and coastal erosion that expose new risks even as they open commercially strategic opportunities including shipping, resource access, and high-latitude fibre/communication infrastructure. Advanced materials such as high-efficiency semiconductors (Kusters et al., 2025), nanomaterials, superconductors, and quantum materials are increasingly treated as strategic assets by OECD and industry reports. They enable low carbon, off grid Arctic operations, lightweight, low-loss power transmission, high efficiency sensors for environmental monitoring, rugged electronics for extreme cold. 2025 saw the lowest Arctic winter sea-ice maximum ever recorded, amplifying feedbacks, coastal erosion, and infrastructure risk. Meanwhile, security competition is rising as shrinking ice increases geostrategic interest in Arctic routes.

The Antarctic is undergoing regionally uneven change with West Antarctica showing strong signals of destabilization, ice-shelf weakening, and long-term WAIS (Hillenbrand et al., 2017) vulnerability driven by Circumpolar Deep Water-induced melt. Industrial and logistical emissions matter: decarbonizing Antarctic science operations is now an active priority. Such as the British Antarctic Survey's net-zero-by-2040 plan, relying on solar PV, energy storage innovations, and transparent carbon



Fig description & source: Water forms under Nepal's Khumbu glacier as the ice melts in this undated handout image. (Alex Treadway/ICIMOD/Handout via Reuters).

disclosures. India's NCPOR–HPCL (Saha, n.d.) collaborations (2025) on cleaner fuels, low-carbon resupply, and microgrid research, a replicable model of industry–polar agency co-design. Advanced energy materials, hydrogen carriers, low-temperature polymers, and biofuels support greener logistics while respecting the strict Antarctic Treaty environmental protocols. “Polar-safe” product design (Wastiaux, 2025), low emissions, minimal contamination, full lifecycle accounting is emerging as an industrial best practice. Dynamic changes like the 2025 mass loss of iceberg A23a (Pare, 2025) highlight growing hazards for ecosystems and shipping routes. Long-term ecological monitoring remains essential for safeguarding Antarctica's biodiversity amid rising pressures.

The Himalaya, a climate and water-security hotspot, is experiencing rapid glacier melt, expanding glacial lakes, and rising GLOF risk. Seasonal shifts and rising snowlines are altering runoff patterns critical for billions downstream and for hydropower planning. Industry has an indirect but crucial role: green manufacturing, circular processes, bio-based chemistry, and cleaner fuels help reduce black carbon, methane, and CO₂ important stressors accelerating regional glacier melt. Indian industries are already moving like Tata Chemicals (Chandan et al., 2025) and others are expanding bio-based chemicals, waste-derived materials, and low-emission production, aligned with climate-resilient manufacturing pathways. Satellite data (ISRO and global missions) show rapid glacial lake expansion and higher 2024–25 snowlines across many basins including the Everest region. Industry can help scale AI-based early warning, integrated sensor networks, and satellite-driven monitoring. On the societal side, Himalayan forums emphasize ecosystem-based resilience, traditional ecological knowledge, gender inclusion, green entrepreneurship, and “Vocal for Local” (International Mountain Conference, n.d.) livelihood models. These

align with India's 2047 (PIB Delhi, 2025; (Spokesman, 2025) sustainability and climate-resilience vision.

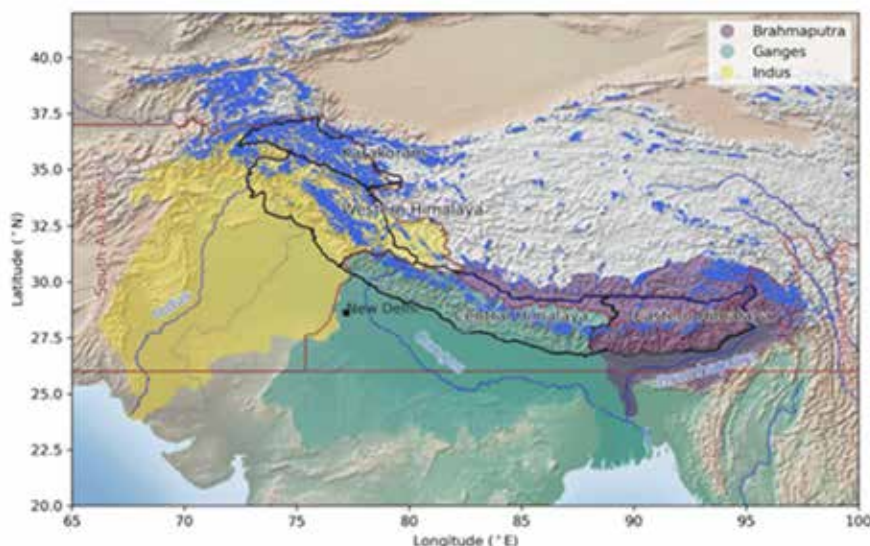


Figure description. Major Himalayan river basins - Indus, Ganga, and Brahmaputra - originating from high mountain glaciers. These transboundary river systems flow across China, India, Pakistan, Nepal, Bhutan, and Bangladesh, illustrating why regional cooperation and shared early warning systems are essential for managing climate-induced hydrological risks. Adapted from Shrestha & Aryal (2022).

Reference

1. Kaplan, S. (2025, March 28). Winter sea ice in the Arctic just hit a record low. The Washington Post. Retrieved November 18, 2025, from <https://www.washingtonpost.com/climate-environment/2025/03/28/arctic-sea-ice-winter-low-record/>
2. Robinson, D. K. R., Nadal, D., & OECD. (2025). Steering The Future of Advanced Materials: Strategic Intelligence in Action. In A. Colecchia & D. Winickoff (Eds.), OECD Science, Technology and Industry Policy Papers (No. 185). Retrieved November 19, 2025, from https://www.oecd.org/content/dam/oecd/en/publications/reports/2025/10/steering-the-future-of-advanced-materials_9add3995/a15874fa-en.pdf
3. Kusters, J., Bhattacharjee, D., Bish, J., Nicholas, J., Stewart, D., & Ramachandran, K. (2025, July 18). 2025 global semiconductor industry outlook. Deloitte Insights. Retrieved November 19, 2025, from <https://www.deloitte.com/us/en/insights/industry/technology/technology-media-telecom-outlooks/semiconductor-industry-outlook.html>
4. European Union. (2025, June 24). Arctic Circular Economy Summit 2025. European Circular Economy Stakeholder Platform. Retrieved November 19, 2025, from <https://circulareconomy.europa.eu/platform/en/news-and-events/all-events/arctic-circular-economy-summit-2025>
5. Heron, A. (2025, August 13). Scientific Reports: At the helm of Arctic Climate Research | For Researchers | Springer Nature. Retrieved November 19, 2025, from <https://www.springernature.com/gp/researchers/the-researchers-source/behind-our-brands-blogpost/scientific-reports-collections-climate-change-/27804538>
6. Pare, S. (2025, September 4). 40-year-old 'queen of icebergs' A23a is no longer world's biggest after losing several 'very large... Live Science. Retrieved November 19, 2025, from <https://www.>

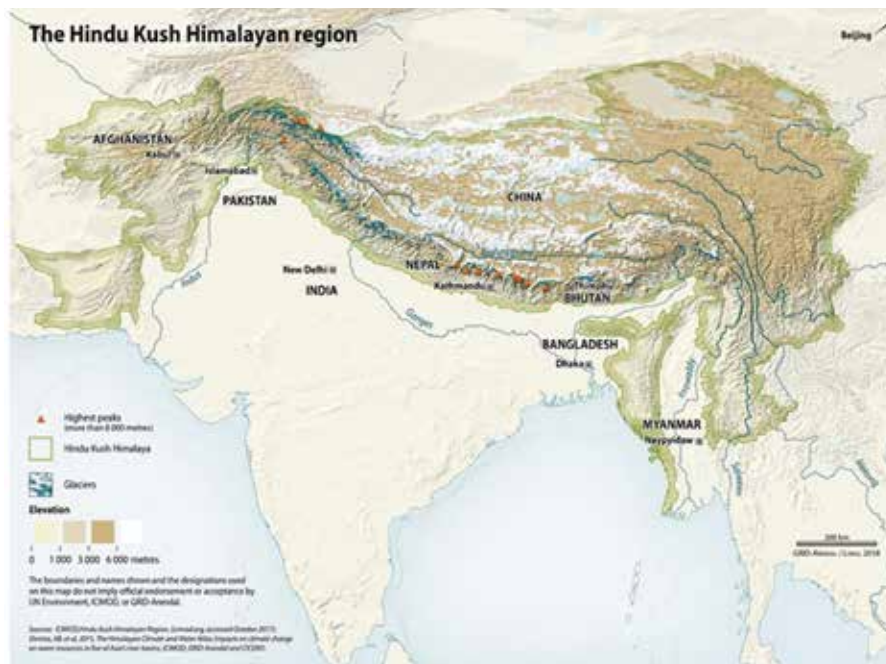


Fig description & source: Stretching over 3500 kilometres and across eight countries – Afghanistan, Bangladesh, Bhutan, China, India, Nepal, Myanmar and Pakistan – the Hindu Kush Himalaya are arguably the world’s most important ‘water tower’, being the source of ten of Asia’s largest rivers as well as the largest volume of ice and snow outside of the Arctic and Antarctica. Together these rivers support the drinking water, irrigation, energy, industry and sanitation needs of 1.3 billion people living in the mountains and downstream.

GRID-Arendal. (n.d.). The Hindu Kush Himalayan region (Resource #12806).

livescience.com/planet-earth/antarctica/40-year-old-queen-of-icebergs-a23a-is-no-longer-worlds-biggest-after-losing-several-very-large-chunks-since-may

7. Saha, S. (n.d.). News: National Centre for Polar and Ocean Research (NCPOR), Goa. Retrieved November 19, 2025, from <https://ncpor.res.in/news/view/908>
8. Chandan, R., Tata Chemicals Limited, & KPMG Assurance and Consulting Services LLP. (2025). Business Responsibility and Sustainability Report for the financial year 2024-25. Retrieved November 19, 2025, from https://www.tatachemicals.com/upload/content_pdf/Tata-Chemicals_BRSRfinal.pdf
9. International Mountain Conference. (n.d.). Building Climate-Resilient Livelihoods and Sustainable Development: Action Research for Local Empowerment in Central Himalayan (Uttarakhand) Region through an Ecosystem Approach. Retrieved November 19, 2025, from <https://imc2025.info/imc25/abstract/building-climate-resilient-livelihoods-and-sustainable-development-action-research-for-local-empowerment-in-central-himalayan-uttarakhand-region-through-an-ecosystem-approach/>
10. PIB Delhi. (2025, November 11). G.B. Pant National Institute of Himalayan Environment (NIHE) to organize 3-day Himalayan Conclave from 13th November, at Almora, Uttarakhand. Retrieved November 19, 2025, from <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2188903>

11. Spokesman, R. (2025, November 14). Himalayan Conclave 2025: Focus on Climate Action, Sustainable Livelihoods and India's 2047 Vision. Rozana Spokesman. Retrieved November 19, 2025, from <https://www.rozanaspokesman.com/news/nation/141125/himalayan-conclave-2025-focus-on-climate-action-sustainable-liveliho.html>
12. Hillenbrand, C., Smith, J. A., Hodell, D. A., Greaves, M., Poole, C. R., Kender, S., Williams, M., Andersen, T. J., Jernas, P. E., Elderfield, H., Klages, J. P., Roberts, S. J., Gohl, K., Larter, R. D., & Kuhn, G. (2017). West Antarctic Ice Sheet retreat driven by Holocene warm water incursions. *pmc.ncbi.nlm.nih.gov*. <https://doi.org/10.1038/nature22995>
13. Wastiaux, M. (2025, October 14). Ecodesign principles for sustainable product development: Real climate impact starts here. Hedgehog. Retrieved November 19, 2025, from <https://www.hhc.earth/knowledge-base/articles/ecodesign-principles-real-climate-impact-starts-here#:~:text=Durability%2C%20reusability%2C%20and%20repairability;credentials%2C%20from%20origin%20to%20recyclability>.

THE PEOPLE

The Speakers/Delegates*

**arranged panel wise*

SaGAA OPENING REMARKS



Dr Rasik Ravindra
Former Director
National Centre for Polar
and Ocean Research, Goa

Dr Rasik Ravindra is the current Chairman of Research Advisory Committees of NCPOR, the Society of Earth Scientists (of India) and the INSA -SCAR National Committee. He is also the Senior Vice President of LIGHTS and an Expert Member of the Committee on Antarctic Governance and Environmental Protection (CAG-EP). He held the position of the Director of NCPOR (2006-2012) after relinquishing the post of Deputy Director General in GSI in 2005. Dr Ravindra participated in Indian Expedition to Antarctica in 1987-1988 for the first time and subsequently led Ninth Antarctic Expedition in 1989- 1991, revisiting the icy continent in 1996-1997, 2003-2004, 2007, 2009, and 2010 in various capacities for specific assignments, contributing to different facets of Antarctic science, logistics and policy. He led the first Indian Expedition to the South Pole in 2010 and the first Indian Arctic Expedition in 2007. Dr Ravindra was Chairman of the DST constituted Program Monitoring Committee on Dynamics of Himalayan Glaciers (2007-2012) and was appointed Chair, Panikkar Professor, in October 2012 by MoES. He has served as an elected Member of the UN Commission on Limits of Continental Shelf for the 2014-2017 Term and Secretary General of 36 th International Geological Congress (2019-20). He has received the SCAR Medal for International Coordination, the National Award for Polar Sciences and Cryosphere-2013, the National Mineral Award-1990, the Antarctic Award-2002, H. N. Siddiqui Gold Medal from IGU in 2011, Prof Prem Bahadur Verma Memorial Lecture Award, Prof R C Mishra Memorial Gold Medal 2017, Life Time Achievement Award from Paleontological Society of India, and Dr W D West Oratory Award, 2018.



Padma Shri Dr P S Goel

Raja Ramanna Chair Professor
Indian Space Research
Organisation, HQ, Bangalore

Dr P S Goel is a distinguished Indian space scientist and technologist who has made pioneering contributions to India's satellite technology, and created Ministry of Earth Sciences. He earned his B.E. in Electrical Engineering from the University of Jodhpur, M.E. in Applied Electronics and Servomechanism from the Indian Institute of Science, Bangalore, and a Ph.D. from Bangalore University. Joining ISRO at its nascent stage, he developed the Satellite Attitude Control System, and contributed to missions including Aryabhata, Bhaskara I & II, Rohini, APPLE, IRS, INSAT-2, TES, and Space Recovery Experiment (SRE) satellites. He served as Project Engineer (AOCS) for APPLE, Associate Project Director (INSAT-II), and Director, ISRO Satellite Centre (1997–2005). He was also Member of Space Commission. As Secretary, Department of Ocean Development, he transformed it into the Ministry of Earth Sciences (MoES), becoming first Chairman Earth Commission, and led landmark initiatives such as India's Tsunami Warning System, IMD modernization, and deep ocean exploration. He later served as Chairman, RAC-DRDO, President, INAE, Member National Security Advisory Board, Vice President, Aeronautical Society of India, and Vikram Sarabhai Distinguished Professor, ISRO. A Padma Shri awardee (2001), Dr. Goel is a Fellow of INSA, IASc, NASI, and TWAS, and currently serves as Hon Distinguished Professor at NIAS, and Honorary Distinguished Professor at ISRO HQ, chairing key committees for Chandrayaan-2, Gaganyaan, and the Manned Submersible Mission of MoES.



