

Socio economic fluctuations caused due to Ice sheet depletion in Antarctica and Arctic regions

Anjani Mamidala^{1*} and Akanksh Mamidala²

^{1*}*Sem VIII, Chemical Engineering Department, Chaitanya Bharathi Institute of Technology, Hyderabad 500075, India*

²*Sem VI, Chemical Engineering Department, Chaitanya Bharathi Institute of Technology, Hyderabad 500075, India*

(Received 13 September, 2019; accepted 22 December, 2019)

ABSTRACT

In today's world of economic growth, climate change is receiving less amount of attention. Minor percentage of the world's population are aware of the changing patterns of climate and are accepting the amateurish effects caused by climate change and they also accept the fact that global warming is caused due to human activities since the industrial revolution in the 18th century. Climate change is a devastating problem which is being observed in the past few decades. According to the scientists, if we don't act towards climate change within 2035, that will be the point of no return. Ice caps, glaciers, ice mountains are being affected due to climate warming. Ice caps are defined as a mass of glacial ice spread over 50,000 square kilometers consisting of 99% of fresh water on earth. There are only two ice sheets in the world which play a vital role in the sustainability of living beings on earth. Ice sheets have the ability to trap CO₂ present in the atmosphere. Ice sheets also play a vital role in reflecting sunlight from the Earth's surface and regulating the Earth's global average temperature. In the present century the percentage of ice sheet has reduced exponentially and the global average temperature has increased to 0.94°C. In this paper, the types of ice sheets, role played by the ice caps in regulating the Earth's atmosphere, effects caused due to depletion of ice sheets and the methods for retaining the ice sheets from melting is being concentrated.

Key words : Amateurish effects, Depletion, Economic growth, Ice caps, Retaining, Sustainability.

Introduction

World, today has advanced in all aspects of science and technology and its whole concentration is only on country's economic growth. We've reached to a stage where we have accomplished major life changing events which seemed to be impossible in the earlier decades. Human beings have struggled a lot to reach to this stage in the advancement of science and technology, but have neglected the grave effects caused by this revolution on the environment. One such adverse event caused is global warming. Global warming is caused due to the

emission of greenhouse gases which trap the sun's heat and do not allow that heat to be reflected back into the outer space. Due to the entrapment of the sun's heat in the atmosphere, there is a rapid rise in the atmospheric temperature and is said to fourfold in the coming centuries. The ice sheets present on the earth's surface contribute to the reflection of the solar heat into the outer space by trapping carbon dioxide since millions of years. Ice sheets are areas with enormous amount of ice spread over a vast region. Ice sheets are also called as continental glaciers as they are formed by the accumulation of large, crystalline ice, snow. Now, ice sheets are present in

Antarctica and Greenland on the earth's surface. The inner surface of the ice sheet is warmer due to the presence of geothermal heat even though its outer surface is cold.

Over the past 40 million years, Antarctica is covered with ice while the ice sheet has advanced and retreated with climate change, this has been the constant feature of landscape in Antarctica. Two million years ago, regions of North America, Eurasia and South America was covered with huge ice sheets. This was regarded as the last ice age. During this period, 1/3rd of the earth's surface was covered with ice which was recorded as the period of having large amount of ice. But due to accumulation of greenhouse gases, climate change, global warming and other factors, the ice sheet area has fallen to 1/10th of the earth's surface. The area covering from Great Britain to Moscow in Russia was covered with the Scandinavian ice sheet. In the regions of Northern Asia, Barents-Kara ice sheet was spread which created shallow lakes whose remains are still visible in the northern part of Russia. Today's Chile was once covered with the Patagonian ice sheets which were spread over the regions of Andes Mountains to the southern part of South America. Due to the dry climatic conditions observed in the central Argentina and the arid Atacama Desert, this Patagonian ice sheet did not spread over vast regions because these dry climatic regions acted as a barrier for the ice sheet to spread over these regions.

