



Continued warming of the atmosphere results in continued loss of ice in all forms, whether in Arctic, Antarctic or the Himalaya; Formation of new ponds and lakes; Nordenskiöld, Svalbard, Norway.

Summary

Science is making it abundantly clear, confirming that global warming leads to more frequent and intense extreme weather events, droughts, and tropical cyclones, not to mention continued warming of the ocean and the atmosphere due to the current rates of human-led greenhouse emissions and continued loss of ice in all forms, whether in Arctic, Antarctic or the Himalaya. However, 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, urgent action is required to reduce greenhouse gas emissions and mitigate the effects of climate change. Raising awareness and engaging in multiple platforms is essential to encourage faster climate action.

The Arctic is melting more rapidly than other Polar realms. It raises concerns about the cryospheric regions' fragile ecosystem and the potential for conflict over territory and resources. Science shows that melting Arctic ice can lead to monsoon extremes, cloud bursts and hydrological disasters, resulting in homelessness and migration in the Indian sub-continent.

The Himalayan region has a multi-hazard profile, including earthquakes, landslides, flash floods, avalanches, and glacial lake outburst floods (GLOFs). These hazards are often interlinked and exacerbated by population density, steep slopes, fragile ecosystems, and anthropogenic activities. A holistic and integrated approach involving various stakeholders, from governments to local communities, is needed to help manage such hazards. Developing an early warning system for earthquakes, GLOFs, and impact forecasting for flash floods is essential. Flash floods in the Himalaya are frequent along steep sloped arid, and semi-arid regions, with low vegetation cover and high soil erosion

rates. They can be predicted and monitored using various methods, and mitigation measures can be implemented to reduce the risks. However, there are multiple challenges to impact forecasting and early warning systems.

The cryosphere is an area occupied by snow, ice, glaciers and permafrost and is a sensitive tool to slightest perturbation in the climate systems. The melting of permafrost in the Arctic has serious consequences in terms of release of methane and pathogens. Since, data on the permafrost in the Himalaya is limited, there is a need to enhance efforts to identify and map permafrost in these regions. There is a need for advancement in technological solutions in the cryosphere in order to predict future climatic changes. Advancement in cryosphere monitoring includes both space borne and air borne monitoring techniques that use multispectral information of the electromagnetic spectrum. Technologies such as SAR and LiDAR are considered to be the game changers. Apart from remote sensing, multi-model ensemble approaches are also required to provide valuable insights into the ongoing changes in sea ice dynamics, highlighting the vulnerability and potential consequences of Arctic and Antarctic sea ice loss in the coming decades.

The Ministry of Earth Sciences (MoES) unveiled India's Arctic Policy in March 2022. The Policy document is buttressed by six pillars of scientific research and cooperation, environmental protection, economic and human development, transportation and connectivity, governance and international cooperation, and national capacity building in the Arctic. With science as the bedrock, the aims and objectives of India's Arctic policy are well aligned with the global Arctic needs. Science is the most critical objective of India's Arctic involvement, focusing on microphysical and microbiological processes, permafrost, atmospheric instruments, Indian monsoon and Arctic climatic variability and more. India is engaging on Arctic issues through institutional collaborations, prioritization of activities, points of contact in key ministries, interaction with think tanks, and consultative mechanisms with Asian observers. India's socioeconomic and cultural involvement in the Arctic includes enhancing international cooperation, industry and policy persons' interactions, celebrations of International Yoga Day on June 21 in the Arctic nations such as Russia, Denmark and Finland, and increasing awareness about the Arctic issues within the country. These multidimensional efforts should be sustained with a people centric multi-stakeholder approach, more engagement, and capacity building in shipping, scientific observation, and Arctic education.

India's concerns are also well-directed towards the Antarctic, especially since the Antarctic Treaty of 1961, created to isolate Antarctica for preservation. The Treaty has been under doubt regarding its effectiveness and there is a call at various fora for the spirit of the Treaty to be reworked to better address contemporary geopolitical concerns. Significant concerns about the future of the Antarctic Treaty include changes in geopolitical power dynamics, increasing human involvement, and the possibility of certain member nations altering the provisions of the Treaty. There are also concerns about the governance system of the Antarctic Treaty System, which may pose a risk to

the functionality of the Antarctic governance model. To address these concerns, scholars suggest a move towards inclusiveness. However, there are currently no indications that any party will seek a review of the Treaty. The prohibition on mineral resource activities in Antarctica can only be removed if a binding legal regime on Antarctic mineral resource activities is in force. Overall, the future of the Antarctic Treaty remains to be determined in light of changing global geopolitics and increasing human involvement.

From being the cornerstone of the Blue Economy with a diverse set of opportunities in terms of living and non-living resources to providing multiple ecosystem services such as regulation of monsoon, global biological productivity, driving regional and global climate systems, oceans play a significant role in supporting the planet's systems. Oceans cover 75 per cent of earth, offering a 'sea-of-opportunities' but also a 'sea-of-challenges' due to climate change and anthropogenic exploitative/extractive activities. India's large coastline of 7500 km can be utilised for the production of hydrogen energy due to the ready availability of oceanic water, apart from wind energy.

The challenges around oceans can be categorized into knowledge-solution, infrastructural, foundational and governance challenges. The knowledge-solution challenge highlights gaps in understanding the nature of different challenges to the oceans. The infrastructural challenge focuses on the need for ocean observing systems and digital solutions to address ocean-related risks and hazards such as sea level rise, algal blooms, storms, tsunamis, cyclones and other disasters impacting the coasts and other regions.

Furthermore, 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 some of the maritime security challenges. However, the issues related to energy exploration, trade and transportation require a more focused attention.

The role of youth in polar studies in a nation with the youngest demographic dividend in the world needs to be bolstered, as this generation is more likely to bear the consequences of climate change. They must be encouraged to pursue careers in climate and environmental science and learn to understand the policy ramifications of their work, shifting from conventional careers in various academic fields. Emerging academic fields such as climate accounting, sustainability management accounting, sustainable finance, ecosystem accounting, zero emission economy and others are providing new platforms to the youth interested in careers in climate change. In India, Polar knowledge goals are being integrated at the elementary, higher studies and at the professional level.