Dr B Meenakumari

Former Chairperson
National Biodiversity
Authority, Chennai

Dr B Meenakumari is former Chairperson of the National Biodiversity Authority, is a distinguished marine biologist and one of India's leading fisheries scientists. Prior to joining the NBA, she served as Deputy Director General (Fisheries) at the Indian Council of Agricultural Research (ICAR), New Delhi—becoming the first woman scientist to hold this prestigious position. With over 38 years of service in ICAR, she also served as Director of the Central Institute of Fisheries Technology (CIFT), Cochin, where she had earlier led the Division of Fishing Technology and worked in various capacities as Scientist, Senior Scientist, and Principal Scientist. Her extensive research spans the development of advanced fishing gear for coastal and deep-sea operations, conservation of fishery resources, responsible and eco-friendly fishing methods, reservoir gear upgradation, remote sensing and PFZ validation, pollution monitoring, environmental impact assessment, and studies on marine corrosion and biofouling. Author of over 200 research publications, Dr. Meenakumari has been widely recognized with honors including the Young Scientist Award of Kerala Science & Technology, Women and Technology Innovation Award, PanjabRao Deshmukh Agricultural Scientist Award, VASVIK Award, Marie Curie Mahila Vijnana Puraskar, Dr. M. S. Randhawa Memorial Award, and the Society of Fisheries Technologists Award. Her thesis on "Innovations in Fishing Technology" was awarded DSc by the Vidyasagar University, West Bengal. Currently she is pursuing initiatives in societal applications in fisheries research and committed to conservation of the bioresources and its sustainable use in the country.



Dr Mukul Das

Director
Shriram Institute for
Industrial Research

Dr Mukul Das currently the Director of the Shriram Institute for Industrial Research in Delhi. He brings a wealth of expertise in Food Toxicology, Nanotoxicology, Carcinogenesis, and Xenobiotic Metabolism. For several consecutive years, he has been recognized in the prestigious Elsevier-Stanford list of the world's top 2% scientists. Dr. Das played a pioneering role in investigating and mitigating some of the public health crises in India: the argemone oil contamination in

cooking oil; the tragic child fatalities linked to empty stomach litchi fruit consumption at Muzaffarpur, Bihar; and association of children death to *Cassia occidentalis* seeds in Saharanpur, UP. His impactful research has significantly advanced public health and food safety standards. He has authored more than 300 scientific papers and has more than 7 patents to his credit. Under his leadership, the Shriram Institute has expanded its research and development initiatives, while enhancing its analytical and technical services for industrial sectors. With state-of-the-art facilities and Dr. Das's visionary guidance, the institute continues to reach new heights of excellence.



Prof. B. S. Balaji
Dean, School of
Biotechnology
Jawaharlal Nehru
University, New Delhi

Prof. B. S. Balaji is a distinguished biotechnology researcher and educator at the School of Biotechnology, Jawaharlal Nehru University (JNU), with over 24 years of academic and industrial experience. Holding an M.Sc., Ph.D., and an MBA in Technology Management, he specializes in radiopharmaceutical gene targeting, solid-phase peptide and peptide nucleic acid (PNA) chemistry, dendrimer synthesis, and both homogeneous and heterogeneous catalysis. His research spans interdisciplinary frontiers—from molecular imaging for cancer to the design of nanoparticles, aptamers, and metallo-dendrimers. Prof. Balaji is deeply committed to advancing science education in India. He has developed major SWAYAM MOOCs in Organic Chemistry, which have collectively attracted around 30,000 enrollments over the past few years and have been translated into eight Indian languages to enhance accessibility. His Arctic MOOC, launched in 2025, has also received significant engagement with around 5,000 enrollments. Additionally, he has developed several courses for the SWAYAM Prabha TV channel, which have accumulated more than 100,000 (1,00,000) views, reflecting his impact on nationwide STEM outreach. His dedication to inclusive education is evident in his development of 3D-printed, tactile STEM teaching tools, including Braille-enabled molecular models for visually impaired learners. In recognition of his pedagogical excellence, Prof. Balaji received the Association of Chemistry Teachers' P. R. Singh Award (2021) and the Making India Employable Award. He has also held prestigious fellowships, including the CSIR Senior Research Fellowship, the COE Postdoctoral Fellowship at Hokkaido University, and a Research Fellowship under the NIH ICMIC P50 Grant in the USA.



Dr K V George
Chief Scientist
CSIR – National
Environmental Engineering
Research Institute
(CSIR-NEERI)

Dr K V George is a Chief Scientist at the CSIR – National Environmental Engineering Research Institute (CSIR-NEERI) in Nagpur, where he has devoted over three decades to environmental research and policy-relevant science. He holds a B.E. in Civil Engineering and an M.E. in Environmental Engineering from the Government Engineering College, Jabalpur, Ph.D. in Environmental Engineering from IIT Delhi. With more than 35 years of experience at NEERI, Dr. George leads critical work in air pollution control, including air quality monitoring, emissions inventory, dispersion modelling, receptor modelling, and meteorological data analysis. As part of his leadership, he also heads the Air Pollution Control Division. He has authored a number of peer-reviewed publications and is currently supervising two doctoral research scholars. In addition, Dr. George is recognized as a QCI-NABET Functional Area Expert in air quality and air pollution – underscoring his impact on regulatory and policy frameworks. Dr. George plays a vital role in national-level studies, like technology evaluation of coal gasifiers of Morbi, the need of SO₂ emission reduction needs of Indian coal based thermal power plant, air assimilative capacity based stack height. Dr. George was a member of Indian Antarctica Expedition in 2000 for research work at MAITRI Station and spent 3 months at Antarctica.



Ambassador Pankaj Saran
Member National Security
Advisory Board, Govt. of
India, New Delhi

Ambassador Pankaj Saran is the Convenor of NatStrat, a Delhi-based independent Center for Research on Strategic and Security Issues, and a commentator and consultant on security and strategic issues. He is a former diplomat with four decades of experience in foreign, strategic, and national security affairs. Ambassador Saran has served in different capacities within the Prime Minister's Office, the NSCS, the MEA, and Indian Missions abroad. He has served as Ambassador of India to Russia, High Commissioner to Bangladesh, and Head of the Northern Division in the Ministry of External Affairs dealing with Nepal and Bhutan. From 2018 to 2021, Ambassador Saran served as the Deputy National Security Adviser for Strategic Affairs, dealing with regional and global strategy formulation, maritime security, Arctic affairs, and India's neighbourhood. He has written for The Times of India, Hindustan Times, and The Economic Times, among other newspapers and journals. He is Currently Member of the National Security Advisory Board.



Amb. Sibi George
Secretary (West), Ministry
of External Affairs

Ambassador Sibi George is the Secretary (West) at the Ministry of External Affairs, Government of India. A distinguished diplomat of the 1993 batch of the Indian Foreign Service, he has previously served as India's Ambassador to Japan, Switzerland, The Holy See, The Principality of Liechtenstein, Kuwait, and the Republic of Marshall Islands. His diplomatic career began in Cairo as Political Officer, followed by assignments in Doha as First Secretary handling Consular, Community, Information and Media affairs, in Islamabad as Political Counsellor, and in Washington D.C. as both Political and Commercial Counsellor. He also served as Deputy Chief of Mission in Indian Missions at Tehran and Riyadh. At the MEA headquarters in New Delhi, he has worked in the East Asia Division, coordinated the India-Africa Forum Summit, and headed the Administration, Establishment, and Welfare Divisions. In recognition of his exemplary service, he received the S. K. Singh Award for Excellence in the Indian Foreign Service in 2014. Hailing from the Podimattam family of Pala in Kottayam district, Kerala, Ambassador George is a gold medallist in both graduation and post-graduation, and an alumnus of the American University in Cairo. He has undergone professional training at LBSNAA



Dr M Ravichandran
Secretary
MoES, Govt. of India

Mussoorie, SSIFS New Delhi, IIM Ahmedabad, IIM Bengaluru, IIFT New Delhi, and ISB Hyderabad. He is married to Joice John Pampooorethu, an artist, and they have two daughters, Elhita Thampuran and Ayilya Thampuran, and a son, Jeff Vakhan Thampuran.

Dr M Ravichandran, a distinguished physicist and seasoned earth scientist, is serving as the Secretary to Government of India in the Ministry of Earth Sciences (MoES) since October 2021. With an illustrious career spanning over polar research. Beginning his scientific journey at Indian Institute of Tropical Meteorology (IITM), Pune (1988–1997), he subsequently advanced ocean observation at National Institute of Ocean Technology (NIOT), Chennai (1997–2001), and oceanographic research at Indian National Centre for Ocean Information Services (INCOIS), Hyderabad (2001–2016). As Director of National Centre for Polar and Ocean Research (NCPOR), Goa (2016–2021), he strengthened India's scientific and strategic presence in the Arctic and Antarctic through initiatives in long-term climate observation, glaciology, and polar ecosystem monitoring. His research interests encompass atmospheric physics, ocean dynamics, polar sciences, and ocean observing systems, reflected in over 160 peer-reviewed publications with more than 7,600 citations. Internationally, Dr. Ravichandran has served as Vice-President of Scientific Committee on Antarctic Research (SCAR, 2018–2022), Council Member of International Arctic Science Committee (IASC, until 2022), Co-Chair of Indian Ocean Panel of GOOS/CLIVAR, and member of International Argo Steering Team and the SIBER program. He continues to lead India's national coordination of Arctic and Antarctic expeditions, advance research on ice-sheet melting and ocean–atmosphere coupling, and guide interdisciplinary studies aligned with the Ministry's Arctic Policy and Antarctic initiatives, reinforcing India's role in global polar and climate science.



Dr Shailesh Nayak
Director
NIAS, Bengaluru

Dr Shailesh Nayak is the Director of National Institute of Advanced Studies (NIAS), Bengaluru, Editor-in-Chief of the Journal of the Indian Society of Remote Sensing, and Life Trustee of India International Centre, New Delhi. He previously served as Chair, Earth System Science Organisation (ESSO) and Secretary, Ministry of Earth Sciences (MoES), Government of India (2008–2015), and as Chancellor of TERI School of Advanced Studies, Delhi. His leadership strengthened India's initiatives in climate science, weather services, polar and ocean sciences, geoscience, and ocean technology. Holding a Ph.D. in

Geology from M.S. University of Baroda (1980), Dr. Nayak began his career at ISRO's Space Applications Centre in 1978, getting to hold the position of Director – Marine and Water Resources, where he led projects on ocean colour, coastal management, glaciers, and water resources, contributing to India's Coastal Regulation Zone policies. As Director of INCOIS (2006), he established the Indian Ocean Tsunami and Storm Surge Early Warning System and developed Marine GIS, enhancing services on fishing zones, ocean forecasts, and the Indian Argo project. His research focuses on the blue economy, sustainable development, and science diplomacy. He serves on Governing Boards of In-Space, the Foundation for Ecological Security, and National Centre for Sustainable Coastal Zone Management, and chairs several national scientific committees. A Fellow of multiple national and international academies, Dr. Nayak has received the Padma Shri (2024), IGU Hari Narain Lifetime Achievement Award (2013), ISCA Vikram Sarabhai Memorial Award (2012), and Bhaskara Award (2009). He has over 190 publications and 200 invited lectures worldwide.



Dr Sulagna Chattopadhyay

President, SaGAA; Editor-in-Chief, Geography and You

Dr Sulagna Chattopadhyay is the founder-Editor of ISSN and RNI accredited *Geography and You (G'nY)*, a journal-magazine focusing on climate change, development, and the environment in particular, being published since 2001. She has been working for nearly three decades in the field of climate change, polar studies, disaster management, and biodiversity. She has been involved in various research and outreach programmes and has co-authored two books, *Climate Change and the White World; Science and Geopolitics of the White World: Arctic-Antarctic-Himalaya* published by Springer along with six other books on varied topics. She is also a founding member of LIGHTS and has been the convenor of national and international conferences/ seminars, notable being the round table conclave on seas and oceans around India, SaGAA in 2011, 2012, 2015, 2017, 2019 and 2020. She has been a member of the National Biodiversity Authority, FICCI Geospatial Award Jury and is in the Advisory Body of CEMAS, Mumbai University, and has engaged in various efforts toward conservation and climate change. She has a deep interest in polar studies and policy and has built a think tank SaGAA for policy and advocacy of the three poles. She also won an Environmental Documentary Short Film Contest, STL-2 : 2015 for her short film titled *O Bhai Saab*. She was awarded Business Excellence and Innovative Best Practices Academia Award, 2019 by NDIM.

Technical Panel 1: Breaking the Ice | From Isolation to Cooperation in a Multipolar World



Vice Admiral Pradeep Chauhan

Director-General,
National Maritime
Foundation (NMF),
New Delhi

Vice Admiral Pradeep Chauhan, AVSM & Bar, VSM, IN (Retd), is the Director-General of the National Maritime Foundation (NMF), New Delhi, India. As a maritime practitioner, his experience stems from a four-decade-long distinguished career in the Indian Navy during which he has held four sea-going commands including that of the aircraft carrier, the Viraat. The admiral enjoys international renown as an incisive strategic analyst and is a prolific writer on maritime and strategic issues, with 105 published articles and research-papers to his credit. Defence Academy, the Defence Services Staff College, the Naval War College, and the National Defence College, with BSc, MSc and MPhil degrees under his belt, Vice Admiral Pradeep Chauhan is the Director-General of the National Maritime Foundation (NMF), New Delhi, which is India's foremost resource centre for the development and advocacy of strategies for the promotion and protection of the country's maritime interests. Under his stewardship, the NMF has gained very considerable traction and has grown in stature as the go-to knowledge-point for all Indian maritime endeavours.



H E May Elin Stener
Ambassador,
Royal Norwegian Embassy
to India, Sri Lanka, Bhutan
and Maldives

H. E. May-Elin Stener is currently Ambassador of Norway to India, Sri Lanka, Bhutan and Maldives. Prior to taking up this position, from 2020-2023, she was the Deputy Director General of the Regional department in the Ministry of Foreign Affairs of Norway, covering Africa, Asia, Latin -America and the Middle East, as well as peace and reconciliation issues. May-Elin headed the section for Horn of Africa and West-Africa between 2018-2020. She was Norway's Deputy Permanent Representative to the United Nations headquarter in New York (2014-2018) as well as Deputy Head of the Norwegian Embassy in Pretoria, South Africa (2007-2011). She has worked for the Norwegian Foreign Service since 1995, and has extensive diplomatic experience multilaterally, with a focus on humanitarian affairs. She has also been posted to the UN offices in Geneva and has headed the Section for Humanitarian Affairs in the Ministry. Stener is married with one adult daughter and two adult stepchildren. She is a lawyer by training.



Dr Mrutyunjay Mohapatra
Director General
India Meteorological
Department (IMD)

Dr. Mrutyunjay Mohapatra is the Director General of Meteorology, India Meteorological Department and 3rd Vice President of WMO. With Doctoral Degree in Physics and more than 30 years of experience in meteorology, he has made significant contributions in the improvement of early warning services of IMD, specially with respect to cyclones and impact based forecasting. He brought laurels to the country from various international and national agencies and is popularly known as "The Cyclone Man of India". He is recipient of various national and international awards and recognitions from different agencies for bringing out paradigm shifts in weather forecasting and cyclone warning services including Honorary D.Sc. from five Universities. American Meteorological Society Award for exceptional leadership and services in enhancing tropical cyclone prediction and warning systems in the Indian Ocean region and above all the United Nation Sasakawa Award 2025 for disaster risk reductions.



Amb. Pooja Kapur
Additional Secretary
(Northern Europe)
Ministry of External Affairs

Amb Pooja Kapur is a career diplomat who joined the Indian Foreign Service in 1996, Ms. Kapur has served as India's Ambassador to the Kingdom of Denmark from 2021-24 and India's Ambassador to the Republic of Bulgaria and the Republic of North Macedonia from 2017- 21. She was also India's G20 Sous-Sherpa when India was part of the G20 Troika. Ambassador Kapur has wide-ranging experience in European and Indo-Pacific affairs, alongside multilateral matters. She has served at Indian Embassies/High Commissions in Paris, London, Kuala Lumpur and Brussels. In the Ministry of External Affairs, she has headed the Central Europe Division and ASEAN Multilateral (Indo-Pacific) Division as well as held charges pertaining to India's relationship with Western Europe, South East Asia, the United Nations and the Commonwealth. Ambassador Kapur is a frequent speaker at international conferences and events and was the Chief Coordinator of the Delhi Dialogue from 2014–17. Ms. Kapur was a Chevening scholar at the University of Oxford and also has a Masters in Public Administration from the Ecole Nationale d'Administration in Paris, along with a B.A. (Honours) and M.A. in Political Science from the University of Delhi. A university topper and recipient of several academic scholarships and awards, she is a published author. Ms. Kapur speaks Hindi, English and French. She is married and has a son.