Ice sheets are formed in areas where the snow that falls in winter do not melt in summer. Over millions of years the snow piles up into thick mass of ice, growing denser and compressing the older layers. Ice sheets are constantly in motion, slowly flowing downhill under their own weight. The ice moves thoroughly fast near the coast called as ice streams, glaciers and ice shelves. According to scientists, if the Greenland ice melted the sea level would rise by 6 meters. The melting of Antarctic ice sheet results in the rise in sea level by 60 meters. Firstly, due to the decrease in ice sheets the local animal habitat becomes extinct and is indirectly affecting the food chain. Secondly, as the ice sheets absorb carbon dioxide, they convert this carbon dioxide into methane and has been storing methane, a greenhouse gas for millions of years. Due to the deletion of ice caps the methane stored is released back into the atmosphere which in turn increases the global temperature and results in further depletion of ice sheets. This results in a cyclic process which re-

sults in the reduction of carbon dioxide trapping due to which the Earth would certainly become inhabitable. One of the drawbacks of depleting ice sheet is the rise in sea level which would affect millions of people worldwide living in coastal regions. There are two primary causes for global mean sea level rise- added water from melting ice sheets and glaciers, and the expansion of sea water as it warms. The melting of Antarctica's ice sheet is responsible for 20-25% of global sea level rise. Without the presence of greenhouse gases on the earth's atmosphere, the temperature would have been freezing but due to the excess presence of greenhouse gases, there is a total energy imbalance that is causing a rise in the temperature.

Due to the increase in carbon dioxide content in the atmosphere the mass of ice has been decreasing worldwide. The Antarctic ice sheet has been melting 6 times faster than in 1979. Researchers estimated that the amount of water reaching the oceans from Antarctica is equal to 3 Olympic sized swimming pools per second. Further researchers added that due to the increase in carbon dioxide content, Greenland has lost about 15% of its ice cover and there has been a massive retreat of ice glaciers. Even though the worldwide global average temperature is 0.94°C, the Antarctica has warmed 2.5 °C and is increasing at a rapid rate. Due to the sudden increase in temperature, the surrounding water bodies have become warmer in turn resulting in the melting of ice. Ice caps also play a major role in regulating the ocean currents and cools down the warm water coming from the equator. Due to the decrease in ice sheets the warm water is not cooled in a consistent manner, which increases the overall temperature of the oceans. Thus, due to the increase in overall temperature the pH of the oceans decreases which tends to increase the acidic nature. Due to the acidity in oceans vast number of corals would die and it would result in adverse effects of food chain, as corals are the basic stepping blocks of food chain. These corals consist of 25% of the oceans plants and animals and supports the food chain that includes thousands of different creatures. This results in food scarcity which in turn causes internal and international conflicts. As the coastal regions would become uninhabitable due to the increase in sea level, millions of people need to flee from their homes and this would disrupt the economy of a country causing major structural damage and providing basic needs would become an adverse task.

According to the climate statistics of 2017, the average global atmospheric carbon dioxide was 405.0 parts per million. The level of carbon dioxide on the earth's atmosphere has seen a rise which was not been observed in the past 800,000 years. This shows that the amount of carbon dioxide getting trapped in the Ice caps is getting reduced and the carbon dioxide released is concentrating the atmosphere.

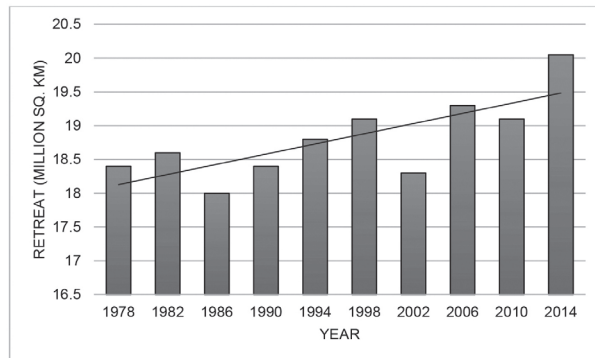


Fig. 1a. Depletion of ice sheets from 1978 to 2014 in Antarctica

Classification of ice sheets

Depending on the size of ice sheets and the region they are present in, the classification of ice sheets is essential.

