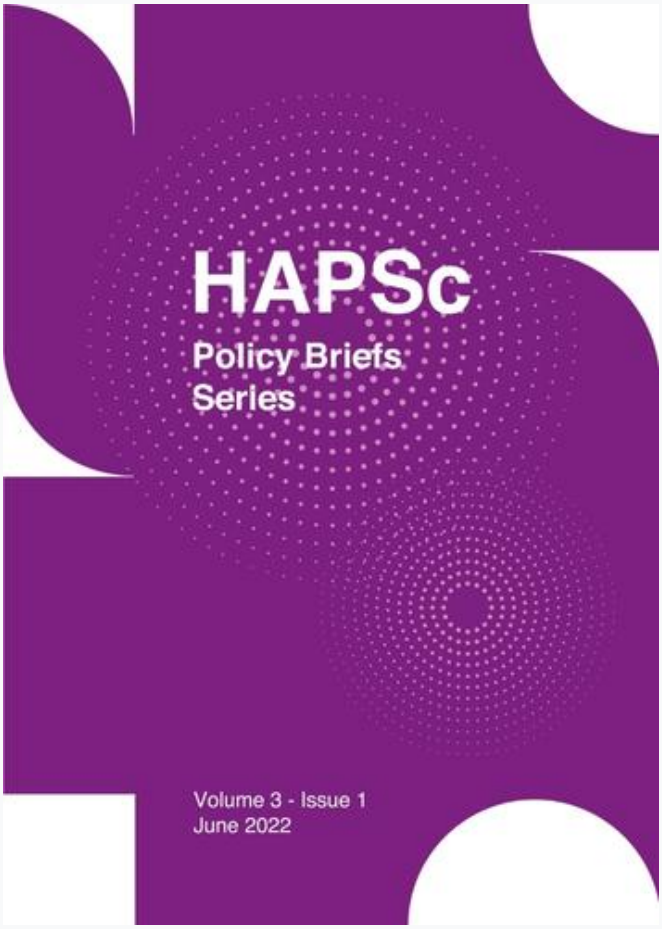
HAPSc Policy Briefs Series

Vol 3, No 1 (2022)

HAPSc Policy Briefs Series



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doi: 10.12681/hapscpbs.31002

To cite this article:

Nikitaki, C. E., & Moustou, A. (2022). Permafrost: A Frozen Minefield in the Northern Hemisphere. *HAPSc Policy Briefs Series*, *3*(1), 130–138. https://doi.org/10.12681/hapscpbs.31002

 ISSN: 2732-6578 (print version) 2732-6586 (online)

Permafrost: A Frozen Minefield in the Northern Hemisphere[1]

Chadoula Evangelia Nikitaki[2] & Areti Moustou[3]

Abstract

Some of the world's biggest countries have areas covered by permafrost, among them Russia, the United States, Canada and China. Permafrost, the soil that was once considered permanently frozen, has been thawing fast while releasing carbon dioxide and methane into the atmosphere. This paper explains what permafrost is and analyses the impact of its subsidence. Official reports from governments and prestigious international organisations were examined along with resources from scientific journals. Notably global warming is amplified, economy is at risk by infrastructure failure and human health is endangered by the hidden diseases inside permafrost. Furthermore, this paper, apart from identifying the significance of the problem, provides possible solutions to counter permafrost thawing and ensure the safety of the people. Suggestions are being proposed, among them, the establishment and funding of permafrost scientific networks and permafrost insurance for the directly affected people.

Keywords: Permafrost, Climate Change, Carbon Dioxide, Global Warming, Northern Hemisphere.

