The melting of the Arctic ice caps poses a risk of triggering 19 climate tipping points, which can dramatically change the natural climate systems; Thinning sea ice, Canadian Arctic.

PHOTO COURTESY: ROXANNE DESGAGNÉS/UNSPLASH

1. Setting the Context

1.1 Context

SaGAA-LIGHTS has been working towards bringing scientists, policy makers, academia and industry together since 2009 to facilitate a comprehensive dialogue on diverse concerns and opportunities in the face of constantly changing climatic and geopolitical contexts. India has made significant contributions to this cause, whether it be in matters related to the global commons on the high seas or in the remote, frozen lands of Antarctica. The following sections provide a brief overview of the thematic areas that the forum aims to address through the SaGAA 7 Conference and this Report.

1.2 Climate Change: Impact on the Poles

The impact of climate change has become a serious concern in recent years, and the Sixth Assessment Report of the IPCC, 2021 confirms that global warming is leading to more frequent and intense extreme weather events, droughts, and tropical cyclones. The average global temperature has already surpassed the limit of 1.2°C set in the Paris Accord of 2015, and the Report clearly identifies anthropogenic activities as the primary cause of global warming. However, policy makers have been slow to respond to the extensive warnings of the scientific community, with climate discussions complicated by the inclusion of other interests, business opportunities, and economic constraints. It is therefore crucial to raise awareness and engage in multiple platforms to encourage faster climate action.

The Arctic, Antarctic, and Himalayan cryosphere are particularly vulnerable to the impact of climate change, with their rapidly changing conditions a cause for concern. In the Arctic, temperatures have risen twice as fast as the global average in the past 50 years (NASA, 2021), leading to the melting of sea ice and a decline in Arctic sea ice extent by an

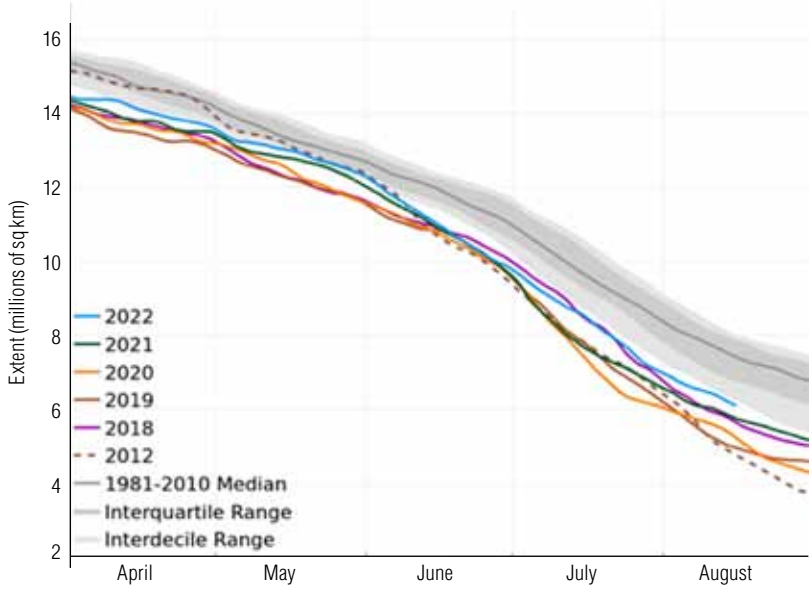
average of 12.8 per cent every decade since satellite records began in 1979 (NSIDC, 2021) (Fig. 1.1). Similarly, warming trends have been observed in the Antarctic, particularly in the West Antarctic Peninsula, where temperatures have increased by 2.5°C over the past 50 years (Turner et al., 2016). This warming has resulted in significant ice mass loss, primarily from the melting of ice shelves, which has the potential to contribute to sea level rise (Rignot et al., 2019). In the Himalayan cryosphere, warming has resulted in the retreat of glaciers that are a critical source of water for millions of people living downstream. Studies suggest that Himalayan glaciers have lost over 15 per cent of their volume since the 1970s, with the rate of loss accelerating in recent years (Mukherjee et al., 2020).

sea level rise
Himalayan
cryosphere

Not all regions of the world are warming at the same rate, with the Polar regions experiencing accelerated warming compared to the oceans and equatorial regions, making it difficult to obtain a clear picture. The Arctic, which is the focus of the SaGAA 7 Conference, has warmed nearly four times faster than the global average in the last four decades (Retanen et al., 2022). However, the observed warming trend in the Arctic, Antarctic, and Himalayan cryosphere underscores the urgent need to reduce greenhouse gas emissions and mitigate the effects of climate change.