There are many kinds of ice sheets:

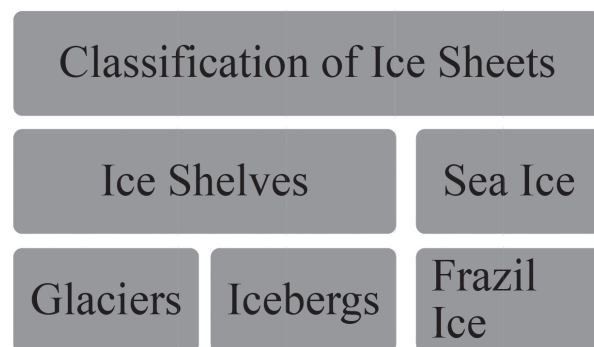


Fig. 2(a). Classification of Ice Sheets

Ice shelves

Ice sheets which are extended over the sea and float on it but attached to the land are called ice shelves and their thickness ranges from few hundreds to over a kilometer. The glacial pressure pushes the ice sheet ahead to such an extent that its growth is ceased due to sea currents. Ice shelves are regarded

as the most stable ice sheets for millions of years as they are formed by the accumulation of snowfall and it is generally found in the regions of Antarctica. Ice shelves play a major role in regulating the rise in sea level and they prevent the slipping of glaciers into the water bodies. Glaciers will slip in the water bodies at a rate five times faster in the absence of ice shelves.



Fig. 2b. Ice shelf in Antarctica over the Ross Sea

Sea ice

Sea ice is the representation of frozen ocean water and it is mostly found in far off polar oceans and 25 million square kilometers of the earth's surface is covered by sea ice. Most of the sunlight is reflected back to the space due to the presence of bright surface on sea ice. The movement of ocean water is controlled by the sea ice. Sea ice contributes to the ocean's global "conveyer-belt" as it regulates the cold, dense water to move towards the equator while the warm water moves from the equator towards the poles. Change in global climate takes place due to changes in sea ice as it causes disruption in the normal ocean circulation. The insulating effect of sea ice contributes a lot in curbing the process of heat exchange between the oceans and the overlying atmosphere.

Glaciers

Glaciers are large, thickened ice masses which are formed by fallen snow over many years and they are formed when snow remains stagnant in a particular location long enough until they transform into ice. The unique ability of glaciers is that they move at very low speeds. Glaciers occupy about ten percent of the earth's total land area and presently