Introduction

Permafrost or permafrost soil is widely considered as the soil that stays at or below the freezing point of water for at least two years (Krugger et al., 2009). However, many also consider that permafrost is something more of an iced, deserted, mainly unproductive land area that largely extends in the northern hemisphere. The truth is that permafrost is neither permanent nor frozen (Huissteden, 2020) and its soil extension is far greater than that of the northern hemisphere. To be more exact, permafrost stretches through the North-American and Eurasia continents and stores around 1672 gigatones of carbon (United Nations Environment Programme, 2012). For example, China has 23% of its land covered in permafrost (Zhang, 2013). Approximately 65% of Russia is covered in permafrost (Streletskiy et al., 2019). Alaska's permafrost covers more than 80% of its soil (National Snow and Ice Center, 2021). In addition, it can be seen, that large areas, coming across as forests or oriented for agricultural activity, are in fact, based on permafrost soil (Huissteden, 2020). Although, the most shocking fact is that even whole cities are built and function efficiently, onto this type of ground (Huissteden, 2020).

[1] To cite this paper in APA style: Nikitaki, C.E. & Moustou, A. (2022). Permafrost: A Frozen Minefield in the Northern Hemisphere. *HAPSc Policy Briefs Series*, *3*(1), 130-138. https://doi.org/10.12681/hapscpbs.31002
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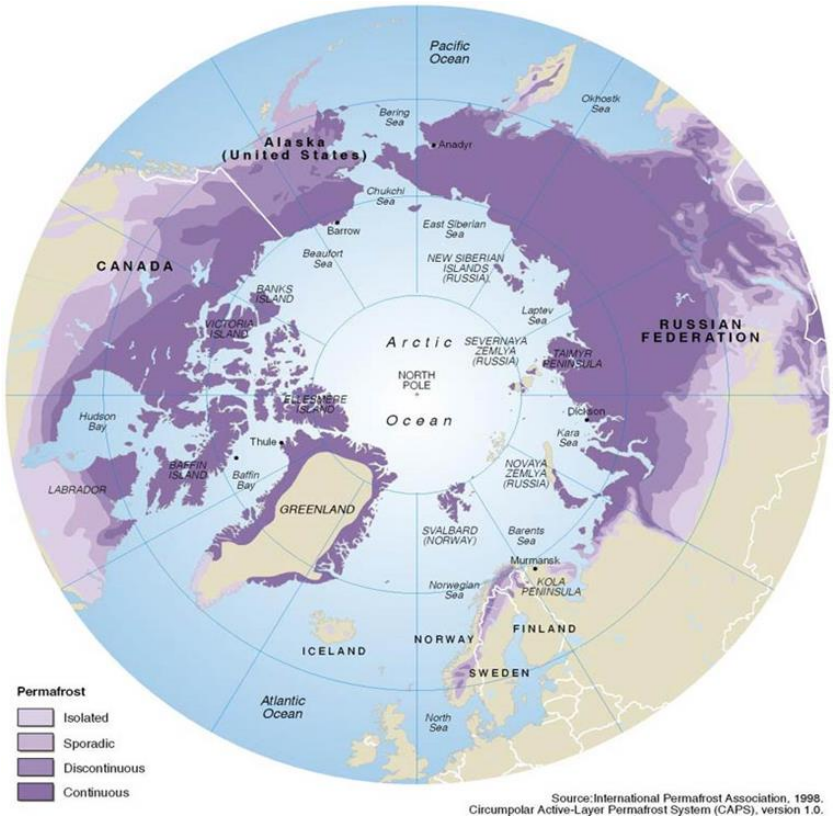
ISSN: 2732-6578 (print version) 2732-6586 (online)

Map: Permafrost in the Northern Hemisphere



As it can be perceived, permafrost mainly occurs in colder regions in the north and south, or even at high altitudes, such as the Alps (Huissteden, 2020). Permafrost can also be detected at the bottom of the Arctic Ocean. At the soil surface of permafrost soils, the top layer, which is mainly referred as the “active layer”, thaws in summer and refreezes in winter every year. The base of the active layer is called “permafrost table”. The active layer is thinner in colder regions and thicker in the warmer climates of its zone.