In conclusion, the current warming trend and its impact on the Arctic, Antarctic, and Himalayan cryosphere are major concerns, with potential impacts on sea level rise, water

Fig. 1.1: Arctic sea ice extent (area of ocean with at least 15 per cent sea ice)



The graph shows Arctic sea ice extent along with daily ice extent data for four previous years and the record low year (as of August 16, 2022).

Source: National Snow and Ice Data Center, University of Colorado Boulder

action
awareness

scarcity, and the planet's ecosystems. Urgent action is required to reduce greenhouse gas emissions and mitigate the effects of climate change. It is important to raise awareness and engage in multiple platforms to encourage faster climate action.

Senior scientists, policy makers and academics such as Dr M Ravichandran, Dr Shailesh Nayak, HE Ambassador Hans Jacob Frydenlund, Shri Sanjay Verma, Ambassador Pankaj Saran, Dr R Krishnan, Dr K J Ramesh, Dr R P Singh, Dr Bhaswati Das, Er Sonam Wangchuk, Dr Monica Singhania, addressed these concerns at SaGAA 7, highlighting challenges along with suggesting recommendations.

1.3 The Arctic

The Arctic region, once largely unknown and uninhabitable, is seeing a heightened research effort from multiple countries, resulting in a better understanding of its climatology, oceanography, ecology, glaciology, anthropology, and exploration geology. The Arctic is experiencing a warming trend, which is causing significant alterations in sea ice, snow coverage, and frozen ground. The Arctic is melting more rapidly than other Polar regions resulting in temperature spikes and fluctuations that are becoming more frequent and prolonged.

resource extraction
melting permafrost

The melting of Arctic sea ice is opening up opportunities for resource extraction, shipping, and tourism. Still, it also raises concerns about the impact on the region's fragile ecosystem, particularly indigenous communities, and the potential for conflict over territory and resources. The loss of sea ice and changes in ocean currents are affecting the migration patterns of marine mammals and fish, making it difficult for indigenous hunters to access traditional fishing grounds. Additionally, the melting permafrost and changing weather patterns are affecting traditional hunting and gathering practices, damaging infrastructure, such as homes and roads, and threatening food security and cultural heritage.

Polar vortex

The collapse of the Polar vortex, which typically shields the Arctic from warm equatorial air masses, during extreme heat waves or cold snaps, may be responsible for the enhanced warming of the region. The intensity of the Polar vortex is determined by the temperature contrast between the Arctic and the Tropics, but this difference is decreasing because of the Arctic's rapid warming.

albedo

The melting of the Arctic ice caps poses a risk of triggering 19 climate tipping points, which are dramatic changes in the natural climate systems. The ripple effects of this melting is felt around the globe, including the albedo effect, sea level rise, extreme weather conditions, thawing permafrost, and a threat to biodiversity and the economy. The albedo effect refers to the reflective ability of any surface, which determines the earth's terrestrial or outgoing radiation. Thick ice and clouds have a high albedo, reflecting back most of the sun's rays, while barren surfaces and open seas have a low albedo, meaning they absorb the majority of incoming heat. The loss of glaciers and snow contributes to maintaining the earth's delicate

solar insolation balance. Sea level rise is also a significant outcome of melting Arctic ice caps, causing flooding in coastal areas and posing a high risk of land loss for island nations such as Indonesia, the Caribbean, Polynesia, and the Indian Ocean islands.

flooding

1.3.1 India and the Arctic Connections

The Indian monsoon is closely linked to the Arctic glaciers, and the Arctic oscillation plays a role in driving the monsoon and melting Arctic ice (Chowdhury, 2021). The melting of Arctic ice due to global warming can affect the land-sea temperature differences, leading to monsoon extremes that may cause hydrological disasters, homelessness, and migration in India (Rai, 2021).

Arctic oscillation
monsoon extreme

India's investment in scientific research in the Arctic includes the establishment of a research base in Svalbard, Norway, for conducting research on climate change, oceanography, and glaciology. India has also collaborated with Russia and Norway on scientific research projects in the Arctic (Bhatia and Bhattacharya, 2021).