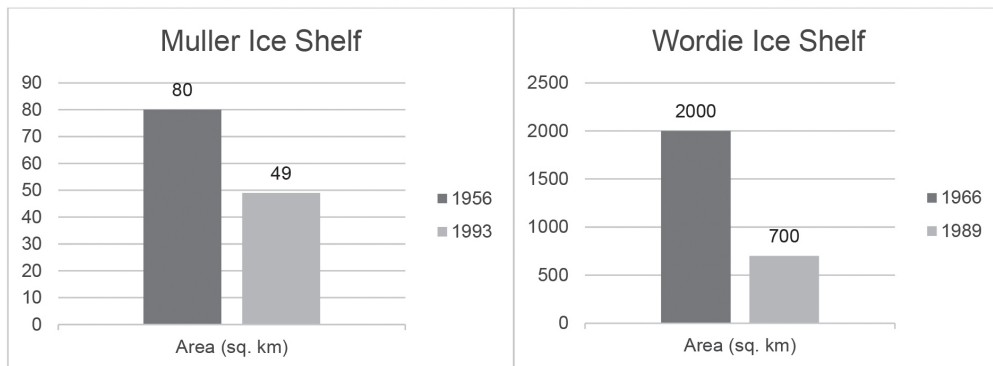


Fig 2c. Ice Shelf reduction over the years in Muller and Wordie

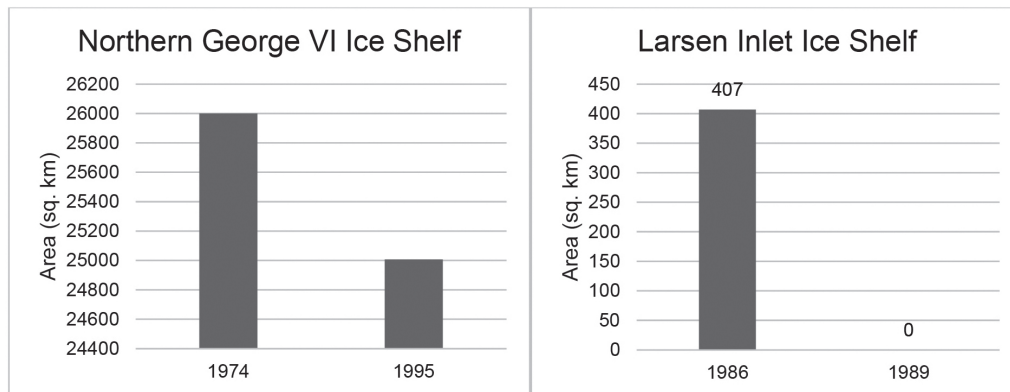


Fig. 2d. Ice Shelf reduction over the years in Northern George VI and Larsen

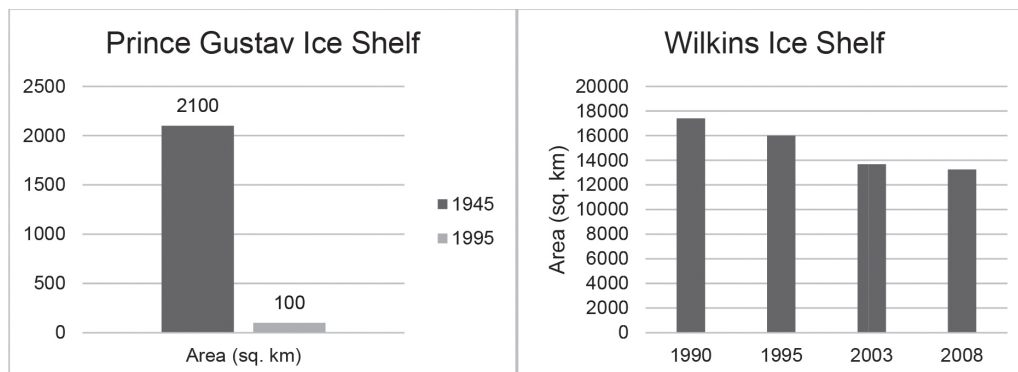


Fig. 2e. Ice Shelf reduction over the years in Prince Gustav and Wilkins

these glaciers are present in the polar regions as well as on the top on mountain ranges. Glacial movement affects the land beneath them and causes changes in the landforms over a period of hundreds of years. Glaciers are formed from fresh water and by melting, they provide drinking water and aid to irrigation. Glaciers also aid in generating hydroelectric power and they are also viewed as tourist attractions. But, due to the retreat of glaciers, glacial erosion increases which causes instability to the

land over the mountain ranges.

Icebergs

Pieces of ice that are formed on land over thousands of years and then tear apart and float over ocean or lakes are known as Icebergs. The size of icebergs are generally larger than five meters. Breakage of glaciers, ice shelves or larger icebergs result in the formation of icebergs and these icebergs travel along the ocean currents and sometimes are caught in