Plenary: From Poles to the Monsoon | How Cryosphere-Ocean Feedback is Rewriting India's Future Climate



Dr. A. Suryachandra Rao

Director

Indian Institute of Tropical
Meteorology, Pune

Dr A Suryachandra Rao, Director of the Indian Institute of Tropical Meteorology (IITM), Pune since June 2025, is a distinguished climate scientist specializing in climate variability and prediction, coupled ocean-atmosphere dynamics, ocean modeling, and high-performance computing. He joined IITM in 2008 and has served in various capacities, including Scientist-G, Project Director of the Monsoon Mission, and Head of the High-Performance Computing (HPC) Division, before becoming Acting Director in April 2025. Dr. Rao began his research career at the National Institute of Oceanography, Goa, and subsequently held international research positions at the Institute of Marine Affairs (Trinidad & Tobago) and the Frontier Research System for Global Change (FRSGC), Tokyo, where he also collaborated with Mitsubishi Heavy Industries on advanced climate modeling frameworks. With over three decades of research experience, Dr. Rao has made significant contributions to understanding monsoon dynamics, air-sea interactions, and coupled climate modeling, enhancing India's operational forecasting capabilities under the Monsoon Mission. His work has informed applications in agriculture, hydrology, and disaster risk reduction, while his mentorship has shaped a new generation of climate researchers. Dr. Rao's scientific excellence has been recognized through numerous honors, including the Dr. A.P.J.

Technical Panel 2: Breaking Barriers Within | National Outcomes and International Outlook



Prof. N. V. Chalapathi Rao

Director

National Centre for Earth
Science Studies (NCESS)

Prof. N. V. Chalapathi Rao is the Director of National Centre for Earth Science Studies (NCESS), Thiruvananthapuram. Holds PhD degrees from Osmania University and University of Cambridge and a Senior Alexander von Humboldt Fellow at the Technical University of Clausthal, Germany. He previously served with the Ore Dressing Division, Indian Bureau of Mines, Ministry of Mines, at Nagpur (1998-2007) before joining Banaras Hindu University (BHU) in 2007, where he became Professor in 2013. He is currently on deputation as Director, NCESS (2024-2029). His research spans the petrogenesis of kimberlites, lamproites, lamprophyres, mantle xenoliths, and Indian Shield geodynamics, including the Deccan and Rajmahal basalts, Proterozoic basins, mafic dykes, and Cretaceous–Tertiary mass extinctions. He has authored 127 SCI papers, co-edited six volumes, and supervised 17 Ph.D. and 50 Master's theses. Through his DST-SERB grants, he established national facilities like the Electron Micro Probe Analyzer (2016) and Scanning Electron Microscope (2018), benefiting researchers across India.



Dr MV Ramana Murthy

**Mission Director, Deep Ocean
Mission, Ministry of Earth
Sciences**

Dr. M.V. Ramana Murthy, Mission Director of Deep Ocean Mission of Ministry of Earth Sciences since 2022 and served as Director, National Centre for Coastal Research (NCCR) for 9 years. As a Director of NCCR, Dr. Murthy is involved in providing scientific solutions to coastal issues, focusing on coastal resilience, climate adaptation, and the blue economy. Before joining NCCR, he served as the Head of the Ocean Structures & Island Desalination Division at the National Institute of Ocean Technology (NIOT). Having 32 years of experience in Ocean Technology and Coastal Research, he has successfully demonstrated many societal oriented projects such as Establishment of Desalination Plants in UT Lakshadweep, Coastal protection and Beach Restoration at Pondicherry and Urban Flood Warning System (I Flows) for Mumbai and Chennai, Monitoring Health of Coastal Waters as part of SDG 14. Recently completed projects include preparation of DPR for Kalpsar Dam with Govt of Gujarat to create a largest fresh water reservoir and Integrated Ocean Management initiative for development of framework for Blue Economy to be implemented by govt of India and Shoreline Management plans for Coastal States of Tamil Nadu, Pondicherry, Kerala and Andhra Pradesh. Recent assignment include Development of Marine Spatial Plans for ecologically sensitive area of Lakshadweep islands for holistic development and Pondicherry, an urban city along south east coast of India and Nature based Solutions for Coastal Protection. He is AICTE – INAE Distinguished Visiting Professor under (DVP) Scheme, member of many technical and policy formulation committees and member of MoEF&CC as Expert Appraisal committee for Infra structure and CRZ projects . Recent international collaboration include - India Pacific Ocean Initiative (IPOI) for Marine Ecology Pillar with Australia, Coastal Protection with Vietnam, Sea level Change and Marine Litter with JAMSTEC and Establishment of Coastal Research Facility at Fiji. Recipient of Ocean Technology award of 2021 and served as President of Ocean Society of India.



Dr Kenichi Matsuoka
Scientist
Norwegian Polar Institute,
Norway

Dr. Kenichi Matsuoka is a Senior Research Scientist at the Norwegian Polar Institute (NPI), specializing in Antarctic glaciology. He earned his Ph.D. from Hokkaido University, Japan, in 2002 and subsequently served as a Research Assistant Professor at the University of Washington, USA, in 2005. Joining NPI in 2010, he qualified as a full Professor in 2013. Over the course of his career, Dr. Matsuoka has conducted extensive research on seasonal snow, mountain glaciers, and polar ice sheets. At NPI, his work has encompassed both coastal and inland regions of East Antarctica in collaboration with numerous international partners, including the National Centre for Polar and Ocean Research (NCPOR), India. He has also made significant contributions to the Scientific Committee on Antarctic Research (SCAR), serving as Norway's representative to its Physical Sciences Group, co-founding the SCAR map product Quantarctica, and chairing the RINGS Action Group as its founding chair.



Dr O P Mishra
Director
National Centre for
Seismology, MoES,
Government of India

Dr Om Prakash Mishra is the Director of the National Centre for Seismology (NCS), Ministry of Earth Sciences, India. As a distinguished Earth scientist and Fellow of the National Academy of Sciences, India, renowned for his pioneering contributions in Applied Geophysics, Seismology, and Disaster Risk Management. With over 30 years of experience across diverse domains of Earth sciences, he holds an M.Sc. Tech in Applied Geophysics from IIT (ISM) Dhanbad, a Ph.D. and D.Sc. in Seismology from the Geodynamics Research Centre, Ehime University, Japan, and a Post Graduate Diploma in Management (Finance) from AIMA, New Delhi. Dr. Mishra has held key positions including Director, SAARC Disaster Management Centre, New Delhi, and served the Geological Survey of India for nearly two decades (1995–2014). Earlier, he worked on a joint project with IDRC-Canada and CMPDIL, Coal India (1992–1995) and as a Visiting Guest Professor at GRC, Japan (2005–2006). Representing SAARC Member States, he has collaborated with multiple UN agencies such as UNDP, UNESCAP, UNISDR, UNOCHA, and UN-Habitat, as well as organizations including IRP, ADPC, ADRC, USAID, and ECO. A widely travelled academic, he has led flagship UNISDR and World Bank projects on disaster resilience in South Asia. Dr. Mishra is a Life Member of leading global scientific bodies including AGU, SSA, SSJ, JPGU, AOGS, IUGG, ISCA, MGMI, IMS, IIPA, IGU, ISES, and AEG. He has supervised 40 postgraduate and doctoral researchers, including 10 Ph.D. scholars, and authored over 150 publications, edited volumes, and thematic reports in leading international journals.

Technical Panel 3: Melting Frontiers | Forging Pathways of Ocean-Polar Synergy



**H.E. Rasmus
Abildgaard
Kristensen**, Ambassador,
Embassy of Denmark
in India

H.E. Rasmus Abildgaard Kristensen (born 1974) is Denmark's Ambassador to the Republic of India and non-resident Ambassador (designate) to Nepal, Sri Lanka, Bhutan, and the Maldives. Ambassador Kristensen assumed his position in February 2025. As Ambassador, he leads a team of experienced diplomats and public servants at the Embassy of Denmark in New Delhi. He is responsible for overseeing Denmark's engagement with India on a broad range of political, economic, commercial, consular, and other matters that shape the bilateral relationship. Ambassador Kristensen has had a distinguished career in the Danish Foreign Service, with extensive experience gained from overseas assignments and other international roles, including as Denmark's Ambassador to Indonesia, Timor-Leste, Papua New Guinea, and ASEAN from 2017 to 2020. Throughout his career, Ambassador Kristensen has specialized in international climate and energy policy. He served both as Head of Department for Green Diplomacy and Climate at the Danish Foreign Ministry and Head of the International Department at the Danish Ministry of Climate, Energy and Utilities. In addition to his diplomatic career, Ambassador Kristensen has held a senior position in the private sector as Vice President and Head of Group Public Affairs at Danfoss, a multinational cleantech company based in Denmark.



Sunil Kumar Singh
Director
National Institute of
Oceanography (NIO), Goa

Dr Sunil Kumar Singh is the Director of the CSIR-National Institute of Oceanography (CSIR- NIO). A distinguished scientist specializing in Geochemistry and Isotope Chemistry, Palaeoclimate and Palaeoceanography, Nutrient Cycling, and Biogeochemistry, his research spans the Indian Ocean, Ganga Plain, and the Himalaya. He joined CSIR and assumed his current post on June 27, 2017, and is due to retire on March 31, 2031. Prof. Singh earned his B.Sc. (Hons.) in Physics (1989) and M.Sc. (Tech.) in Geophysics (1992) from Banaras Hindu University, followed by a Ph.D. in Isotope Geochemistry (1999) from the Physical Research Laboratory (PRL), Ahmedabad/ MSU, Vadodara. His academic journey includes post-doctoral fellowships at PRL, Ahmedabad (1999) and CNRS-CRPG, Nancy, France (1999–2002), followed by positions as Scientist-SD (2002–2004), Reader (2005–2009), Associate Professor (2010–2014), and Professor (2015–2017) at PRL, Ahmedabad. He served as Director, CSIR-NIO (2017–2019).



Dr. Grinson George
Director,
ICAR-Central Marine
Fisheries Research Institute
(CMFRI)

Dr. Grinson George is a distinguished fisheries scientist and administrator with over two decades of high-impact experience in research, policy, and multilateral coordination, currently serving as the Director of the ICAR-Central Marine Fisheries Research Institute (CMFRI) in Kochi. His strong scientific foundation, including a Ph.D. in Marine Science (NIO/Goa University) and Post-Doctoral research at the Plymouth Marine Laboratory (PML), UK, is centered on Fisheries Oceanography, Marine Biodiversity, and the strategic application of Remote Sensing/GIS for resource assessment and climate change impact analysis. A key aspect of his career is his extensive regional engagement; he served as the Senior Programme Specialist (Fisheries) at the SAARC Agriculture Centre (SAC) in Dhaka, where he was responsible for coordinating the fisheries and aquaculture programs across all eight South Asian Nations to promote sustainability and policy harmonization. Furthering his international profile, he was an active participant in the Indo-Sri Lanka Joint Working Group (JWG), contributed to the PML-UK REVIVAL project, and featured in a related DBT-funded PODCAST focusing on scientific outreach. He also gained hands-on expertise working in the Maldives for one year. This unique combination of advanced scientific leadership at CMFRI and proven multilateral policy coordination makes him a critical figure in marine resource management both nationally and regionally.



Dr Manish Tiwari

Scientist F

National Centre for Polar
and Ocean Research
(NCPOR), Goa

Dr Manish Tiwari is the Group Director (Arctic Operations) and a scientist at the National Centre for Polar & Ocean Research in Goa. His research interests are quantifying past climatic and oceanographic changes through isotopic and geochemical studies of marine sediment. He is particularly interested in understanding the teleconnections between the Indian monsoon system and polar regions. Dr. Tiwari holds a PhD in Geology from Physical Research Laboratory, Ahmedabad and has obtained Bachelor's and Master's degrees in Geology from Banaras Hindu University, Varanasi. He has received several awards and honours for his outstanding contributions, including the "Young Scientist Medal" of the Indian National Science Academy, the "Young Scientist Award" of the Indian Science Congress Association, and the "Certificate of Merit" by the Ministry of Earth Sciences, among others. Dr. Tiwari has also led externally funded research projects and established state-of-the-art laboratories at NCPOR. He has mentored 9 Ph.D. students, including current ones. He has more than 80 peer-reviewed scientific papers, and served as an editor and reviewer for renowned scientific journals.

Technical Panel 4: Science Without Borders | Global Models that still Work



Prof Naresh Chandra Pant

Professor (Retd.)
Department of Geology,
University of Delhi

Prof Naresh Chandra Pant, a geologist by profession, has made significant contributions in establishing the extension of East African Orogen in east Antarctica, described high-pressure metamorphism from Indian Archean craton (Bundelkhand), applied innovative and uncommon application of Electro Probe Micro Analysis for estimating the bulk composition of selected micro-domains, inferring sub-ice geology of east Antarctic shield from proximal marine sediments and many others. He is involved in Indian Antarctic activities for last three and a half decades out of which last ten years have been in management activities of the science programme of Indian Antarctic Expeditions. Besides, he has been a chief officer of the Geosciences of SCAR for the last ten years and currently is the Deputy Chief Officer. He is also a member of the SCATS. He currently Chairs the INSA national committee on SCAR. He has contributed to establishing, developing, and nurturing micro-domain characterisation laboratories in India and propagating chemical geochronology in the country. He recently retired as Senior Professor from the University of Delhi, and prior to that he has served in GSI and IIT (Kharagpur). He has received National Mineral Award (1996), the Antarctic Silver Jubilee Award, and the British Council Innovation Award in the form of ICECAP-2 project (2015-2017). Prof Pant has over hundred international and national research publications and has produced 10 doctoral students out of which three have been awarded PhD's on their work on Antarctica.



Dr Thamban Meloth
Director
National Centre for Polar and
Ocean Research (NCPOR),
Goa

Dr Thamban Meloth is the Director of the NCPOR, Goa. His field of specialisation includes cryosphere and palaeoclimatology. His current research focuses on Antarctic ice core studies, polar snow biogeochemistry and Himalayan glaciology. He was instrumental in establishing India's first and state-of-the-art Ice Core Laboratory at NCPOR in 2005, and also pioneered the Antarctic snow and ice core studies at NCPOR. He was also a member of the first Indian Scientific Expedition to the South Pole in 2010. He has conducted several expeditions to Antarctica, Arctic, Southern Ocean and Indian Ocean. In recognition of his scientific contributions, he has been awarded National Geoscience Award by Ministry of Mines, NIPR Visiting Scientist Award by the National Institute of Polar Research, Japan; Prof Naganna Gold Medal by the Mineralogical Society of India; START Young Scientist

Award by International Geosphere Biosphere Programme; and Young Scientist Award, by the Indian Science Congress Association (ISCA). He is a Fellow of the National Academy of Sciences, India and has more than 120 papers in peer-reviewed journals to his credit.