India's Arctic connection is not only scientific but also political. India became an Observer at the Arctic Council in 2013, enabling it to observe and contribute to the Council's work on sustainable development and environmental protection. India's participation in the Council could facilitate collaborations with member nations in Polar sciences, biotechnology, and earth sciences (Bhatia and Bhattacharya, 2021). India's collaboration with Russia includes joint oil and gas projects, access to the Northern Sea Route for trade, and the development of oil fields (Ministry of External Affairs, 2021).

Northern sea route

India sees potential in Arctic tourism and has been exploring opportunities in recent years, attracting travellers seeking to experience the unique landscapes and wildlife of the region (Ministry of External Affairs, 2021). However, India's pursuit of energy security through hydrocarbon exploration in the Arctic region may pose a challenge to its commitments to the Paris Agreement and the Kigali Amendment (Bhatia and Bhattacharya, 2021).

Arctic tourism
hydrocarbon exploitation

Speakers who addressed Arctic endeavours at SaGAA 7 were Dr Anand Jain, Dr Sarat C Tripathy, Dr Paul Dodd, Mr Hjalti Omar Agustsson, Rear Admiral Monty Khanna, Dr R P Pradhan, Cmde Sujeet Samaddar and, Shri Sanjay Baveja.

1.4 The Himalaya

The IHR is an essential source of water for millions of people, but it is vulnerable to various disasters, including GLOFs, landslides, cloud bursts, and avalanches. The retreat of the Himalayan glaciers, caused by climate change, poses a severe threat to the stability of water resources and the lives of those living in the foothills. There is an urgent need for a robust early warning system that can identify and assess hazardous glacial lakes and landslide-prone areas, monitor changes, establish early warning systems, and

early warning systems

pollution
cleaner fuels

implement mitigation measures to reduce risk. The Indian government has taken steps to reduce pollution, such as promoting cleaner fuels, electric vehicles, and waste processing plants, but more needs to be done. The impact of climate change in the Himalaya is challenging to monitor, but countries like Bhutan, Nepal, and India have initiated programmes such as the National Action Plan for Adaptation to Climate Change (Bhutan) and the National Communication on Climate Change Mitigation and Adaptation (India) to address this issue.

Scientist who spoke on Himalaya at SaGAA 7 include Dr Santonu Goswami, Dr O P Mishra, Dr Miriam Jackson, Dr Vimal Singh, Dr S A Romshoo, Dr Parmanand Sharma, Dr Aparna Shukla, Dr Manasi Debnath, Dr Nisha Mendiratta, Dr V M Tiwari and, Dr Rajeev Mehajan.

1.5 The Antarctic

alarming rate

Antarctica, the southernmost continent on earth, is facing the consequences of global warming. Ice shelves in the deeper south of Antarctica are losing volume at an alarming rate, with an increase from 25 cu km per year during 1993-2003 to 310 cu km per year during 2003-2013 (Paolo et al., 2015). Although ice sheet thinning has been observed in West Antarctica and on the Antarctic Peninsula, the same has not been observed around East Antarctica (Pritchard, 2009). In fact, some parts of the East Antarctic ice sheet have been thickening, particularly deep in the interior (Davis et al., 2005). Nevertheless, the overall melting of ice sheets observed is significant, and the effects of global warming in Antarctica cannot be ignored. This is similar to the situation observed in the Karakoram Himalayas.

commercial mining

Antarctica is divided into sections by overlapping territorial claims from seven nations, including Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom, which are currently in abeyance. India ratified the conservation of Antarctic Marine Protected Areas in October 2021 to prevent over fishing of krill at CCAMLR, but this effort was vetoed by China and Russia in 2022 (The Hindu, 2022). It is worth noting that India does not participate in fishing for krill. While commercial mining has never been the focus in Antarctica due to a moratorium until 2048, the situation is different in the Arctic, where nations hold sovereign rights to the icy high-north realms, and exploration has almost always been part of the national plan of most of the Arctic nations.

1.5.1 The Antarctic Treaty

scientific preserve

The Antarctic Treaty, signed in 1961, has been hailed as a successful Treaty that has helped to maintain Antarctica as a scientific preserve. The Treaty allows for freedom of scientific investigation while banning any military activity. This has made it a model for treaties related to oceans and space. Despite the Antarctic region being rich in resources, the Treaty has helped keep the moratorium on mining and exploration activities intact. However, the relationship between science and politics in the frozen realms of the

Antarctic and Arctic is complex, with science often being the strategic front (Chaturvedi, 2014).