Fig. 2f. Global conveyer belt

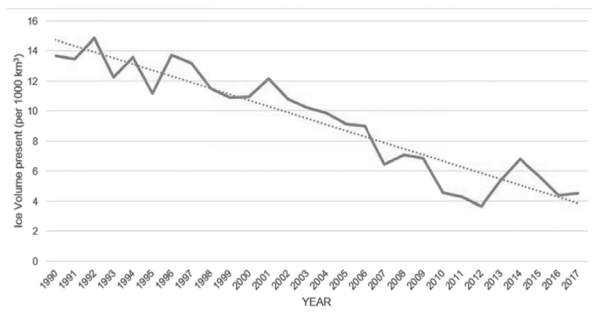


Fig. 2g. Yearly maximum and loss in amount of sea ice

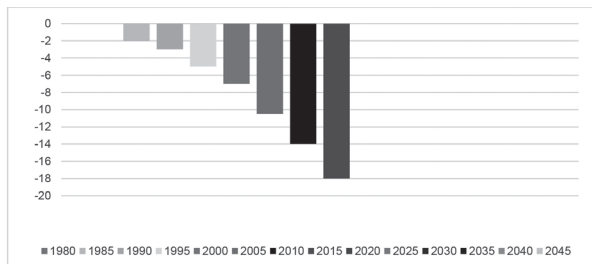


Fig. 2h. Depiction of cumulative decrease in glacier ice over the years

shallow water. Warm water tends to break the icebergs and this results in the size reduction of the icebergs and finally they melt and increase the sea level. Icebergs, being a cold fresh water source, can influence the sea currents and ocean circulations far from its origin. Icebergs also influence ocean's life as they release nutrients into the ocean and these nutrients teams up with plankton, fish and other sea life.

Frazil Ice

Frazil ice is formed in open calm water when the water and air temperature dive to very cold readings and they consist of loose, randomly oriented ice crystals. Frazil ice crystals form around the impuri-

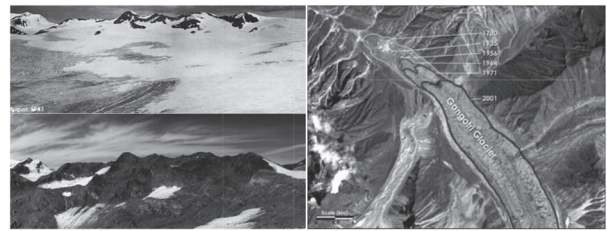


Fig. 2i. The retreat of glaciers over the past few decades



Fig. 2j. An enormous 150-foot tall iceberg near Ferrlyand, Newfoundland, Canada

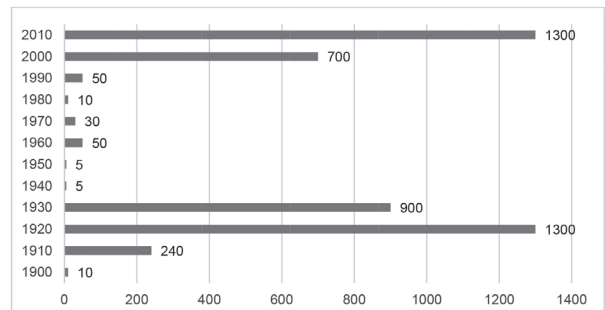


Fig. 2k. Depletion of number of icebergs from 1900 to 2010

ties in water or on snow grains that have fallen into the ocean surface. These frazil ice form small crystals that can be carried by water currents to the bottom. These crystals quickly increase in number by combining with impurities under water and get sucked up into water pipes which restrict the flow of water.

Role Played by Ice Caps in Regulating Earth's Atmosphere

The vanishing Arctic and Antarctic ice caps are not only vital for polar bears or penguins but also to all the living beings as they affect everyone directly or indirectly. Ice caps have thinned by almost 60% since 1975 which in turn affected the food chain and

also the acidity of ocean waters. Ice caps play a major role for the sustainability of living beings on earth and also play a major role in maintaining earth's atmosphere and avoiding extreme weathers. Even though everyone is striving to tackle global warming, there is a very little percentage of people who actually understand the importance of ice caps, whose role is generally neglected. Some of the benefits of these ice caps are- ice caps reflect sunlight which in turn reduces the amount of heat absorbed by the land and the oceans. Due to this reflectivity, the amount of heat trapped in the earth's atmosphere is less and helps in maintaining a uniform climatic condition. Ice caps also help in regulating ocean currents worldwide by sending cold water towards the equator and the warm water reaching the poles, which help in regulating earth's temperature. One of the major roles played by ice caps is trapping of methane under their surface. Scientist have discovered that there are millions of tons of methane beneath the ice caps, which when released