Prof Camilla Brekke
Director
Norwegian Polar Institute
(NPI), Norway

Camilla Brekke is appointed Director of the Norwegian Polar Institute (2023-). Prof. Dr. Brekke was Pro-Rector for research and development at UiT The Arctic University of Norway, Tromsø, Norway from 2021 to 2023. Brekke was Vice-Dean Research at the Faculty of Science and Technology from 2018 to 2021 and Deputy Centre Leader from 2019 to 2021 at Centre for Integrated Remote Sensing and Forecasting for Arctic Operations (CIRFA) at Department of Physics and Technology, UiT. Brekke is a full Professor since 2016. In 2009, she joined the Department of Physics and Technology, UiT as an Associate Professor. From 2002 to 2009, she was a Scientist with the Norwegian Defense Research Establishment, Kjeller, Norway. From 2001 to 2002, she was a Young Graduate Trainee with the European Space Agency, Noordwijk, The Netherlands. In 2001, she was a System Developer with Ericsson, Asker, Norway. From 2012 to 2013 (4 months) and in 2018 (4 months), she was a visiting scientist at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA. Her research is focused on synthetic aperture radar and ocean colour remote sensing for Arctic and marine applications. She received the Cand. Mag., Cand. Scient., and Ph.D. degrees from the University of Oslo, Oslo, Norway, in 1998, 2001, and 2008, respectively. She was an exchange student to National University of Singapore in 1998 (spring).



V Narayanan
Secretary, Department of
Space, Chairman, Space
Commission and Chairman,
ISRO

Dr. V. Narayanan, Distinguished Scientist (Apex Grade), assumed charge as Secretary, Department of Space, Chairman, Space Commission and Chairman, ISRO on 13 January 2025. A renowned rocket and Spacecraft Propulsion expert, he joined ISRO in 1984 after a brief early career with TI Diamond Chain Ltd., MRF and BHEL. He holds an M.Tech in Cryogenic Engineering and a Ph.D. in Aerospace Engineering from IIT Kharagpur, where he earned a Silver Medal, the Distinguished Alumni Award (2018) and the Life Fellowship Award (2023). Before becoming ISRO Chairman, Dr. Narayanan served as Director of the Liquid Propulsion Systems Centre (LPSC) for seven years, providing leadership in the development of liquid, semi-cryogenic and cryogenic propulsion systems for India's launch vehicles and satellites. Under his guidance, LPSC delivered 226 propulsion systems and played a pivotal role in several major missions. He also chaired the LPSC-

IPRC Coordination Committee, Project Management Council–Space Transportation System (PMC-STs), and the Human Rated Certification Board (HRCB) for the Gaganyaan programme. A central figure in India's cryogenic propulsion capability, Dr. Narayanan led the development of the Cryogenic Upper Stage for GSLV Mk-II when foreign technology was denied. As Project Director of the C25 stage for LVM3, he ensured its successful development and operationalisation. He contributed significantly to Chandrayaan-2 and Chandrayaan-3 missions, Aditya-L1, Gaganyaan, and several next-generation propulsion systems, including semi-cryogenic and green propulsion technologies. Recipient of 26 prestigious awards, including the ASI Gold Medal, National Design Award, APJ Abdul Kalam Award (2023) and the 2024 IAA Laurels for Chandrayaan-3, Dr. Narayanan is widely respected in national and international scientific communities and has published numerous technical papers and reports.



Shri Nilesh M Desai
Director
Space Application Centre
(SAC), ISRO

Shri Nilesh M Desai, Distinguished Scientist, is the Director of the Space Applications Centre (SAC), ISRO, Ahmedabad, since 1st January 2021. Born on 1st April 1964 in Navsari, Gujarat, he graduated as a gold medalist in Electronics and Communication Engineering from L.D. College of Engineering, Gujarat University (1985–86). Joining ISRO in 1986, he has had a remarkable 35-year career dedicated to the design and development of Microwave Radar Systems and advanced applications of Earth Observation, Navigation, and Communication technologies for societal and strategic use. He has led key projects including RISAT-1 C-Band SAR, Oceansat-2 and Scatsat-1 Scatterometers, Chandrayaan-2 SAR and Lander Altimeter, and Airborne SAR for Disaster Management, among others. He also played a pivotal role in developing NavIC user receivers, SatCom hubs, and ComNav-based applications integrating communication and navigation systems. As Associate Director and Deputy Director at SAC, he provided visionary leadership in promoting indigenous space technologies and capacity-building, including UN-CSSTEAP courses on SatCom and GNSS. Shri Desai has authored or co-authored over 175 technical papers and 225 SAC/ISRO reports, and has represented India at major international forums such as ICG, Austria, France, Germany, Russia, and the UK. A recipient of ISRO's Performance Excellence Award (2018), Individual Merit Award (2010), and Team Award (2012), he is also deeply engaged in outreach through Smart India Hackathon, Vikram Sarabhai Space Exhibition, and academic mentoring. He currently serves as President of ISRS and Vice President of ISSE (Ahmedabad Chapter).

Plenary: Is the Paris Climate Agreement goal enough to save the Polar Ice Sheets?



Dr Waliur Rahaman
Scientist E,
National Centre for Polar and
Ocean Research (NCPOR), Goa

Dr. Waliur Rahaman, Scientist-E at the Isotope Geoscience Division, NCPOR, is an isotope geochemist whose research focuses on understanding Earth's surface and oceanic processes across modern to geological timescales, with a particular emphasis on paleoclimate and paleo-oceanography. He employs stable and radiogenic metal/metalloid isotopes as tools to quantify these processes. Dr. Rahaman began his research career at the Physical Research Laboratory (PRL), Ahmedabad, as a Junior Research Fellow during his Ph.D. in isotope geochemistry, and his outstanding work earned him the prestigious Alexander von Humboldt Fellowship from the Humboldt Foundation, Germany, in 2011. Since joining NCPOR in 2012, he has established ISOTRACE, a state-of-the-art metal-free clean chemistry laboratory equipped with advanced instruments such as Multi-Collector ICPMS (MC-ICPMS) and Quadrupole ICPMS for trace element and isotope analyses. Under his leadership, ISOTRACE has gained recognition as one of India's premier isotope geochemistry laboratories, reflected in its high-impact publications. Currently heading the Isotope Geochemistry Section at NCPOR, Dr. Rahaman has supervised three Ph.D. scholars and actively supports researchers from institutions including DU, BHU, AMU, IIT Kharagpur, IIT Kanpur, IISER Pune, and IISER Kolkata. His group continues to pioneer research on non-traditional stable isotopes and their applications in paleo-oceanographic studies.



Prof Sachin Kumar Sharma

Director General,
Research and Information
System for Developing
Countries (RIS), New Delhi

Professor Sachin Kumar Sharma, Director General of RIS, is a leading expert in international trade, development cooperation, and global economic governance. With over two decades of experience, he has contributed extensively to research, policy analysis, advocacy, and capacity-building across key themes such as agricultural subsidies, food security, sustainability, investment, market access, LDC graduation, transparency, and negotiations in the WTO, FAO, G20, and regional trade agreements. Prof. Sharma holds an M.Phil. and Ph.D. in Economics from Jawaharlal Nehru University (JNU), specialising in the WTO, quantitative techniques, agricultural policy, and international trade. He is proficient in econometrics, GTAP-based Computable General Equilibrium modelling, Partial Equilibrium analysis, and advanced statistical tools, bringing strong analytical rigour to trade policy research. A prolific academic, he has authored six books, numerous peer-reviewed articles, book chapters, and working papers. He regularly contributes to policy discourse through articles in major newspapers and participation in international forums. Before joining RIS, he served as a Professor at the Centre for WTO Studies (CWS), Indian Institute of Foreign Trade, where he led multidisciplinary teams of economists and legal experts on a wide spectrum of trade and development issues.



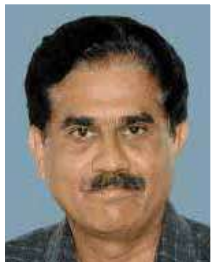
H. E. B Höskuldsson
Ambassador
Embassy of Iceland in
India, New Delhi

H. E. Benedikt Höskuldsson is the Ambassador of Iceland to India, Nepal, Sri Lanka, New Zealand, and Australia. A seasoned diplomat, he has previously served as Iceland's Special Envoy for Climate, Permanent Representative to IRENA, Member of the Nordic Development Fund Board, and Senior Advisor at Sustainable Energy for All. His postings span Vienna, Tokyo, Berlin, and Iceland's Ministry for Foreign Affairs, where he led portfolios on natural resources, energy, environment, and overseas trade. Since 2022, he has co-chaired the India-Iceland Joint Task Force on Energy Cooperation. Ambassador Höskuldsson holds degrees in Economics and International Business and is a recipient of the Order of Nordstjerne from the King of Sweden and Distinguished Alumni Award from Lewis & Clark College, Oregon, USA.



Shri Dheeraj Pande
Director, Atomic
Minerals Directorate for
Exploration and Research
(AMD), Chennai

Shri Dheeraj Pande, an eminent exploration geologist, serves as the Director, Atomic Minerals Directorate for Exploration and Research (AMD), Department of Atomic Energy (DAE), Government of India from May 1, 2024. With over 36 years of distinguished service in AMD, he has made pioneering contributions to the exploration and augmentation of atomic and critical mineral resources such as uranium, thorium, lithium and rare earth elements vital for India's energy security and technological advancement. Throughout his career at AMD, Shri Pande has been involved in diverse exploration projects and mineral resource estimation particularly across complex terrains in the Indian shield and fold belts. His scientific leadership has been instrumental in the prospecting and development of key uranium deposits in the country. For his outstanding contributions, he was honoured with the DAE Group Achievement Award-2016 and the National Geoscience Award-2019 by the Ministry of Mines, Government of India. He has published more than 50 scientific articles in various national and international journals. His published works, including studies on uranium mineralisation in the Middle Siwalik sandstones of Himachal Pradesh, highlight his scientific engagement in Himalayan geological settings.



Dr S C Shenoi

**Fmr Director,
Indian National Centre
for Ocean Information
Services (INCOIS)**

Dr. S. Satheesh Chandra Shenoi, is the Former Director of the Indian National Centre for Ocean Information Services (INCOIS). With over 40 years of research experience, Dr. Shenoi has made pioneering contributions to both marine science research and management. Beginning his career at the National Institute of Oceanography (NIO), Goa (1983–2009), he played a key role in the Arabian Sea Monsoon Experiment (ARMEX), redefining the ocean's active role in monsoonal processes and improving satellite-based sea surface temperature estimation by 50%. Following the 2004 Indian Ocean tsunami, he led critical studies that enhanced tsunami source estimation and contributed to the establishment of India's Tsunami Early Warning Centre and the Ocean State Forecasting System, placing India among the few nations with operational ocean forecasting capabilities. His earlier hydrographic and current-meter observations during 1987–1994 were instrumental in mapping and explaining the seasonal circulation patterns of the Indian Ocean. Elected Fellow of the Indian Academy of Sciences in 2007, National Academy of Science, India in 2009 and few other science academies. Dr. Shenoi has authored over 100 international research papers, with interests spanning observational oceanography, ocean currents, monsoon-ocean interactions, and satellite oceanography. He also established the International Training Centre for Operational Oceanography (ITCOcean) in collaboration with IOC/UNESCO, enhancing global capacity-building and INCOIS's international visibility.



Prof. Balaji Ramakrishnan

**Director, National Institute
of Ocean Technology
(NIOT), Chennai**

Prof. Balaji Ramakrishnan has been the Director of the National Institute of Ocean Technology (NIOT) since September 6, 2024. A Professor in the Department of Civil Engineering at IIT Bombay since 2011, he earlier served as Senior Coastal/Port Engineer at Sogreah Consultants, Dubai (UAE), contributing to major waterfront development projects across the Middle East, India, and other Asian countries. His expertise spans port, harbor, marina, and coastal infrastructure design and development. He has published extensively, including 3 monographs, 75 peer-reviewed journal papers, and 82 conference papers. His excellence has been recognized through numerous awards, notably the Professor S.P. Sukhatme Excellence in Teaching Award (2024), Distinguished Alumni Award (IIT Madras, 2022), IEL Marine Engineering Prize (2018 & 2022), Institution

Prize (2015), R.J. Garde Research Award (2012), Maritime Award by the Ministry of Shipping (2006), and ASME Best Graduate Student Paper Award (2002). His research group has earned fellowships and recognitions from UNESCO-IHE, POGO-SCOR, DST, CSIR, UKIERI, IGARSS, DAAD, AGU, PIANC-COPEDEC, OMAE-ASME, and COPRI-ASCE. Prof. Balaji has led multiple Government- and Ministry-sponsored projects for the Ministry of Earth Sciences, Ministry of Shipping, and DST, along with consulting projects for major ports, maritime boards, state agencies, and private firms. He spearheaded a landmark five-institute collaborative field campaign (IITB, NIOT, NCCR, NIO, NCU) and fostered international academic and scientific exchanges.

Technical Session 6: Bridging the Poles at Home | Strengthening a Comprehensive Third Pole Outlook



Ambassador Sanjay Verma

Member, Union Public Service Commission (UPSC), Former Secretary (West), Ministry of External Affairs (MEA)

Ambassador Sanjay Verma, Member of the Union Public Service Commission (since February 2024), served 34 distinguished years in the Indian Foreign Service. As Secretary (West) in the Ministry of External Affairs from March 2022 to February 2024, he oversaw India's relations with 50 European and Central Asian countries, as well as multilateral engagements with the United Nations, Commonwealth, and NAM. His extensive diplomatic career spanned economic, political, consular, diaspora, public affairs, protocol, and humanitarian assistance domains - most notably coordinating Operation Rahat in Yemen. He has served across Asia (China, Dubai, Nepal, the Philippines), Africa (Ethiopia, Djibouti), and Europe (Spain). A former university-level hockey player, his interests include collecting first-edition books, Bollywood memorabilia and collectibles, reading, music, popular Indian culture, and cinema - believing the Hindi film song to be "the finest poetry." He views cricket and cinema as parallel instruments of nation-building.



Dr Anil V. Kulkarni
Distinguished Visiting Scientist, Divecha Centre for Climate Change, Bengaluru.

Dr Anil Vishnupant Kulkarni is a distinguished scientist at the Divecha Centre for Climate Change, Indian Institute of Science, Bangalore. He acquired a post-graduation degree in Applied Geology from the University of Roorkee, now known as the Indian Institute of Technology-Roorkee. In 1987, he was awarded a Commonwealth Fellowship at McGill University, Montreal, Canada and obtained a Master's degree in Geography, followed by a doctorate in Geology, from Shivaji University, Kolhapur, Maharashtra. Dr Kulkarni has developed many remote sensing-based methods and models to understand the Himalayan cryosphere. The techniques are widely used to map snow and glaciers. The models are used to assess glacier mass balance, stream runoff, and the influence of climate change. Moreover, a velocity, slope and flow law model was developed to estimate ice-thickness distribution. The technique is used to provide a better estimate of glacier-stored water. Mass balance and climate models are combined to understand glacial mass loss under different emission scenarios, indicating the threat to water resources under high

emission scenarios. He published around 120 papers in prestigious international and national journals. These contributions made Dr Kulkarni one of the leading authorities and identified him among the top 2% of researchers worldwide in geological and geomatics engineering.



Dr V S Prasad,
Director (Scientist G)
of the National Centre
for Medium-Range
Weather Forecasting
(NCMRWF), New Delhi.

Dr V S Prasad is the Director (Scientist G) of the National Centre for Medium-Range Weather Forecasting (NCMRWF), under India's Ministry of Earth Sciences. He earned his Ph.D. in Meteorology & Oceanography from Andhra University, Visakhapatnam, and completed post-doctoral work at Kyoto University, Japan. With over three decades of experience, Dr. Prasad has played a key role in developing state-of-the-art data assimilation systems and operational ensemble forecasting in India. Under his leadership, NCMRWF conducted India's first global-scale reanalysis project.

His research focuses on data processing, satellite data retrieval, and data assimilation. He has authored over 100 scientific publications and contributed significantly to understanding Indian monsoon dynamics, extreme weather events, and numerical weather prediction systems. Dr. Prasad has been recognized with several awards, including the B. N. Desai Gold Medal, N. Melanchthon Phillip Prize, Mausam Bi-annual Award, and a JSPS fellowship.



Dr Aparna Shukla, Scientist
F, Ministry of Earth
Sciences, New Delhi.