Antarctic Treaty

Scientific activities have played a significant role in supporting the political engagement of Antarctic Parties with the continent. The seven states that maintain territorial claims in Antarctica all operate research stations within their own zones, while non-claimant states have used scientific activities and expeditions to challenge the territorial claims. Science has also provided the motive and means to negotiate and adopt the Antarctic Treaty. Despite the challenges posed by the Cold War, the Treaty has been successful in developing an effective and enduring regime for Antarctica (Chaturvedi, 2014).

The Antarctic Treaty of 1959 has developed into a complex governance system called the ATS, which addresses important issues such as tourism regulation, biological prospecting, and climate change. The ATS has become more complicated due to the diverse membership and growing governance agenda. This requires a focus on the changing role of Antarctic Science and a critical examination of existing power dynamics. The Treaty was created to promote peace and scientific cooperation in Antarctica, but security concerns continue to influence the laws and policies governing the region (Hemmings and Rothwell, 2012).

The Indian Antarctic Act, 2022 has been enacted to provide for national measures towards the protection of the Antarctic environment and regulation of activities in the region (Ministry of Law and Justice, 2022). An Antarctic Governance and Environmental Protection Committee is proposed, to be headed by the Secretary, MoES. It will be bestowed with functions such as granting permits for activities including an Indian expedition, vessel or aircraft registered in India to enter Antarctica and will ensure the compliance of international laws for the protection of Antarctic environment. The Act includes measures such as environmental impact assessment, permit for expedition being contingent upon a waste management plan, prohibition of activities such as disposal of radioactive wastes in the pristine continent, etc. (Ibid.). It also specifies the offences and penalties for the contravention of the Act's provisions.

1.5.2 Antarctica: From Commercial Interest to Global Knowledge

mineral negotiations

Antarctica has long been a subject of international interest due to its rich mineral resources. In the 1970s, the idea of a minerals regime in Antarctica was considered unlikely and unfeasible due to economic, technological, and geopolitical constraints. However, by the 1980s, with the growth of the global population and the intensification of the oil crisis, the potential for commercial activity in Antarctica became more appealing (Liu, 2010).

As the prospect of commercial activity in Antarctica increased, India, Brazil, China, and Uruguay formed a lobby to promote the interests of third-world countries in mineral negotiations. However, the ATS member states faced dilemmas regarding

the reconciliation of the legal status quo with equitable plans for mineral resource development. Despite this, the ATS member states reiterated that their respective positions on territorial claims in Antarctica could not be compromised (Liu, 2010).

CRAMRA

In 1988, the CRAMRA was opened for signature. It prescribed tough procedures for exploration and development, including provisions related to environmental protection. However, the prospects of CRAMRA dimmed when the Australian government refused to sign it in 1989, citing environmental conservation concerns. Australia instead sought international support for a comprehensive environmental protection convention and an Antarctic Wilderness Park. This decision was supported by France, leading to the eventual collapse of CRAMRA (Hemmings, 2011).

permanent hostage
natural reserve

The crisis of consensus in the ATS exposed the dubious and disputed ownership crisis of a continent with abundant resources. The ATS had made the pursuit of science and scientific knowledge a 'permanent hostage' to the colonial legacy of territorial claims and counter-claims (Liu, 2010). The inability to resolve territorial claims in Antarctica continued to hinder the development of regulations for commercial activities in the region. However, the US decision to sign the Protocol on Environmental Protection to the Antarctic Treaty in 1991 restored dialogic politics and consensual diplomacy to the ATS and reaffirmed the state and status of Antarctica as a global knowledge commons. This protocol aimed to protect Antarctica's environment and designated the continent as a natural reserve dedicated to peace and science (Hemmings, 2012).

The emergence of the Greenpeace movement and other environmental groups played a significant role in opposing mining in Antarctica. This led to the emergence of a new non-state contributor and claimant to knowledge production, value addition, and representational practices in the ATS, eventually becoming the ASOC (Treaty Secretariat, 2017).

1.5.3 Protection of Antarctic Environment

CEP
research integrity

The Protocol on Environmental Protection to the Antarctic, established in 1991, designates the Antarctic as a protected area for peace and scientific research. It prohibits mining activities except for scientific purposes and is monitored by the CEP. New scientific advancements and the rise of bioprospecting pose challenges to the Antarctic's environmental and research integrity. The Antarctic regime needs to continuously adapt to address these challenges.