could pose a hazardous threat to humankind. This methane gas has been trapped beneath the ice caps for thousands of years and they can be released into the atmosphere due to the presence of gaps in these ice caps. Scientists discovered that the amount of methane beneath these ice caps is twice that of which is present in the atmosphere. If all the methane is released into the atmosphere the global temperature would sky rocket and would result in global extinction. The other important role is that these ice caps regulate weather and limits severe weather conditions. Due to the presence of ice caps the amount of moisture present in the atmosphere is regulated. If the ice caps melt down, large amounts of water gets added to the oceans and seas causing large sized waves and making it easier for strong storms to form. So, ice caps help in sustainability of living creatures and regulates the food chain from simple phytoplankton's to human beings.

Effects Caused due to Depletion of Ice Sheets

Global climate change has already seen a drastic alteration due to the depletion of ice sheets. Glaciers have shrunk, ice on rivers and lakes is breaking up earlier, plants and animals are shifting at a rapid pace. Few effects of depletion of ice caps is accelerated sea level rise, more intense heat waves and unequal distribution of temperature worldwide. Scientists predict that even if the usage of fossil fuels is reduced, the scope of climate change will continue throughout this century and may go beyond. Due to human activity, warming of Earth would continue for several decades and this rise will not be smooth or uniform for a particular region over time. Due to the depletion of ice sheets the formation of permafrost would gradually decrease causing instability to the land. Due to this instability, the amount of methane released from permafrost would in turn increase the global temperature. Ice sheets affect the weather of a particular region directly or indirectly. For instance, the amount of precipitation in some areas in the US has increased gradually and others have a very low precipitation level. Depletion of ice sheets disrupts the ecology of a particular region, that is, due to the depletion of Antarctic ice sheet there were patches of rainfall in the Atacama Desert which did not receive rainfall for the past 400 years. This resulted in the devastation of its microbial life due to irregular climatic conditions. On the other hand, droughts and heat waves have become more intense in the southwest and the temperatures are

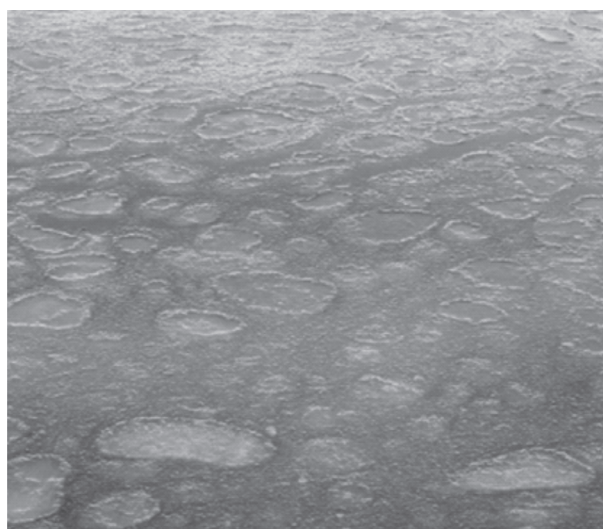


Fig. 2l. Frazil ice in Antarctica

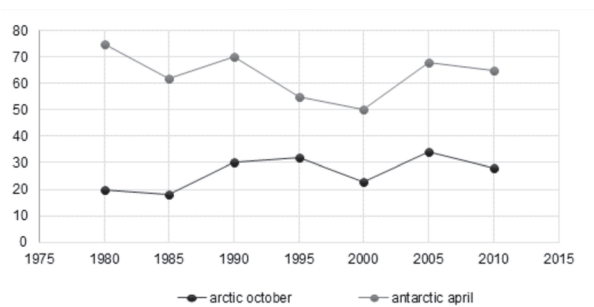


Fig. 2m. Rate of formation of frazil ice per unit area in Antarctica and Arctic regions