However, it is not only the temperatures to increase above the permafrost that determines the temperature of the soil itself. Factors such as vegetation, topography, winter snow cover and soil properties, play an important role in the temperature regime of permafrost. The active layer and how thick it is, is considered an important state variable for permafrost soils. Global warming is affecting the active layer thickness and by extension the carbon and nutrient cycle of permafrost soils.

Scientific interest on permafrost is being drawn more and more intensively than before and the main reason is the potential carbon dioxide and methane emissions to the atmosphere. They estimate that inside the Arctic permafrost, around 1,500 billion metric tons of carbon, is trapped in and that approximately 5%-15% of this greenhouse gas will be emitted by 2100, which will be more than

enough for the global temperatures to be increased at the point of 0.3 - 0.4 degrees of Celsius (Mittelman, 2020).

This paper examines the ways in which permafrost affects the environment, the economy and humanity in general. The analysis begins by taking into account and analyzing some of permafrost greatest consequences. It continues by suggesting ways to counter down permafrost's impacts in some of humanity's most important aspects of life and last but not least, the conclusions are being reported.

Research Methods

From the perspective of data collection, the method which is followed is literature review and the information has been derived from books, scientific journals, surveys and reports of national and international organizations or institutes and articles from the internet press. Some of the secondary data analysed come from the National Aeronautics and Space Administration (NASA), the National Park Service U.S. Department of the Interior, the National Snow and Ice Data Center, the United Nations Environment Programme and the United States Arctic Research Commission. Furthermore Polar Science, the Arctic Yearbook 2020 and Physical Geography are among the scientific journals studied.

Impact of permafrost thawing

i) On the Environment

To begin with, permafrost thawing has impacts on natural resources. Among them we can notice the disappearance of lakes and changes in the movement of animal populations. In Russia, polar bears and reindeers move to different places which affect the food chains in the new habitats they enter, as well as birds change their migration routes which can introduce new animal diseases (Doloiso & Vanderlinden, 2020). Additionally degrading permafrost, results in the erosion of land which comprises landslides and rock falls, because the ground is no longer stable and can be cut off more easily. Alaska and Siberia have higher erosion rates in their ice-rich coastlines than the rocky coastlines in Greenland and eastern Canada (United Nations Environment Programme, 2012). Furthermore, one phenomenon related to permafrost thawing are the "drunken forests" in which the trees lean in random directions (United States National Park Service, 2019). From all these issues we can understand the dangers of permafrost degradation to the ecosystem, which can be completely damaged and altered.

Specifically, permafrost soils contain twice as much the quantity of carbon that already exists in the atmosphere (United Nations Environment Programme, 2012). Accordingly, if it continues to thaw climate change will be accelerated. The released CO2 and methane from permafrost combined with the greenhouse gases from human activities will amplify global warming to an unprecedented extent (NASA, 2018). The vicious cycle of melting permafrost is evident since, as we have already mentioned, global warming is also the cause of permafrost thawing and its consequence.

Considering the environment we have to mention that the world's largest oil spill on land in 1994, Russia was directly associated with permafrost thawing. Around 160.000 tons of oil were spilled in the Vozei oilfield while the pipeline broke because of the degrading permafrost it was going through (United Nations Environment Programme, 2012). Such events of infrastructure failure are increasingly notable and we will explore them more while talking about the impacts of permafrost loss on economy.

ii) On the Economy

To continue, the animal populations which move to new places, since their old habitats become unfriendly, are a danger to small towns and villages and to indigenous animal populations in the Arctic. Wolves intruding Russian villages have become a common problem. They attack the reindeer on which people base their income and food (Doloiso & Vanderlinden, 2020). Likewise the environmental changes, for instance the shifting herds and livestock population, impact on native communities' revenue.