Dr Aparna Shukla currently works as a Scientist at the Polar and Cryosphere Division of the Indian Ministry of Earth Sciences (MoES), and is based in New Delhi. Her background is in geology, and she holds a PhD on Himalayan Cryosphere specializing in the debris-covered glaciers. Aparna has served in different capacities at the apex organisations in India including the Geological Survey of India, University of Kashmir and Wadia Institute of Himalayan Geology. Her current responsibilities include scientific and economic administration of the India's Polar expeditions to Arctic, Antarctica, Southern Ocean and Himalaya. She is also in-charge of Ministry of Earth Science's extramural funding to national and international projects in the cryosphere and hydrology domain. She is passionate about enabling state-of-the-art research and capacity building to advance India's interests and contributions in polar and cryosphere science. Aligning the government initiatives with national priorities and international

goals, popularising and promoting polar and cryosphere research to a larger audience remains the core of her endeavours.

As an outcome of her research in Himalayan Cryosphere, she has published >50 research papers in international journals of repute (including the Science). She has mentored many doctoral students and graduate and postgraduate trainees. She has been part of editorial board of national and international journals in the field of glaciology, geoinformatics and geomorphology.



Dr Milap Chand Sharma

Professor at CSRD, JNU

Dr Milap Chand Sharma is a Professor at the Centre for the Study of Regional Development, School of Social Sciences, Jawaharlal Nehru University (JNU), New Delhi. He holds M.A., M.Phil., and Ph.D. degrees and specializes in Glacial Geomorphology, Palaeoclimatic Reconstruction, Chronology and Mass Movements in the Himalayas. He has over 115 research communications in the Quaternary International, Quaternary Science Reviews, Geomorphology, Progress in Physical Geography, GeoScience, Anthropocene, Zeit fur Geomorphology, Nature, Nature Plants, Nature Scientific, Current Science, Geological Society of America Bulletin and others; with over 3100+ Research citations.

Plenary: The Living Grasslands | Linking Pasture, People, and Policy in the Himalaya and the Arctic



Ms Karen Marie Oseland

**Advocacy & Networking
Specialist, ICIMOD, Nepal**

Ms Karen Marie Oseland is an Advocacy & Networking Specialist, HKH-Arctic Lead, at ICIMOD, where she has led the organisation's Arctic-Hindu Kush Himalaya (HKH) initiative since April 2025. She focuses on strengthening cooperation between the Arctic and Himalayan regions, bringing her deep expertise in international relations and climate diplomacy. With several years of experience in Arctic affairs, Karen has previously worked on the Climate & Arctic team at the Norwegian Embassy in Washington, D.C., collaborated with the High North Center for Business & Governance at Nord University in Bodø, and contributed to The Arctic Institute. She also offered consultancy services in Washington, D.C. on climate and nature-based solutions. From 2019 to 2020, she worked at ICIMOD as a Climate & Energy Analyst, focusing on hydropower policy and Arctic-HKH linkages. Karen holds a Master of Science in Global Affairs (Energy & Environment Policy) from New York University, and three Bachelor's degrees in Geosciences, Political Science, and Global Studies from Pacific Lutheran University. In addition, she earned a Post-baccalaureate Certificate in Geographic Information Systems from Pennsylvania State University. At ICIMOD, she is playing a key role in shaping trans-regional strategies that bridge mountain and polar regions, underlining her commitment to inclusive climate advocacy and cross-regional knowledge exchange.

Technical Session 7: Turning the Tables | From Novel Ideas to Expert Insights



Dr Avinash Kumar,
Scientist E, National
Centre for Polar and Ocean
Research (NCPOR), Goa

Dr Avinash Kumar is a Scientist E and Scientist-in-Charge (Outreach and Cooperation) at the National Centre for Polar and Ocean Research (NCPOR), Goa, India. He specializes in Marine Geology, Remote Sensing and GIS, Sea Ice and Climate Dynamics, with a research focus on understanding the role of polar regions and oceans in global climate change. His work investigates multi- and intra-decadal variability in Antarctic and Arctic sea ice, ocean-atmosphere interactions, Arctic warming linkages with Asian weather extremes, Antarctic ice-shelf prediction modelling, and the impacts of ocean heat flux, salinity, and hydrodynamic processes. Dr. Kumar holds a Ph.D. in Marine Geology from Mangalore University, an M.Sc. in Marine Geology from Cochin University of Science and Technology, and a B.Sc. in Geology, Physics, and Chemistry from Patna University. He has received several honours, including the Outstanding Employee Award (2024) from NCPOR, Certificate of Merit (2021) from the Ministry of Earth Sciences, Atal Vigyaanika Shikhar Samman (2020), and the KOPRI Asian Polar Science Fellowship (2020). His professional journey began as a Junior Research Fellow (2005–2008) under the Department of Science and Technology (DST), followed by a Senior Research Fellowship (2008–2010) under the Council of Scientific and Industrial Research (CSIR). He joined NCPOR as Research Scientist B (2010–2013), promoted to Scientist C (2013–2017) and Scientist D (2017–2021), and currently serves as Scientist E (2021–present), leading polar research initiatives and international scientific cooperation.



Dr Archana Singh
Scientist-D at the National
Centre for Polar and Ocean
Research (NCPOR), Goa

Dr Archana Singh is a Scientist-D at the National Centre for Polar and Ocean Research (NCPOR), Goa, and has been actively involved in India's Arctic research and expedition activities for over a decade. Her research focuses on Polar Ecology, Environmental Studies, and Biogeochemical Processes in the Arctic region. She holds a Bachelor's degree in Chemistry from Hindu College and a Master's in Organic Chemistry from Delhi University. In her PhD work, Ms. Archana focused on biogeochemistry and biotechnology of organic biomolecules from the Arctic environment. At NCPOR, Ms. Singh leads and co-leads several projects addressing polar biogeochemical dynamics. She has authored around 17 peer-

reviewed publications, including research articles, reviews, and book chapters, and has participated in seven Arctic expeditions and cruises, many of which she has undertaken in leadership roles.

In addition to her scientific research, Ms. Singh plays an active role in the management and operational coordination of the Indian Arctic Programme and Expeditions. She has also represented India at various Arctic Council meetings and currently serves as India's representative in the IASC Terrestrial Working Group and ICARP IV Research Priority Team 7 (RPT7). She is also the Co-Chair of the SIOS Research Infrastructure Coordination Committee.

Ms. Singh was selected as the Indian representative for the Arctic Frontiers Emerging Leaders Programme 2025, supported by the Royal Norwegian Embassy, New Delhi. A strong advocate for science communication, she has been an invited speaker at numerous scientific, policy, and public forums and has received the DST-AWSAR Award (2021) for her impactful popular science writing.



Dr Vikram Goel

**Scientist-D at the National
Centre for Polar and Ocean
Research (NCPOR), Goa**

Dr. Vikram Goel is a Scientist-D at the National Centre for Polar & Ocean Research (NCPOR), where he specializes in Antarctic glaciology with a focus on ice dynamics, surface mass balance, and the evolution of Antarctic coast. His research integrates geophysical techniques—including ice-penetrating radar, seismics, GNSS systems along with remote sensing and ice-flow modelling—to investigate how Antarctica's coast is responding to climate change. Dr. Goel completed his doctorate from the University of Oslo, Norway, in 2019, under Antarctic Glaciology PhD studentship program supported by the Ministry of Earth Sciences. His work is informed by extensive fieldwork across five Antarctic expeditions, during which he has conducted 1500+ km of ground-based radar surveys and participated in complex field Operations. He has been involved in several international collaborative projects, more recently leading geophysical surveys in the SENS project on the Nivlisen Ice Shelf and the multinational RAICA-CP expedition in West Antarctica. His research has been published in journals such as *The Cryosphere* and *Journal of Glaciology*, and he has contributed to landmark datasets including Bedmap3. Recognized with NCPOR's Outstanding Employee Award in 2025, Dr. Goel has been actively involved in polar science leadership roles beyond his research activities. He currently



Dr Geetha Sasikumar, Principal Scientist in the Shellfish Fisheries Division of ICAR–CMFRI, Kochi

serves as the early career researcher representative to the SCAR RINGS Action Group and as one of India's national representatives to the SCAR GeoSciences Group, contributing to the coordination of international polar research efforts.

Dr Geetha Sasikumar is a Principal Scientist in the Shellfish Fisheries Division of ICAR–CMFRI, Kochi, with nearly three decades of research experience in cephalopod and bivalve fisheries management, bivalve mariculture, stock assessment, and environmental monitoring. She has played a pivotal role in disseminating scientific bivalve farming techniques, incorporating location-specific refinements that facilitated the successful adoption and commercialization of mussel farming along the west coast of India. She holds a B.F.Sc. in Fisheries Science and an M.F.Sc. in Aquaculture from the Kerala Agricultural University, and a Ph.D. in Biosciences from Mangalore University. As a member of the 12th Indian Scientific Expedition to the Southern Ocean (ISE-SO-12), she contributed to studies on cephalopod biodiversity, squid ageing, and Antarctic trophic ecology. Her scientific output includes numerous peer-reviewed publications, technical reports, species descriptions, stock assessments, and outreach manuals, along with key contributions to national frameworks such as the Marine Fish Stock Status of India. She currently leads the national research programme on the Assessment and Management of Small-scale Bivalve and Gastropod Fisheries in India (2024–29), while also contributing to molluscan mariculture development and advancing practical strategies for sustainable marine fisheries.



Dr Lakshmi Devi P, Assistant Professor, Centre of Research in Marine Sciences, JAIN, Kochi

Dr Lakshmi Devi P, currently working as Assistant Professor, Centre of Research in Marine Sciences, JAIN (Deemed to be University), Kochi campus, completed her Master's and Doctoral Degree in Marine Biology, from the Department of Marine Biology, Microbiology and Biochemistry, School of Marine Sciences, Cochin University of Science and Technology, Kerala, India. She has 10 years of experience in post graduate and undergraduate teaching as well as research. Her areas of specialisation include Marine biodiversity, Taxonomy and Habitat Ecology and have a few papers published in this discipline. Presently, Dr Devi's scientific attempts are focused on the development of biodiversity inventory, climate change studies

and Ecosystem management. Her recent research endeavours extend to the Indian Arctic Program, wherein she acts the Co-Investigator of the on-going project on Borealisation and Climate change driven animal migrations in the Norwegian Arctic, which is critical for shaping global climate adaptation strategies.



Shri Keshav Verma
Research Associate,
Indian Council of World
Affairs (ICWA), New Delhi.

Shri Keshav Verma is a Research Associate at the Indian Council of World Affairs, New Delhi. He is pursuing Doctor of Philosophy in International Relations from the Department of International Studies, Political Science and History, CHRIST (Deemed to be University), Bengaluru. His research areas are Global Commons, Indo-Pacific, Non-Traditional Security, India's Foreign Policy, etc. Previously, he was a Senior Researcher at the Centre for East Asian Studies, CHRIST University and a Project Assistant in collaboration with George Washington University, Washington D.C., funded by the U.S. Department of State. He has published several research articles, book chapter and op-eds on various platforms such as SCOPUS, Springer, UGC CARE 1, Peer-Reviewed Journals and Think Tanks. He is also a reviewer of Journal of Political Science and International Relations, Science Publishing Group, New York.

Technical Session 8: Changes in High-Seas Realm | Innovating for Ocean Sustainability



Dr M A Atmanand

Former Director of the
National Institute of
Ocean Technology (NIOT),
Chennai

Dr M A Atmanand has 40 years of experience in the field of ocean technology and retired as the Director of the National Institute of Ocean Technology Chennai. He is a Guest Professor at the Indian Institute of Technology, Madras - Chennai and a Visiting Professor at the National Institute of Technology (NIT), Calicut, India. He is nominated as Chair of the Marine Systems Panel, Naval Research Board, Defence Research and Development Organisation (DRDO), Govt. of India. He is the Governor's nominee to the Planning board of Bharathidasan University.

An Instrumentation and Control Engineer by profession, he took his undergraduate degree from University of Calicut, Master's and doctorate degrees from Indian Institute of Technology, Madras, India. He has presently coined specific courses based on his vast experience in Ocean technology and is sharing the same with the students.



Prof. Manell E Zakharia

Distinguished Professor,
Underwater Acoustics and
Signal Processing, France

Prof. Manell E Zakharia is a distinguished Professor in Underwater Acoustics and Signal Processing, with over four decades of expertise in sonar systems, acoustic imaging, and environmental acoustics. Affiliated with the French Naval Academy (École navale / IRENAV, Brest, France), he has made significant contributions to underwater acoustics, synthetic aperture sonar, and advanced signal processing for seabed and marine environment imaging. A former President of the French Society of Acoustics and the European Acoustics Association (EAA), Prof. Zakharia has actively contributed to the relaunch of Acta Acustica as an open-access journal and received the prestigious EAA Award in 2011 for his outstanding contributions to promoting acoustics in Europe. Prof. Zakharia is an Honorary Fellow of the ASI, Acoustical Society of India. His collaborations with "Expertise France – NIOT" have supported Indo-French

initiatives in marine technology and the blue economy. Through his publications, technical leadership, and continued engagement in marine research, Prof. Zakharia has established himself as a leading figure at the intersection of underwater acoustics, remote sensing, and environmental monitoring.



Dr Stuti Banerjee
Senior Research Fellow,
Indian Council of World
Affairs (ICWA),
New Delhi

Dr Stuti Banerjee is a Senior Research Fellow at the Indian Council of World Affairs (ICWA), New Delhi, where she conducts research on North America, Latin America and the Caribbean, the Indo-Pacific, and the polar regions. Her work focuses on producing analytical studies on politics, economy, strategy, and security, with particular emphasis on U.S. and Indian foreign policy and the polar policies of both nations. Prior to joining ICWA, she served as an Associate Fellow at the Centre for Air Power Studies (CAPS), New Delhi, where she was part of the Nuclear Security Project studying the development of nuclear energy in Asian countries. She has also worked as a Research Intern at the Observer Research Foundation (ORF). Dr. Banerjee holds a Ph.D. from the American, Canadian, and Latin American Studies Division, School of International Studies, Jawaharlal Nehru University (JNU), New Delhi.

Technical Session 9: Building Ocean Resilience | An Ecosystem Approach



Dr R S Maheskumar,
Director and Head of
Department (Scientist-G)
at the Centre for Marine
Living Resources & Ecology
(CMLRE), Kochi

Dr R S Maheskumar currently serves as the Director and Head of Department (Scientist-G) at the Centre for Marine Living Resources & Ecology (CMLRE), under India's Ministry of Earth Sciences. In this role, he oversees the national programme for mapping and managing marine living resources, coordinating deep-sea biodiversity research, and driving ecosystem-based strategies for sustainable exploitation. He specializes in atmospheric aerosol–cloud–precipitation interactions, a unique intersection of atmospheric science and marine ecology, which helps inform how climatic variables influence marine ecosystems. With a Ph.D. in Physics (1999, Pune University), an M.Tech in Atmospheric Sciences (Andhra University), and an M.Sc in Applied Physics (Gandhigram Rural University), Dr. Maheskumar brings strong interdisciplinary training to his leadership.

Under his direction, CMLRE contributes significantly to two major national objectives: the inventory and optimal use of commercially exploitable marine living resources, and understanding the response of these resources to environmental changes, such as acidification and ecosystem stress. He also plays a pivotal role in India's Deep Ocean Mission, specifically focussing on exploring and conserving deep-sea biodiversity within the Indian Exclusive Economic Zone using advanced technologies. Dr. Maheskumar's leadership aligns with CMLRE's broader mission: to conduct transformative research on marine ecology, deliver actionable science for sustainable blue economy practices, and strengthen India's global presence in ocean science.