Speakers who addressed Antarctic endeavours are Dr Avinash Kumar, Dr Waliur Rahaman, Dr Sandip R Oza, Ms Tiina Jortikka-laitinen, Dr Koteshwar Rao, Dr N C Pant, Dr Sanjay Chaturvedi, Dr Rasik Ravindra, Dr Rahul Mohan, Dr Kenichi Matsuoka.

1.6 The Deep Ocean Mission

India initiated the Deep Ocean Mission in 2018 with the objective of investigating and utilising the extensive resources within its 2.2 million sq km EEZ in the deep ocean. Led by the MoES, this comprehensive endeavour aims to explore the ocean's depths, comprehend its impact on climate change, and gather crucial data for disaster management and early warning systems. The Deep Ocean Mission encompasses the development of advanced technologies for extracting both living and non-living resources from the deep ocean. With a revised budget of INR 6.5 billion, the programme is currently in progress and has enabled India to acquire underwater mining capability. By deploying manned titanium submersible vehicles, India has joined the ranks of esteemed nations such as the USA, Russia, Japan, France, and China, opening avenues for collaboration with countries in the high-north and advancing exploration initiatives (MoES, 2018; MoES, 2023).

EEZ

1.6.1 Matsya 6000

The Matsya 6000 is a manned submersible vehicle currently being developed with the support of NIOT, ISRO, IITM, and DRDO. It has been designed to accommodate three people and can reach depths of up to 6,000 m. Equipped with advanced scientific sensors and tools, it promises to enhance our understanding of the deep ocean.

6000m

1.6.2 Samundrayaan

In October, 2022, India launched its first manned deep ocean mission-Samundrayaan, putting it in the company of nations such as the USA, Russia, Japan, France, and China which have also developed underwater vehicles for subsea activities. Samundrayaan is designed to explore the deep ocean and investigate non-living resources like poly-metallic manganese nodules, gas hydrates, hydrothermal sulphides, and cobalt crusts that are found at depths ranging from 1,000 to 5,500 m. This cutting-edge technology holds great promise for deep sea exploration.

mineral resource

1.6.3 Blue Economy

Oceans are home to 97 per cent of the earth's water and play a crucial role in sustaining the environment by absorbing 30 per cent of global carbon emissions. They are not only a valuable source of economic development, contributing 3-5 per cent to global GDP and facilitating about 80 per cent of global trade (Indian Ocean Rim Association, 2017), but they also support the livelihoods of approximately 3 billion people living near coastal regions (Ghosh and Sridharan, 2023). Recognising the significance of oceanic waters for environmental, economic, and security purposes, nations are increasingly focusing on the protection and conservation of oceans through sustainable practices.

global carbon emission
conservation

The concept of the blue economy, introduced by Prof Gunter Pauli at United Nations

University, Japan in 1994 (Trainings, 2017), envisions an economic model that conserves and sustainably utilises marine and freshwater resources. This model gained further attention during the Rio Earth Summit of 2012, where Small Island Developing States emphasised the need to bridge the gap between the green and blue economy. In response, institutions like the UNEP drafted the report 'Green economy in a blue world', recognising the blue economy as a crucial component of sustainable developmental growth (UN Economic and Social Council and Sustainable Development Solutions Network, 2014).

UNEP

International legal frameworks have played a significant role in shaping practices related to the blue economy. For instance, the World Trade Organisation's Agreement on Fisheries Subsidies in 2022 prohibited subsidies for illegal, unreported, and unregulated fishing. Additionally, the Kunming-Montreal Global Biodiversity Framework, established in December 2022, has fostered consensus among marine nations in preserving oceanic and freshwater resources through biodiversity conservation. Furthermore, the UNCLOS concluded on March 3, 2023, known as the High Seas Treaty or BBNJ, is regarded as a milestone in extending marine life protection and promoting sustainable development in areas beyond national jurisdiction.

biodiversity framework

UNCLOS
BBNJ

India, with its extensive coastline and EEZ spanning over 2.02 million sq km, possesses significant potential for the development of its blue economy. However, this development carries geopolitical implications due to the Indian Ocean's critical strategic and economic importance. India's maritime interests are intricately linked to national security, energy security, and trade. Active participation in regional organisations like the IORA and the IONS demonstrates India's commitment to promoting cooperation and security in the region.