It should be noted that unstable permafrost leads to infrastructure failure. When the permafrost becomes weak it can no longer be a stable ground for the houses, roads, bridges that exist above it. As a result, the human infrastructure can be damaged or be completely destroyed by the changes that occur due to permafrost thawing. Road breakings, destruction of buildings, failure of transportation and water and sewer systems have been observed and continue to occur. Especially over the last two decades there has been a rise in the destruction of infrastructure in Russia (Streletskiy, 2019). Specifically many highways (like the Dalton Highway in Alaska, the Dempster Highway in Canada), roads and railways (in central Siberia, China and Mongolia) traverse vulnerable permafrost areas (U.S. Arctic Research Commission, 2003). Consequently, transportation systems are at high risk.

All countries with permafrost face a great economic risk. The economic costs will rise in order to repair, maintain or rebuild the damaged facilities. The Russian economy depends notably on the contributions from permafrost covered regions (Streletskiy, 2019). Expensive engineering projects are required to provide a sustainable infrastructure in such vulnerable areas. In Alaska it is predicted

that the damage to public infrastructure will mean extra 1 billion dollars expenditure by 2030 (United Nations Environment Programme, 2012).

Particularly, there is a significant difference between Russia's infrastructure on the one side and North America's and Scandinavian countries' on the other. In Alaska, Canada and Scandinavia there are usually small houses and facilities while in the Russian Arctic exist mostly big buildings and industries. Moreover, around more than 5 million people live in permafrost areas in Russia in comparison to 0.9 million residents in permafrost regions in the Arctic in North America (Streletskiy, 2019). Therefore, the impacts of permafrost reduction will affect Russia to a higher extent.

To summarise, we can explain what permafrost degradation means by comparing it to constant and unexpected earthquakes. The impacts of an earthquake are similar to the impacts of permafrost thawing in the Northern Hemisphere. Earthquakes can also cause floods and landslides like permafrost but provoke huge damage to properties as well. Consequently, their impacts on economy are notable, among them the enormous cost to repair and reconstruct the ruined infrastructure. But what is the biggest difference between these two phenomena? Earthquakes are familiar to the people and cannot be averted unlike permafrost thawing which is unknown to most people despite being a serious problem the cause of which is already known, the global warming, but little is done to prevent it.

iii) On Humans

A great danger exists since viruses are able to survive for thousands of years inside permafrost (NASA's Jet Propulsion Laboratory, 2021). Therefore, when it melts the viruses inside it are released to the atmosphere and can result in exposure to humans. In 2016 in Siberia a young boy at the age of 12 died because of anthrax, a disease thought to have been extinct (BBC News, 2016). Anthrax infection was because of permafrost degradation and it resulted in the death of a young boy and of more than 2000 reindeer. This constitutes an extremely dangerous situation for humanity. We can give an example of the covid-19, when humanity finally manages to have this virus extinct, it will exist in the permafrost since many infected people have been buried in these regions. And while the permafrost keeps thawing, it will reappear and measures to have it contained fast, should have been already planned.

Human health is also at high risk from failures of the water and sewage systems due to thawing permafrost (United States Arctic Research Commission, 2015). In vulnerable areas, it is possible the quality of the drinking water will be decreased, leading to serious health problems. Water pipelines

could break and other complications can occur to the systems, endangering the lives of the native people.

In 2016 the families in the Siberian region, where their reindeer died because of anthrax, had to be displaced for fear of their health. However, considering that these people relied on reindeer for their income, they had to find a new source of revenue, so they were forced to leave their home. Communities in the Arctic are facing climate migration (Kieval, 2020). Climate migration from villages and cities in Siberia, Alaska and Canada as well as Scandinavia or even in China and Mongolia is a serious problem. People because of unstable permafrost can no longer have a safe residence, are susceptible to health dangers and may not be able to practice their professions. Shifting animal populations or disappearing lakes render people unable to hunt and fish. Consequently, native people need to search for a new place to live and their governments have to be prepared to provide help and solutions.