Dr. Vijay Kumar,
Scientist G at the Ministry of
Earth Sciences (MoES)

Dr. Vijay Kumar is Scientist G at the Ministry of Earth Sciences (MoES), where he oversees the monitoring and coordination of programmes related to Polar Science and the Cryosphere including the Arctic, Antarctic, and Himalaya, as well as initiatives on the Southern Ocean, water cycle, ocean technology, ocean surveys, and mineral resources. His work encompasses geo-scientific studies of India's Exclusive Economic Zone, delineation of the continental shelf, exploration of polymetallic nodules, and hydrothermal sulphides. His research expertise spans groundwater modelling, hydro-meteorological analysis, climate change, spatial modelling, and lake hydrology. Prior to joining MoES, he served



Dr Sarat Chandra Tripathy,

Scientist-F in the Polar Sciences Group at the National Centre for Polar and Ocean Research (NCPOR)

at the National Institute of Hydrology (NIH), contributing extensively to R&D in hydrology, to consultancy and sponsored projects and conducting specialized training courses on hydrological aspects for field engineers. Dr. Kumar has authored over 100 papers in reputed national and international journals and conferences.

Dr Sarat Chandra Tripathy is a distinguished marine scientist currently serving as Scientist-F in the Polar Sciences Group at the National Centre for Polar and Ocean Research (NCPOR), Ministry of Earth Sciences, Goa. With a specialization in Biological Oceanography, his research focuses on phytoplankton productivity, bio-optics, biophysical interactions, and biogeochemistry of polar oceans by integrating sea-truth and satellite observations. Dr. Tripathy earned his D.Sc. in Environmental Sciences from Nagoya University, Japan (2011), following a Ph.D. in Marine Sciences from Berhampur University, conducted at CSIR-National Institute of Oceanography (2005), and an M.Sc. in Marine Biology from Berhampur University (1998, 2nd Rank). Over his career, he has received several prestigious recognitions, including the INSA grant for the XII SCAR-Biology Symposium (2017), Outstanding Poster Presentation Award at PORSEC-2008, and multiple fellowships. His professional trajectory includes key research and academic roles — from Postdoctoral Fellow at the Institute for Space-Earth Environmental Research (ISEE), Nagoya University, to progressive scientific positions at NCPOR since 2012 — underscoring his contributions to advancing marine and polar oceanographic research. Dr. Tripathy has participated in 4 Southern Ocean and 6 Arctic Expeditions and was the Expedition Leader on 8 occasions. Dr. Tripathy has authored more than 75 peer-reviewed research papers, several book chapters, and edited 02 books. He is a member of various international bodies, such as Vice-Chair & EXCOM/SSC member of SOOS, National Representative for PAME Working Group of the Arctic Council, CLIVAR/CliC/SCAR Southern Ocean Region Panel (SORP), and SCAR Life Sciences Group.



Dr Anu Gopinath

Professor and Head, Department
of Aquatic Environment
Management, KUFOS,
Kochi, Kerala



Ms Neetu Kumari Prasad,

Joint Secretary, Ministry of
Fisheries, Govt. of India

Dr Anu Gopinath is a distinguished oceanographer and Professor in the Department of Aquatic Environment Management, Kerala University of Fisheries and Ocean Studies, Kochi, Kerala renowned for her expertise in polar and marine ecosystem research. Dr Gopinath is a Commonwealth Fellow and has participated in Indian Arctic Expedition three times and was the leader of the 2017 summer batch of Expedition. She is collaborating with NCPOR's Antarctic as well as Southern Ocean Programmes through various projects. Dr Gopinath was instrumental in bringing the UArctic membership to KUFOS and she has developed a MOOC course for UGC –SWAYAM platform for Arctic studies which is entitled as "Understanding the Arctic- Climate and The Need for Environmental Protection" which was listed among the top 100 courses globally by the Class Central Platform in September 2024. She is collaborating with two prestigious programmes of ISRO- National Information System for Climate Sciences (NICES) programme and data validation for India's prestigious satellite Oceansat-3 focusing on the Arabian Sea and Bay of Bengal. She is also collaborating with the Coral Bleach Alert Services (CBAS) of INCOIS Hyderabad. Dr. Gopinath has conducted pioneering studies in oceanic biogeochemistry, particularly on coral bleaching and reef degradation in the Lakshadweep archipelago, highlighting their ecological implications. Her work has been widely featured in national media, including The Hindu and Kochi Bureau, in articles such as "Indian researchers exploring the Arctic," "Kerala academic to create polar science course for UGC," and "Death knell for corals".

Ms Neetu Kumari Prasad, is an I.A.S Officer of 2001 Batch, Telangana Cadre. Currently, She is posted as Joint Secretary (Marine Fisheries) in Department of Fisheries, Ministry of Fisheries Animal Husbandry and Dairying. She has worked extensively in Telangana State and has held several key positions such as Commissioner of Panchayat Raj and Rural Development, Commissioner of Commercial Taxes and Member Secretary of Pollution Control Board. She worked as Warangal Municipal Commissioner, Joint Secretary of Tourism Department, Dist. Collector, East Godavari District, Dist. Collector,

Karimnagar District and Commissioner, PR&RD. During her tenure in Telangana, she has several achievements to her credit such as Received National Award from the Prime Minister of India for implementing Aadhar (Unique Identification Number) linkage with the social security schemes, National Award from the Prime Minister of India, for Excellence in Public Administration, received the National Award for the best state in the capacity of Commissioner Rural Development for good performance in skill development, etc.

Technical Session 10: The Polar Regions | Witnessing a Decade of Geopolitical Shift



Dr Acquino Vimal,
Joint Secretary of the
United Nation Economic
and Social (UNES) Division,
MEA, New Delhi

Dr Acquino Vimal, Joint Secretary of the United Nation Economic and Social (UNES) Division, is a senior diplomat in the Ministry of External Affairs of India. He joined the Indian Foreign Service in 2000. He had served as the Ambassador of India to the Kingdom of Norway (2023-2025), where he promoted Indian-Norway relations, primarily focusing on economic and trade relations; research and academic collaboration as well as political engagement. He has also represented India at various Arctic related events in Norway, including the Arctic Council meetings, Arctic Frontiers Conference at Tromso, Arctic Congress in Bodo and Arctic Security Conference in Oslo. He had also visited Himadri, India's polar research station at Ny Alesund as well as other research and academic institutions dealing with polar issues in India and Norway. Prior to this, he had also served in the Embassy of India in Beijing (2018-2023); High Commission of India, Kuala Lumpur (2014-15); High Commission of India, Islamabad (2011-13); Permanent Mission of India for UN in New York (2008-11); and the Indian Embassy in Tehran (2002-05). At the Ministry of External Affairs in Delhi he had served as a Desk Officer for Afghanistan and as Director in Americas Division as well as in a couple of functional Divisions of the Ministry.



Rear Admiral Monty Khanna, AVSM, NM
(Retd), Member, National
Security Advisory Board,
New Delhi

Rear Admiral Monty Khanna, AVSM, NM (Retd) was commissioned into the Indian Navy in January 1983, where he was awarded the 'Best Naval Cadet' and the Midshipman 'Sword of Honour'. A submariner and surface warfare officer, his afloat commands include the Indian Naval Submarine Sindhuvijay and the frigates Krishna and Gomati. He has held several key appointments, including Naval Assistant to the Vice Chief of Naval Staff and the Flag Officer Commanding-in-Chief, Western Naval Command, as well as serving as the Naval Attaché at Embassy of India, Washington D.C. On promotion to Flag Rank, he was appointed Assistant Chief of Naval Staff (Foreign Cooperation & Intelligence) and later served as Commandant of the Naval War College, Goa (2014–2017), where he conceived and executed the first Goa Maritime Conclave. Subsequently, he was Chief Instructor at the Defence Services Staff College until his retirement in August 2019. He later joined the National Security Council Secretariat (NSCS), New Delhi, as Assistant Military Adviser in December 2019, officiating as the Military Adviser from September 2022 to December

2023. A graduate of Defence Services Staff College, Wellington, and Naval War College, Newport, USA, Rear Admiral Khanna was awarded the Nao Sena Medal in 2000 and the Ati Vishisht Seva Medal in 2017. He has published over 20 professional articles in reputed journals including ORF Issue Briefs, Maritime Affairs, and the US Naval Institute Proceedings, and frequently lectures on leadership, naval and military strategy, Indo-Pacific geopolitics, developments in PLA Navy, shipbuilding, and armed forces restructuring.



Dr Uttam K. Sinha,
Senior Fellow, Institute
for Defence Studies and
Analyses (now Manohar
Parrikar-IDSA)

Dr Uttam Kumar Sinha is a leading voice on transboundary water governance, climate change, and Arctic geopolitics. He joined the Institute for Defence Studies and Analyses (now Manohar Parrikar-IDSA) in 2001. As a Senior Fellow, he leads the Centre for Non-Traditional Security and serves as Managing Editor of Strategic Analysis, the institute's flagship journal published by Routledge.

Over the years, he has held prestigious fellowships and leadership positions, including as Senior Fellow at the Prime Ministers Museum and Library (2018–2020), Academic Visitor at the Harvard Kennedy School (2015), Chevening Gurukul Fellow at the LSE (2008), and Visiting Fellow at the Peace Research Institute Oslo (2006).

Among his many publications, he is the author of *Trial By Water: Indus Basin and India-Pakistan Relations* (Penguin Random House, 2025) and the widely acclaimed *Indus Basin Interrupted: A History of Territory and Politics from Alexander to Nehru* (Penguin Random House, 2021). He writes regularly for the Times of India and Indian Express.



Commodore S Muthu Krishnan,
Dean, Faculty of Arctic
Studies, Naval War College,
Goa

Commodore S Muthu Krishnan is serving in the Indian Navy and has put in close to 28 years of commissioned service. He is a Navigation and Direction Specialist and has commanded 03 warships. He is presently posted as Dean, Faculty of Studies at the Naval War College (NWC), Goa and tenants the additional appointment of DS (Arctic Studies) at the Centre of Arctic Studies (CAS), NWC. He is an alumnus of Defence Services Staff College (DSSC), Wellington and Army War College (AWC), Mhow. He is presently pursuing his PhD in Arctic studies from the Mumbai University. He has spoken at many Arctic forums including at Oslo, Norway during Arctic Security Conference 25. He has been the guide to many researchers on Arctic Matters.



Prof Sasmit Patra,
Member of Parliament,
Rajya Sabha

Prof (Dr) Sasmit Patra, Ph.D. in Management, MBA, and B.A. (Hons.), LL.B., is a second-term Rajya Sabha Member of Parliament from the Biju Janata Dal (BJD), elected from Odisha. He currently serves as the Leader of the BJD Parliamentary Party in the Rajya Sabha and has earlier served as its Chief Whip. A National Spokesperson and General Secretary of the BJD, Dr. Patra has been a member of several key Departmental Parliamentary Standing Committees, including those on Education, Women, Children, Youth and Sports; Law and Justice; and Petroleum and Natural Gas. He has also served on Consultative Committees on External Affairs, Law and Justice, Coal and Mines, and Rural Development and Panchayati Raj, as well as on the Committees on Office of Profit, Privileges, General Purposes, and Ethics. According to the Rajya Sabha records (January 2024), Dr. Patra has asked 436 questions, introduced 16 Private Members' Bills, and participated in 1,388 debates, maintaining an impressive 92% attendance, including 100% attendance in 10 of the 14 sessions since his election in July 2019. Academically, he served as Dean and Professor at Xavier Institute of Management (XIM) University, Bhubaneswar, and is also an Advocate and member of the Supreme Court Bar Association. Renowned for his articulate and impactful parliamentary interventions, Dr. Patra is widely recognized for his contributions to national and Odisha-related policy debates that have influenced public discourse and governance.



Dr Swati Basu,

Fmr Secretary, Principal Scientific Advisor, and Fmr Director, NCMRWF

Dr Swati Basu is the Former Scientific Secretary in the Office of Principal Scientific Adviser, Government of India and an Environmental Scientist with over four decades of leadership in atmospheric and climate sciences. A Fellow of the Indian Meteorological Society and recipient of the Polar Certificate from the Norwegian Polar Institute and the WMO Fellowship, she previously served as Director, National Centre for Medium-Range Weather Forecasting (NCMRWF) and Adviser, Ministry of Earth Sciences. Holding a Ph.D. in Air Pollution Modelling from IIT Delhi, she now contributes to national science policy through various committees of Government of India and Institutes. She has the distinction of being the first Indian woman to go up to 80-degree North in the Arctic during July 2013 representing India.



Dr M Sudhakar,

Fmr Director, Centre for Marine Living Resources and Ecology (CMLRE), Kochi.

Dr M Sudhakar has served two premier research institutions of the country—NIO and NCPOR in Goa. He took charge as Director, CMLRE, Kochi in 2018 till 2020. A veteran oceanographer, he has occupied various positions such as project leader and scientist and has spent more than 1,500 days at sea on-board research vessels, as leader of expeditions to the Southern Ocean and Antarctica. He represented India at the Preparatory Commission for the United Nations Law of the Sea (PrepCom) and was an Elected Member of the Legal and Technical Commission of the ISBA for the term 2007-2011 and (2012-16). Dr Sudhakar was also a member of SCOR, ICSU, serving for the second term until 2014. He was a visiting scientist to the Aachen University of Technology, Germany; a Resource Person of the International Ocean Institute, Malta; Member, National Steering Committee for Science and Astronomy Olympiads and Member, Scientific Committee, International Geological Congress 2020. He was the 'Commissioner General' of Government of India for the Yeosu (World) Expo 2012 held in the Republic of Korea.



Mr Ishaan Gera,

Journalist, Money Control,
New Delhi

Mr Ishaan Gera is a journalist and economic commentator, currently serving as Associate Editor at Moneycontrol. He joined the publication after building his career at other top-tier Indian financial media outlets, including The Economic Times, Business Standard and Financial Express. At Moneycontrol, Ishaan covers macroeconomic trends, government policy, market dynamics, and other data-driven business stories. His work reflects a strong analytical orientation, combining empirical evidence with nuanced insights—highlighted by his articles on India’s economic growth, inflation trajectory, labor force participation, and investment patterns. He has also authored articles for Forbes India. His reporting often centers on the intersection of economics, policy, and society. Mr. Gera became a member of LIGHTS (Learning, Innovation, Governance, Humanity, Technology, Sustainability) in 2022, contributing his economic and policy expertise to the organization.

Delegates

SaGAA VIII 2025
National and
International Delegates

National Delegates



Dr. Ajit Tyagi

President of Indian
Meteorological Society,
Senior Advisor
ajit.tyagi@gmail.com



Dr. Indira Khurana

Director
Coastal Salinity Prevention Cell
dr.indira.khurana@gmail.com



Commodore Debesh Lahiri (Retd.)