IORA
IONS

To support its blue economy, India has been focusing on the enhancement of maritime infrastructure, including ports, shipbuilding, and offshore industries. This increased maritime capability has bolstered India's strategic influence in the Indian Ocean region, enabling the provision of logistical support to other countries in the area. Collaborative efforts with countries such as Japan, the United States, and Australia further contribute to maintaining security and stability in the region.

Speakers who addressed India's Deep Ocean Mission included Dr M V Ramana Murthy, Dr Jenson George, Dr Avinash Kumar, Dr T Srinivasa, Dr M A Atmanand, Dr S Rajan, Captain Sarabjeet S Parmer, Dr G Latha, Dr M Ravichandran, Dr Satheesh Shenoi, Dr Tanu Jindal, and Dr Swapna Panickal.

1.7 Northern Sea Route and the Indo-Pacific Region

Throughout human history, nations have always been intrigued by opportunities for resource exploration. The unfrozen Arctic region, which makes up one-sixth of the world's landmass, is currently experiencing what is known as the 'Cold Rush' (Briggs,

cold rush

2021). As a result, there is a geopolitical competition between various nations, including China which has claimed to be a 'near Arctic' state. This competition is likely to bring about a range of challenges at multiple levels.

near-Arctic

The Arctic region offers vast volumes of unexplored resources, including fossil fuels such as petroleum oil, natural gas, and gas condensates, as well as base metals, rare earth elements deposits, and gemstones (Boyd et al., 2016). However for these resources to be sustainable, they must be commercially and environmentally viable, as well as easily accessible and transportable.

Arctic region

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.

navigation system
NSR

Bypassing the chokepoints such as Malacca, Suez, and Panama, this new route could save 10-15 days in travel time. This would have far-reaching consequences, beyond just cargo transportation. However, the Arctic region is sparsely populated and faces multiple stressors, presenting unique governance challenges. India has ratified all major treaties, including the UNCLOS and is actively involved with international bodies working on the Arctic. India's new Arctic Policy, released in 2022, focuses on six key areas: science and research, environmental protection, economic and human development, transportation and connectivity, governance and international cooperation, and national capacity building for involvement. India's continued interest in the Arctic region is therefore assured, and a calibrated approach is necessary to fully understand the region's changing potential. By focusing on these key areas and working collaboratively with other Arctic nations, India can contribute to the sustainable development of the Arctic region while ensuring its own strategic interests.

choke points

Arctic Policy

Speakers who addressed Northern Sea Route and the Indo-Pacific Region are Major General B K Sharma, Dr M Sudhakar, Cmde Debesh Lahari, Dr R Srikanth, Dr Sulagna Chattopadhyay, Dr R P Pradhan, and Dr Stuti Baneerjee.

1.8 Clean Energy

Hydrogen and geothermal energy are two promising sources of clean energy that could help address the urgent need to reduce greenhouse gas emissions and mitigate the impacts of climate change. Hydrogen, when produced using renewable sources such as solar or wind power, can be used as a fuel for vehicles, power generation, and heating. It produces no greenhouse gas emissions when burned and can be stored for long periods

Hydrogen
geothermal

of time. Geothermal energy, on the other hand, involves harnessing heat from the earth's core to generate electricity or provide heating and cooling for buildings. It is a reliable and consistent source of energy that can operate round the clock without interruption. The urgency for these forms of energy production is clear as the world continues to rely heavily on fossil fuels and faces the consequences of climate change. Switching to clean energy sources like hydrogen and geothermal is essential to reduce greenhouse gas emissions and ensure a sustainable future for generations to come.

Speakers who addressed clean energy include Dr Dilawar Singh and Ms Kunzes Dolma.

1.9 Conclusion

The significant and widespread changes that are taking place in the Polar regions have created a pressing need for ongoing research to enhance our comprehension of local, regional, and global processes. These changes extend beyond man-made geographical boundaries, necessitating the involvement of multiple nations and communities on a global scale, each with their own set of interests and constraints. As a result, it is crucial to establish an interface between science and geopolitics in the Arctic and Antarctic. Although there are several fora for sharing scientific or geopolitical findings, an interface between them is rare. The principles that govern the Polar regions are based on science but also require the involvement of multiple countries and communities. Therefore, it is necessary to hold discussions on platforms such as SaGAA, where various interdisciplinary issues can be discussed.