Suggestions

First and foremost, as very little research is being conducted on this issue, the funding for further investigation is considered crucial. By further investments in research teams and investigation centers, ways to counter this phenomenon can be gradually discovered. Research is being done but it is still in experimental stages. For example, Total, Gaz de France and the French Petroleum Institute are collaborating with the French National Centre for Scientific Research (CNRS) to start experimenting with the process of extracting methane from ice, mainly with injections of hot water into its deep layers (Geo, 2021). In this way methane can be used as an opportunity for alternative electricity or heating source (Geo, 2021). Permafrost scientists believe that the development of data archives and free exchange of information can be extremely beneficial (Barry, 1988; Barry and Brennan, 1993). Arctic science nowadays demands a more intensive collaboration and that is why some scientific foundations (e.g. the U.S. National Science Foundation) give no funding for research unless all the data is accessible to all interested parties (U.S. Arctic Research Commission Permafrost Task Force, 2003).

Economically wise, as this topic is extremely unpredictable, the establishment of networks with long-term monitoring actions on permafrost is essential. In this way, all of the costs that permafrost's sudden changes cause, can be minimized to a satisfying and effective degree (Streletskiy et al., 2019). Meanwhile, for the industries and municipalities on permafrost ground, the same monitoring networks should be interwoven with their plans and operations in order to avoid excessive damage.

In addition, the governments should bear in mind that they can apply and follow policies that ensure the greatest wellbeing possible of their citizens. Sometimes, damages can not be prevented and this is the reason why essential insurances to the victims must be available. It is vital for the citizens to continue their everyday lives without the constant unnecessary fear of repair or relocation. However, this option should not just stay in governmental rhetoric. Permafrost insurance, whether it is private or public, should be accessible and more importantly affordable. Governments should back up poor families and individuals by either paying or subsidizing a proportion of their costs. The same policy can be followed in order to boost the healthcare field in combination with plans to prevent the spreading of diseases.

Furthermore, according to research conducted by the University of Edinburgh in 2019, plants in permafrost environments play a major role in the control of the temperature of the soil (University of Edinburgh, 2019). Plants and trees have the ability to shade the ground and protect it from the warmth of sunlight, and at the same time, their roots are extracting the water from the soil, drying it out and making it a better insulator (University of Edinburgh, 2019). In addition, plants, even after they die, affect permafrost positively. They contribute to the creation of dry organic soils that are excellent insulators (University of Edinburgh, 2019). That being said, a rewilding project together with the reforestations and the protection of the flora in these regions should be one of the basic steps to counter permafrost thawing.

In a similar tone, the fauna can also play a significant role in this rewilding project. It has been shown that by removing the woody vegetation and enhancing the grassland in arctic climates, permafrost thawing can be delayed (University of Oxford, 2020). In order for that to be achieved, large herbivore mammals would be needed, such as bisons or horses. These animals can work as a means of reducing the woody vegetation and restore the grassland, which can capture more easily the carbon dioxide emissions. The rewilding is one of the “nature-based solutions” of climate change and it can offer a smooth transition to a satisfying regularity (University of Oxford, 2020).

Conclusions

Therefore, permafrost thawing leads to multiple complications and the significance of the problem should not be underestimated. The interconnected environmental, economic and health consequences pose a great threat not only to the countries covered by permafrost but to the whole international community. Notably the carbon dioxide and methane emissions from permafrost soils to the atmosphere, will generate an irreversible impact on climate and environment. Apart from ecosystem disturbances and contribution to global warming, degrading permafrost threatens the economy and

infrastructure. Houses, buildings, roads, pipelines are at risk because of the unstable ground in combination with the rising economic costs to rebuild or repair them.

Consequently, we can understand that permafrost thawing is a tangible problem which cannot be neglected anymore. Strong cooperation at international level is required to ensure an effective strategy to battle this problem. Especially funding needs to be allocated so that monitoring and scientific permafrost networks can be created which will contribute to the reduction of infrastructure failure costs and the protection of natural resources. Above all, the safety of the people directly associated with permafrost land must be a priority, by a permafrost insurance policy which will emphasize on reimbursement or other help for permafrost related damages. To conclude, it is highly important to pay attention to the prevention and efficient management of permafrost thawing immediately, so as to secure a safer future for everyone.

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