Executive Director
National Maritime Foundation
Email: debeshlahiri@gmail.com



Mr. Shree Verma

President & CEO
Polar Technologies (India)
shree.verma@polartech.org



Mr Dhaval Lakhani

Deputy Director (Senior
Program Manager)
National Security Council
Secretariat.
Email: dhaval.lakhani@gov.in



Shri P. Jagadeesan,

Regional Director, AMD,
Western Region, Jaipur
Email: rdwr.amd@gov.in



Shri Rakesh Mohan,

Deputy Regional, AMD, Northern Region,
New Delhi

Email: drd-nr.amd@gov.in



Shri Kamal Nain Rai

Former Chief Executive (CW&E)
and Advisor (Special Projects),
DRDO

knrai@yahoo.co.uk



Shri Anant Verma

Vice President,
Polar Technologies (India)
anant.verma@polartech.org



Dr. Sheffali Gulati

Faculty-in-charge Child Neurology
Division Department of Pediatrics
AIIMS Delhi



Priyanka Saha Verma

General Manager,
Polar Technologies (India)
Email: priyanka.saha@polartech.org



Sh. Prabhas Kr Pande

Expert, NMHS Project,
University Of Delhi
prabhaspandey.geo@rla.du.ac.in



Dr. (Ms) Swayamprabha Das

National Coordinator – Marine Conservation, The Climate Project Foundation
das.swayamprabha@gmail.com



Aparajita Singh,

Editor,
Business & Management,
Economics, Political Science and
International Relations, Palgrave
Macmillan, New Delhi
aparajita.singh.1@springernature.
com



Dr. Mahesh Mohan

Assistant Professor, MG University
Mob: 9447871596
maheshmohan@mgu.ac.in



Sh. Pradeep Kumar,

Director, Geological Survey
of India (GSI), Faridabad
pradeep.kumar@gsi.gov.in



Er. Anurag Sinha

Executive Director,
Engineers India Ltd.
anurag.sinha@eil.co.in



Sh. Abhishek Verma,

Superintendent Geologist/
Director, Geological Survey of
India (GSI), Faridabad
abhishek.verma@gsi.gov.in



Dr. Vandana Chaudhary

Scientist G
Ministry of Earth Sciences
Government of India
v.chaudhary@nic.in



Dr. R. Sendhil Kumar,

Scientist-E, Centre for Marine Living
Resources and Ecology
Email: sendhil.r@cmlre.gov.in



**Dr. Sanjay Kumar
Prajapati**

Scientist-F
National Center for Seismology
Sanjaynecessary@gmail.com
sanjay.kp@nic.in



Dr. Ambikapathi

Scientist-D
National Centre for Seismology
ammani.ambikapathy@gmail.com



Dr. Babita Sharma

Scientist-F
National Center for Seismology
babita_s@rediffmail.com
babitamoess@gmail.com



Dr. Babita Sharma

Scientist-F
National Center for Seismology
babita_s@rediffmail.com
babitamoess@gmail.com



Dr. A. Ramesh Kumar

Principal Scientist
Solid and Hazardous Waste Management,
CSIR- NEERI
ar_kumar@neeri.res.in



Dr. Tejavath Charan Teja

Scientist B
Atmospheric Science Group (ASG)
National Centre for Earth Science Studies
charan.tt@ncess.gov.in



Drs Padma Rao,

Scientist D,
SERG, National Centre for Earth Science
Studies
padmarao.b@ncess.gov.in



Dr. Sneha Mukherjee

Scientist B,
SERG, National Centre for Earth Science
Studies
sneha.m@ncess.gov.in



Dr. Yashwanth B. S.,

Scientist-C, CMLRE
yashwanth.bs@cmlre.gov.in



Dr. Bhanumathi Sharma

Associate Professor
Department of Child Development
University of Delhi.
Email: bhanumathisharma@gmail.com



Dr. Raj Kumar Sharma

Senior Research Fellow,
NatStrat
raj.sharma@natstatindia.org



Dr. Madan Yadav,

Assistant Professor,
SSS, IGNOU, New Delhi
Email: mkyadav@ignou.ac.in



**Prof. Dr. Dhiraj Mohan
Banerjee, FNA**

Alexander von Humboldt, British Council
& JSPS Fellow, Former Professor & Head,
Center of Advanced Study in Geology,
University of Delhi
dhirajmohanbanerjee@gmail.com



Dr. Geetha Priya,

Professor at the Centre for Incubation
Innovation Research and Consultancy
(CIIRC),
Jyothy Institute of Technology,
Bangalore
geetha.p@ciirc.jyothyit.ac.in



Rajesh Sachdev

Professor,
RLAC Delhi University
rajeshsachdev.stat@rla.du.ac.in



Ms. Seema

Professor,
Ram Lal Anand College,
University of Delhi
seemagupta.stat@rla.du.ac.in



Dr. Ravish Lal

Assistant Professor
Department of Geology
Ram Lal Anand College
University of Delhi
Ravishlal.geology@rla.du.ac.in



Ravindra Pratap Singh

Assistant Professor
University of Allahabad
Email: rpsinghsaran@allduniv.ac.in



Ms. Rachana

Modern School Vasant Vihar
Teacher-Geography PGT
Email: rachana.om@gmail.com



Dr. Indra Sekhar Sen

Associate Professor
Department of Earth Science
Indian Institute of Technology
Kanpur (IIT Kanpur)
isen@iitk.ac.in



Leimiwon Zimik,

Assistant Professor
Ram Lal Anand College,
University of Delhi
LeimiwonZimik.geology@rla.du.ac.in



Dr. Sambuddha Misra

Associate Professor
Indian Institute of Science (IISc)
Email: sambuddha@iisc.ac.in



Dr. Gipson Edappazham

Associate Professor, JAIN (Deemed-to-be University) Kochi Campus
Email: e.gipson@jainuniversity.ac.in



Ms. Arushi Sharma

National Institute of Hydrology,
Roorkee
arushi.sharma1395@gmail.com



Dr. Abul Amir Khan

HOD, Earth Sciences,
Amity Centre for Atmospheric & Science
Technology (Amity-COAST) Amity University
Haryana
Email: aakhan@ggn.amity.edu



Deva Jefflin A R

Research Scholar
Centre for Incubation, Innovation
Research
and Consultancy, JIIT, Bengaluru
devajefflin.ar@ciirc.jyothyit.ac.in



Mr. Arvind Kumar

PhD Research Scholar
Department of Geography
Delhi school of Economics
University of Delhi
arvindkumardse@gmail.com



Ms. Aishwarya Sanas

Doctoral Candidate,
Department of International Relations
and Governance Studies,
Shiv Nadar Institution of Eminence
aishwarya.sanas.21@gmail.com



Aditya Kumar

Ram Lal Anand College,
University of Delhi
adi75tya44@gmail.com



Mr. Sudheer Kr. Yadav

University of Allahabad,
Uttar Pradesh
geosudheer@gmail.com



Mr. Soumik Das

Jawaharlal Nehru University,
New Delhi
geo.soumik777@gmail.com



Ms. Aditi Singh Gautam

University of Allahabad
aditiphd2025@gmail.com



Ms. Elora Chakraborty

Jawaharlal Nehru University,
New Delhi
elorchakraborty22@gmail.com



Ms. Shivani Gupta

University of Allahabad
shivinigupta0312@gmail.com



Ms. Vanshika Ojha

University of Allahabad
vanshi.02a@gmail.com



Ms. Mayuri Nishad

Jawaharlal Nehru University (SES)
mayuri.smm14@gmail.com



Mr. Aryavendra Pratap Rao

Ram Lal Anand College
(University of Delhi)
aryapratap8736@gmail.com

Chatter Singh

University of Delhi
du.dse.csingh25@gmail.com



**Ms. Disha Manish
Deshpande**

Amity University Gurugram
dishadeshpande011@gmail.com

Ms. Meghna Prasad

Ram Lal Anand College
prasadmeghna10@gmail.com

Ms. Krishna Rajeev S

Amity University Gurugram
krishnarajeevs1@gmail.com



Prajakta Pradhan

Ram Lal Anand College DU
prajaktapradhan2006@gmail.com

Ms. Sayuri Giri

Amity University Haryana
sayurigiri620@gmail.com

Ms. Dipanwita Das

Ram Lal Anand College, Delhi University
dipanwita7744@gmail.com

Asmitdeep

Ram Lal Anand College,
University of Delhi
asmitdeep23@gmail.com

**Mr. Sreehari P**

Ram Lal Anand College
psree4189@gmail.com

**Ms. Saumya Gupta**

Ram Lal Anand College,
University of Delhi
saumgupta526@gmail.com

**Ms. Kritika**

Ram Lal Anand College,
University of Delhi
Kritikat760@gmail.com

**Ms. Archita Sharma**

Ram Lal Anand College,
University of Delhi
archita328@gmail.com

Ms. Kamala Kumari

University of Delhi
kamala_2003@yahoo.com

Mr. Sandeep Lal

ICAF and IDSA
lal.bobby@yahoo.com
Mob No.: +91-8700450046

Mr. Divyansh Rodney

PhD Research Scholar
Jawaharlal Nehru University
divyanshrodney@gmail.com

Mr. Ram Manohar

PhD Research Scholar
Delhi School of Economics
University of Delhi
manoharram465@gmail.com

Mr. Chitranjai Kumar

Journalist
chitranjaikumar@gmail.com

Mr. Aniket Singh

Social Media Team
Ministry of Earth Sciences
Government of India

Mr. Kamal Chand

Social Media Team
Ministry of Earth Sciences
Government of India

International Delegates



Ms. Tinna Sveinsdóttir

Deputy Chief of Mission
Embassy of Iceland
Email: tinna.sveinsdottir@utn.is



Eirik Grimnes Haga

Student Intern, Political team
and Communication,
The Royal Norwegian Embassy,
New Delhi
Eirik.Grimnes.Haga@mfa.no



Ms. Marguerite Salles

Political Counsellor,
French Embassy in India
marguerite.salles@diplomatie.
gouv.fr



Ms. Nora Harboe Dokken

Second Secretary,
Political Team
The Royal Norwegian
Embassy in New Delhi
nora.dokken.harboe@mfa.no



Karine Nigar Aarskog

Director for Communications,
NPI
karine.nigar.aarskog@npolar

Mr Iskander Akhmedov

Attache, Russian Russian Embassy
in India

Mr. Paul Zholobov

Russian Russian Embassy
in India
zholobovpd@gmail.com

Section D

The Discourse

SaGAA VIII 2025

Plenary, Turning the
Tables Abstract, Panel
Abstracts

Plenary Abstracts

Prof (Dr) Sasmit Patra

Member of Parliament, Rajya Sabha

The Indian Parliament | Shaping Governance and collaborations in the cold regions

In the present global context, India's Polar engagement is an essential pillar of climate diplomacy. With Arctic warming accelerating four times faster than the global average and cascading risks emerging across the Himalaya, the science we generate directly impacts India's climate adaptation, food security, and disaster risk reduction frameworks. At a time when climate negotiations are increasingly shaped by data from the Arctic, Antarctic, and high mountain Asia, India's scientific presence becomes a strategic asset in global climate decision-making.

Dr Suryachandra Rao

Director, Indian Institute of Tropical Meteorology

From Poles to Monsoon | How Cryosphere–Ocean Feedback is Rewriting India's Future Climate

Arctic sea ice decline has been accelerating under global warming. Observational evidence and idealised model experiments in which the Arctic becomes seasonally ice-free under greenhouse warming reveal an association between the Arctic sea-ice decline and intense precipitation events (IPEs) over South Asia. The enhanced Arctic sea-ice melt increases mid-latitude waviness and intensifies a circumglobal teleconnection-like pattern, strengthening the subtropical high over East Asia. This, combined with a La Niña-like response in the Pacific, enhances mean summer monsoon precipitation over South Asia. In a future warming scenario, Arctic sea-ice melt is likely a contributing factor for the amplified mean and IPEs over the South Asian region. In addition to the atmosphere association, the freshening due to Arctic sea-ice melt can cause weakening of the Atlantic Meridional Overturning Circulation (AMOC). Changes in the AMOC can have a significant impact on the global climate. Sustained warming due to increased greenhouse gas emissions is projected to weaken the AMOC, which in turn can lead to changes in the location of the Intertropical Convergence Zone (ITCZ), oceanic and atmospheric large-scale circulation, tropical precipitation and regional monsoons.

Dr Waliur Rahaman

Senior Scientist, National Center for Polar and Ocean Research (NCPOR), Goa

Is the Paris Climate agreement goal enough to save the Polar Ice Sheets?

The Greenland and Antarctic ice sheets together store approximately 65 m of global mean sea-level (GMSL) equivalent. Even minor reductions in their volume can profoundly reshape coastlines, displacing hundreds of millions of people and causing irreversible loss and damage beyond the limits of adaptation. Both ice sheets have

exhibited accelerating mass loss in recent decades. The West Antarctic Ice Sheet (WAIS), being largely marine-based and grounded below sea level, is particularly vulnerable; its complete collapse could raise global sea level by 3–5 m. Observational and modelling evidence indicate that both ice sheets may already be approaching critical tipping points. However, future projections remain uncertain due to short instrumental records and poor understanding of ocean–ice–atmosphere feedbacks. Geological archives, therefore, provide crucial long-term insights into ice-sheet behaviour under warmer climatic conditions. A recent study by Rahaman et al. (2025, Nature Communications) revealed that the WAIS underwent near-total collapse during the Pliocene warm period under atmospheric–oceanic conditions comparable to those expected later this century, followed by regrowth during the Pliocene–Pleistocene transition. This finding demonstrates that the fundamental tipping thresholds governing WAIS growth and stability were established during that transitional interval. Paleoclimate analogues such as the Last Interglacial and the mid-Pliocene indicate that global temperatures only 1–2 °C above pre-industrial levels were associated with sea levels several meters higher than today. These records suggest that even the Paris Agreement’s +1.5 °C target may not be sufficient to prevent irreversible ice-sheet retreat, underscoring the urgent need for rapid decarbonization and protection of carbon sinks to climate targets to avert irreversible tipping points.

Ms Karen Marie Oseland,
Advocacy and Networking Specialist, ICIMOD, Nepal
**The Living Grasslands | Linking People, Pasture and
Policy in the Himalaya and the Arctic**

The Himalaya and the Arctic—two of the world’s most rapidly warming cryosphere regions—are linked by shared climate risks, intertwined ecosystems, and communities whose knowledge and cultures are shaped by snow, ice, and pasture. This plenary explores why these distant regions must increasingly be understood together, and how ICIMOD’s HKH–Arctic nexus is advancing that connection. The talk highlights two central pillars.

First, youth leadership: through the Hindu Kush Himalaya–Arctic Youth Leadership Forum, ICIMOD is nurturing a new generation of climate leaders equipped to work across regions, disciplines, and generations. Their voices and vision are essential to shaping the future of cryosphere action.

Second, the living rangelands: dynamic socio-ecological systems sustained by Himalayan yak herders and Arctic Sámi reindeer pastoralists. Their Indigenous knowledge - mobility, weather forecasting, pasture indicators, and collective governance - offers holistic models of resilience where climate adaptation, biodiversity stewardship, and livelihoods are deeply interconnected.

Together, these elements demonstrate why linking people, pasture, and policy across mountain and polar regions is not symbolic but necessary. The plenary calls for sustained support to safeguard rangelands, empower communities, and enable young leaders to co-create solutions for a rapidly changing climate.

Turning the Table | Reverse Panel Abstracts

Dr Archana Singh

Scientist D, NCPOR

Permafrost Thaw: Can We Stop? If Not, Then What?

Accelerated warming is destabilizing permafrost—the permanently frozen ground that stores vast reserves of ancient organic matter, dormant microbial communities, and trapped greenhouse gases. Of particular concern is methane, locked in large quantities within permafrost and far more potent than carbon dioxide in its warming effect. The cascading consequences of large-scale permafrost thaw are difficult to fully anticipate from our current vantage point. Thawing permafrost also triggers natural hazards: ground subsidence, thermokarst collapse, erosion, and widespread destabilization of land. These shifts jeopardize roads, buildings, pipelines, and entire Arctic settlements. Similar risks are emerging in the Himalayas and other periglacial regions, where warming-induced slope failure and landslides increasingly threaten infrastructure, hydropower projects, and civil societies. Compounding these challenges is the possibility that thawing ground could reintroduce ancient or stress-adapted microbes into modern ecosystems. Some may possess pathogenic traits—an unsettling reminder of how unprepared the world was for the emergence of COVID-19. Despite these risks, permafrost also represents an untapped reservoir of bioresources: novel molecules, enzymes, and extremophilic microorganisms with potential industrial and biotechnological value. Addressing both the threats and opportunities requires a multidisciplinary, multinational research effort.

A comprehensive framework for action includes:

1. Monitoring:

Mapping permafrost carbon reserves, identifying thaw hotspots, measuring greenhouse-gas emissions, and probing deep permafrost strata for microbial and biomolecular diversity.

2. Risk Assessment & Preparedness:

Implementing structured pathogen screening, genomic surveillance, and stringent BSL-2/3 biosecurity protocols to evaluate and mitigate microbial risks.