projected to rise rapidly. Global sea level has risen by 8 inches since 1880 and is projected to rise another 1-4 feet by 2100. This results in submerging of major coastal cities which will affect millions of people worldwide and would impose an eminent migration worldwide. Due to this migration there would be internal and external conflicts between states and countries and would result in the instability of the economy. Hence ice caps not only regulate the Earth's climatic conditions but also help in safeguarding the economy of a country.

Methods of Retaining Ice Sheets from Melting

As ice sheets are very important for our existence, we need to acknowledge the importance of these ice sheets and protect them from melting due to global warming. All of mankind should work together by addressing the problem and come up with relevant solutions. During the 21st century there has been a lot of emerging technologies to reduce global warming and also reduce the amount of carbon dioxide in the atmosphere. Usage of solar panels, wind energy, hydrothermal energy for the production of electricity will reduce considerable amount of carbon dioxide. Also, to reduce the amount of carbon dioxide, conventional engineering practices are not enough and hence there have been an advancement of a new stream called "carbon engineering" wherein the atmospheric carbon dioxide is removed directly from the atmosphere. Such practices are required for providing a sustainable environment for the future generations. Reduction of fossil fuels is mandatory and the government needs to play a major role in assessing the amount of carbon dioxide emission.

Conclusion

In the present century global warming have become a buzz and one of the effects of global warming is depletion of ice sheets. We need to protect these ice sheets as they are hosts for many species of wildlife and we need to acknowledge global warming as a problem and only then we can strive for a solution. Without the presence of ice sheets our planet would become inhabitable and the basic food chain would

get disrupted causing famines and starvation. Ice caps also regulate the acidity of oceans, which in turn help in the survival of mosses, shells, corals etc. They also help in regulating the ocean temperature and also avoid causing extreme weather conditions. So, presence of these ice caps regulates the economy of a country and will directly or indirectly effect every individual. It is the responsibility of every individual to protect the natural habitat of the Earth and safeguard this for the future generations.

References

- Aftab Alam Khan, 2018. Why would sea-level rise for global warming and polar ice-melt? *Geoscience Frontiers*. 25 January 2018.
- Alexander V. Wilchinsky, 2015. Study of the impact of ice formation in leads upon the sea ice pack mass balance using a new frazil and grease ice parameterization.
- Alison, J. Cook, British Antarctic Survey, Natural Environment Research Council, 2008.
- Ashifa Kassam, 2017. Massive Iceberg in Ferryland, April 2017.
- Colbourne, E. B. 2017. Physical Oceanographic Environment on the Newfoundland and Labrador Shelf in NAFO Subareas 2 and 3, 2017.
- Eric Rignot, 2019. Four decades of Antarctic ice sheet mass balance from 1979-2017, January.
- Jim Petit, 2017. Polar Science Center, September 2017.
- Jiping Liu, 2016. Has Arctic sea ice loss contributed to increased surface melting of the Greenland ice sheet, April 2016.
- Nala Rogers, Antarctica's Ross Ice Shelf, World's Largest, Is Melting in a Way Not Seen Before, January 2019.
- Rebecca Lindsey, 2018. Climate Change: Glacier mass balance, August 2018.
- Rignot, E. 2011. Acceleration of the contribution of the Greenland and Antarctic ice sheet to sea level rise, March.
- Tobias Heckmann, Retreating Ice: Research in pro-glacial areas matter. *Earth Surface Processes and Landforms*. 41(2): 271-276.
- Tom Yulsman, 2019. Arctic sea ice continues its downward spiral, reaching a record low extent in the month of May, June 2016.
- Wadham, J.L. The Potential role of Antarctic Ice Sheet in global Biogeochemical cycles. *Antarctic Earth Science*. 1(104) : 55-67.