3. Mitigation & Harnessing:

Combining policy-level commitments to reduce global emissions with technological pathways to capture, convert, or biologically process methane and CO₂. In parallel, advancing bioprospecting strategies to explore valuable biomolecules, enzymes, and novel microbial strains. Given the transboundary nature of permafrost systems, this framework underscores the need for ethical governance, including clear intellectual-property rights, sample-access agreements, indigenous engagement, and transparent collaboration among Arctic and non-Arctic nations.

Dr Vikram Goel

Scientist D, NCPOR

Accelerating Coastal Antarctic Research: Learning from Recent Field Innovations

Antarctica loses virtually all its mass through its ~50,000-km long coastline, where localised climate conditions govern ice sheet stability. Predicting the future of Antarctic mass loss is thus closely tied to our understanding of how these coastal regions behave, which requires reconstructing the climatological and ice dynamical history of this region. Despite the importance of obtaining these coastal records, logistical constraints mean most coastal sites remain unvisited as crevasse fields, sea ice conditions, extreme weather, and remoteness from stations limit operations to a handful of accessible locations. Even when sites are visited, these constraints often restrict the scale and duration of scientific work. Recent innovations in field logistics, survey platforms, real-time communications, and multinational cooperation are redefining what is possible. The presenter shares insights from his field experiences and observations of the evolving technology landscape. Beyond specific examples, the discussion explores broader questions: how can we systematically identify promising innovations, evaluate their potential, and accelerate their integration into our operations? The presenter welcomes the audience's ideas and experiences.

Dr Geetha Sasikumar,

Principal Scientist,

Central Marine Fisheries Research Institute, CMFRI

Collaborative Fisheries Science and Stewardship in the Southern Ocean

The Southern Ocean (Antarctic) is a unique ecosystem, connecting the Pacific, Atlantic and the Indian Oceans, with an average depth of about 3,270 m (maximum 7,432m). Many unique Antarctic species have been commercially harvested over time from historical whaling and sealing for oil and pelts to today's fisheries targeting Antarctic krill and the Patagonian and Antarctic toothfishes. Developing collaborative fisheries science and stewardship in this region requires an integrated approach that unites nations, research institutions and policy frameworks under a shared vision of ecosystem resilience. Since the climate change reshapes sea-ice patterns, the ocean productivity and species distribution, the need for collaborative science becomes imperative. No single country can understand or manage these rapid ecological shifts alone, making a shared scientific vision essential. This incorporates joint expeditions, real-time monitoring using autonomous platforms for key resources such as krill, toothfish, icefish, cephalopods, and marine mammals and open-access data that shares the same ocean story. Through such cooperation, we can build a stewardship model rooted in trust, transparency, and shared responsibility. The Southern Ocean gives us a unique chance not just to study change, but also to shape a more resilient and compassionate approach to global fisheries governance.

Dr Lakshmi Devi P

Assistant Professor, Marine Science, Center of Research in Marine Sciences, JAIN University

Opening Arctic Sea Routes and Growing Ecological Threats

Melting of Arctic ice is opening up new navigation channels, such as the Northern Sea Route (NSR). Notably, The Northern Sea Route (NSR) draws intense interest from global powers. Russia, leveraging decades of Arctic infrastructure, is collaborating with China on the “Polar Silk Route,” a major extension of China’s Belt and Road strategy, aimed at integrating Arctic sea routes and scaling up cargo volumes to 20 million tons annually by 2030. India, with growing investments and maritime capacity is exploring connectivity through the Chennai–Vladivostok Maritime Corridor and Arctic partnerships for shipbuilding and polar navigation training. While these shorter Arctic shipping routes offer logistical and economic advantages, they introduce severe environmental and ecological risks. Among these, oil spills pose major, poorly understood risks to Arctic ecosystems, impacting critical habitats and species such as polar bears, seals, and walrus. Recent risk assessments found that 27–38% of polar bears in the Kara Sea were potentially exposed to oil contamination, underscoring the threat to biodiversity and the indigenous communities. Further, increased navigation, especially during Arctic darkness, amplifies artificial light pollution. This degrades visibility and can disrupt the circadian rhythms of Arctic wildlife, leading to increased collisions and behavioral shifts in marine mammals and birds. Icebreakers and freighters generate substantial underwater noise, interfering with communication, migration, and hunting of key marine species; especially whales and seals. This adds stress to already vulnerable populations. Most importantly, higher vessel turnover elevates the risk of bioinvasion, as ships release ballast water carrying non-native organisms or propagate them on biofouled hulls. These invasive species threaten the integrity of food webs and Arctic coastal ecosystems, with potential long-term repercussions.

Mr Keshav Verma

Research Associate, Indian Council of World Affairs (ICWA)

Bridging the Poles and the Stars: The Polar-Space Frontiers Initiative

The Polar-Space Frontiers Initiative (PSFI) proposes a new way of thinking about global commons by connecting two extreme environments — the polar regions and outer space. Although these areas seem far apart, both are cold, remote, fragile, and governed by international treaties that emphasise peaceful use and scientific cooperation. PSFI suggests using the polar regions as “Earth laboratories” where new technologies, environmental tools, and human-adaptation methods can be

tested before future missions to the Moon, Mars, and beyond. At the same time, space-based assets such as satellites, remote sensing systems, and AI-enabled Earth observation can greatly improve polar climate monitoring, biodiversity protection, and maritime governance. The initiative encourages collaboration between polar researchers, space agencies, diplomats, and private industry, especially during the upcoming Fifth International Polar Year (2032–2033). It also highlights opportunities for countries like India to strengthen cooperation in emerging areas such as space-based climate services, and science diplomacy. The initiative offers a forward-looking model for turning scientific innovation into cooperation in a fractured world.

Panel Abstracts

Technical Panel 5: HE Benedikt Höskuldsson

Ambassador, Embassy of Iceland to India, New Delhi

Emerging global trade frameworks and India's policy push for food processing

In an era when geopolitical tensions often complicate international cooperation, sustainable technologies offer a uniquely unifying platform—particularly for ocean-focused nations like India and Iceland. Both countries share a commitment to climate-resilient growth, and the fisheries and ocean economy sectors present some of the most promising avenues for collaboration. Iceland's zero-waste fish processing model, combined with its expertise in deep-sea fishing, automation, and resource efficiency, can complement India's strengths in scale, labor capacity, and expanding processing industries. Emerging trade frameworks and India's policy push for food processing and manufacturing can further accelerate joint innovation in marine and renewable technologies. Developing climate-smart "fisheries hubs" can be central to adaptation, reducing losses, strengthening resilience, and unlocking new blue-bioeconomy opportunities. Drawing on experience from the global climate and energy community, this type of partnership can demonstrate how data, technology, and inclusive planning enable sustainable, future-ready ocean economies.

Technical Panel 5:
Shri Dheeraj Pande

Director, Atomic Minerals Directorate for Exploration and Research (AMD),

Decarbonizing India's Energy Future: The Strategic Role of Nuclear Energy in Climate Change Mitigation

Climate change, driven by escalating greenhouse gas emissions, poses a critical challenge to sustainable development for the 21st century. The accelerating climate crisis has placed the world at a decisive moment where scientific innovation must converge with policy vision. Transitioning to low-carbon energy systems is essential to mitigate these impacts, wherein Nuclear power emerges as a critical component of sustainable energy policies. Nuclear energy provides a stable, large-scale and continuous power supply from small quantities of fuel, producing negligible greenhouse gas emissions during operation. Life-cycle assessments show its carbon footprint is on par with wind energy and substantially lower than fossil fuel based power generation. In addition to reducing carbon emission, nuclear power reduces reliance on imported fossil fuels and supports grid stability through high capacity factors. Yet, its global deployment has been restrained by entrenched geopolitical asymmetries, where access to technology, enriched fuel and advanced reactor systems remains concentrated in a few nations. Such concentration of capability constrains collective progress and undermines the universal goal of climate stability. As the planet approaches critical thresholds of global warming, a paradigm shift is needed: nuclear energy must be seen not as a strategic privilege but as a shared global instrument for safeguarding the Earth's climate system. India's vision offers a balanced and ethical template for this transition. Guided by the ancient Indian philosophy of Vasudhaiva Kutumbakam, (the belief that world is one family), India conceives nuclear energy as a common scientific asset to be harnessed peacefully for human welfare. Its indigenous three-stage nuclear power programme, based on a closed fuel cycle, demonstrates how self-reliance can coexist with global cooperation. Committed to achieving Net-Zero emissions by 2070 and reducing the carbon intensity of its economy by 45% by 2030, India advocates for democratizing nuclear knowledge through equitable transparent partnerships, open research exchange and equitable access to fuel-cycle services. Integrating nuclear energy into global green finance frameworks and climate adaptation agendas would allow developing nations to participate fully in the clean-energy revolution. As innovations in small modular reactors, advanced reprocessing technologies and hybrid nuclear-hydrogen systems and advanced waste-management methods mature, they can redefine the global energy architecture. Overall, nuclear power stands as a scientifically credible and strategically vital pillar for climate mitigation efforts and for realizing long-term Net-Zero goals. Achieving climate neutrality, therefore, demands cooperation rather than competition, rooted in scientific integrity, policy foresight and the spirit of shared humanity. Only through such an alliance nuclear energy can evolve from a symbol of power politics into a universal pillar of climate resilience and sustainable development.

Technical Panel 6:

Dr Anil V. Kulkarni

Distinguished Scientist, Divecha Centre For Climate Change
Indian Institute Of Science, Bengaluru

Himalayan water security under a warm climate: Geopolitical risks

The Himalayan mountain has one of the largest concentrations of snow and glaciers outside the Polar Regions. The mountain generates more runoff due to high orographic precipitation and delayed release due to storage as snow and ice. Therefore, water is supplied during the hot and dry season, making many rivers, such as the Indus, Ganga, and Brahmaputra, perennial. In recent decades, the Himalayan range has experienced a higher temperature rise than the global mean, primarily due to elevation-dependent warming. Due to the increased warming, glaciers are losing mass and retreating. Glacier retreat has accelerated over the past few decades. However, the observed tendencies are not uniform across regions. Glaciers in the Great Himalayan and Pir Panjal mountain ranges are losing mass much faster than in Karakoram. Glacier-stored water in the Karakoram is much more considerable than in other mountain ranges, creating a more sustainable water source for the rivers originating in the Karakoram than in the Great Himalayan and Pir Panjal mountain ranges. It can pose a challenge for the transboundary sharing of water resources. Moreover, substantial changes in glacier area and snow cover can create new hazards and risks for the mountain communities. Retreating glaciers can cause hazards from GLOF. The seasonal snow is likely to melt early, potentially changing the seasonal pattern of stream runoff. It will also lead to the early drying of mountain streams and springs, creating a necessity for new adaptation strategies. It will need to examine current water-sharing agreements between nations and states.

Technical Panel 10:
Cmde S Muthukrishnan

Dean, Faculty of Arctic Studies, Naval War College, Goa

Shifting power equations and disruption are both a risk and an opportunity

The opening of the Northern Sea Route (NSR) represents a structural shift in global geopolitics, trade, and security, not a distant possibility but an emerging reality. By shortening Asia–Europe transit routes, reconfiguring power balances, reinforcing Russia’s centrality, and accelerating infrastructure development, the NSR is creating a new maritime and strategic frontier. China’s growing involvement through its Polar Silk Road further intensifies shifting power equations while raising concerns of over-dependence in Moscow. For India, this disruption presents both risk and opportunity. Although geographically distant, India is strategically, economically, and climatically connected to the Arctic’s future. The panelist argues that India must move beyond ambiguity by positioning itself as a stabilising bridge between rival blocs, a credible alternative to China for Russia, and a responsible voice for the Global South. Internally, strengthened coordination, polar training, shipbuilding and strategic transformation of India’s Arctic Policy into an actionable Arctic Strategy are imperative. The concept of the “Indo-Arctic” is proposed as a new framework for India’s 21st-century strategic imagination.



भारतीय वैश्विक परिषद्

Indian Council of World Affairs

 /Sapru.House

 @ICWA_NewDelhi

 /ICWA_NewDelhi

 www.icwa.in

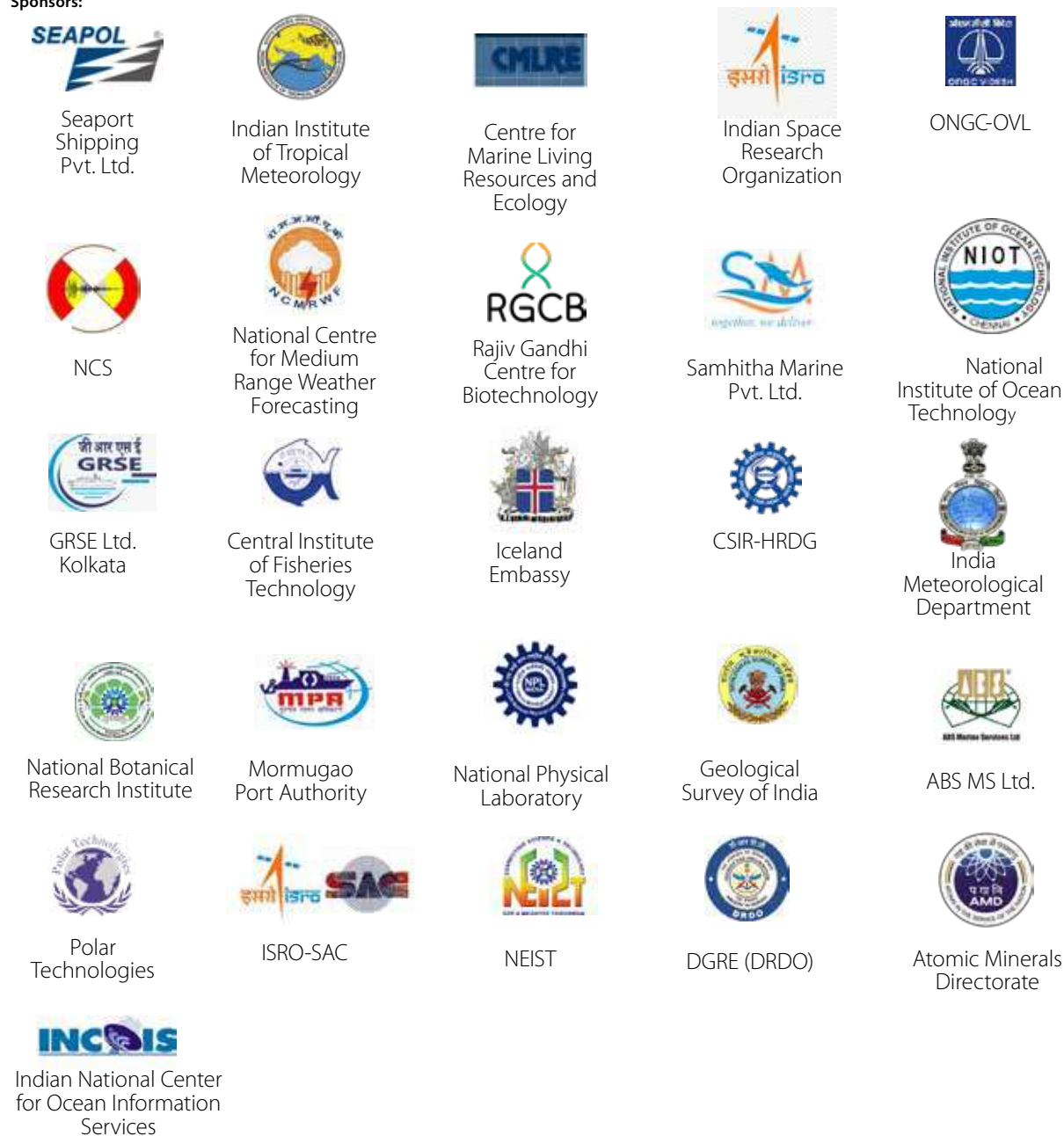
सप्रू हाउस, नई दिल्ली

Sapru House, New Delhi

Partner Organisations:



Sponsors:



Organised by



Knowledge Partner

