An important goal of NUNATARYUK, as with any research project, is to incorporate new information into existing knowledge, put it in perspective, and determine its environmental and societal relevance. Permafrost thaw releases carbon dioxide and methane into the atmosphere, contributing to global warming and significantly impacting Arctic communities. This graphic highlights the risks posed by permafrost thaw to Indigenous and local ways of life in the Arctic.

The permafrost system is made up of multiple interacting components that trigger positive and negative feedback loops. Human activities and changes in climate, as well as landscape characteristics and soil properties, can alter the state of permafrost, leading to hazards. Key hazards include infrastructure failure, mobility and supply disruptions, decreased water quality, food security challenges, and exposure to infectious diseases and contaminants. These hazards have significant environmental, sociocultural, economic, and health-related impacts on Arctic communities.

A variety of adaptation, mitigation, and recovery measures can be taken to address impacts, hazards, and physical drivers. The data presented here are based on several years of interdisciplinary research conducted in the Avannaata municipality in Greenland, in the Tiksi and Bykovskyi areas in Siberia, on Svalbard, Norway, and in the Beaufort Sea Region in Canada. The time and spatial scales of the research reflect those of the affected communities. Physical drivers, hazards, socioeconomic impacts, health-related impacts, and perceptions are often closely intertwined. There are also significant differences not only between regions but also within communities and individual perceptions. This graphic provides a generalised picture, but in reality, many aspects of permafrost thaw are highly place- and context-dependent.

This poster is part of the the *Arctic Permafrost Atlas* (2023) | nunataryuk.org/news/atlas

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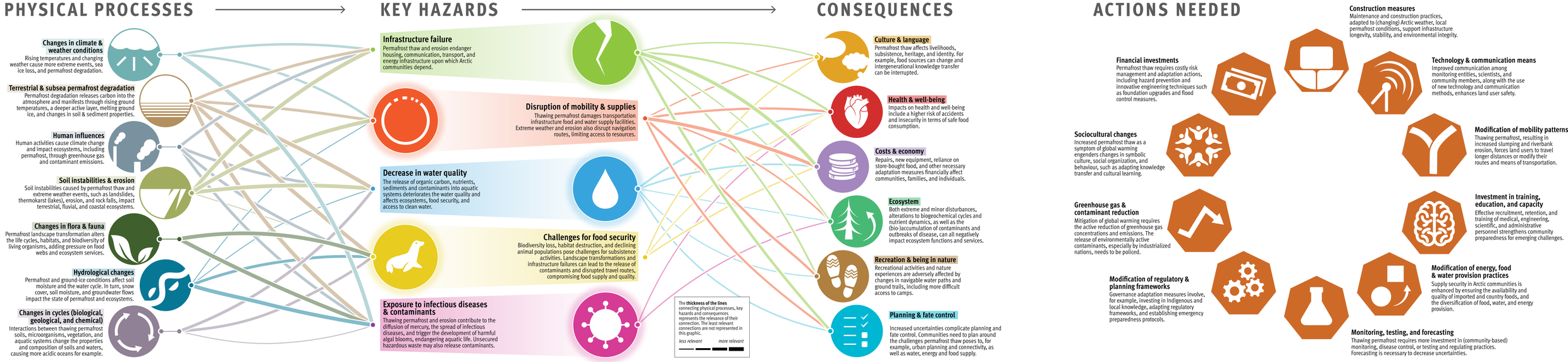
Children in Newtok, Alaska, play near crumbling permafrost cliffs that now lie within a few dozen feet of numerous homes. This Yupik village is one of the most urgent and extreme examples of climate change today. The entire village is sinking as the permafrost beneath it thaws. Erosion has already wiped out nearly over 1 kilometre of Newtok's land, with thawing permafrost rapidly accelerating the loss.

This project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 773421

The Big Picture

It's All Connected


PHYSICAL PROCESSES
Changes in climate & weather conditions
Rising temperatures and changing weather cause more extreme events, sea ice loss, and permafrost degradation.
Terrestrial & subsea permafrost degradation
Permafrost degradation releases carbon into the atmosphere and manifests through rising ground temperatures, a deeper active layer, melting ground ice, and changes in soil & sediment properties.
Human influences
Human activities cause climate change and impact ecosystems, including permafrost, through greenhouse gas and contaminant emissions.
Soil instabilities & erosion
Soil instabilities caused by permafrost thaw and extreme weather events, such as landslides, thermokarst (lakes), erosion, and rock falls, impact terrestrial, fluvial, and coastal ecosystems.
Changes in flora & fauna
Permafrost landscape transformation alters the life cycles, habitats, and biodiversity of living organisms, adding pressure on food webs and ecosystem services.
Hydrological changes
Permafrost and ground-ice conditions affect soil moisture and the water cycle. In turn, snow cover, soil moisture, and groundwater flows impact the state of permafrost and ecosystems.
Changes in cycles (biological, geological, and chemical)
Interactions between thawing permafrost soils, microorganisms, vegetation, and aquatic systems change the properties and composition of soils and waters, causing more acidic oceans for example.
KEY HAZARDS
Infrastructure failure
Permafrost thaw and erosion endanger housing, communication, transport, and energy infrastructure upon which Arctic communities depend.
Disruption of mobility & supplies
Thawing permafrost damages transportation infrastructure food and water supply facilities. Extreme weather and erosion also disrupt navigation routes, limiting access to resources.
Decrease in water quality
The release of organic carbon, nutrients, sediments and contaminants into aquatic systems deteriorates the water quality and affects ecosystems, food security, and access to clean water.
Challenges for food security
Biodiversity loss, habitat destruction, and declining animal populations pose challenges for subsistence activities. Landscape transformations and infrastructure failures can lead to the release of contaminants and disrupted travel routes, compromising food supply and quality.
Exposure to infectious diseases & contaminants
Thawing permafrost and erosion contribute to the diffusion of mercury, the spread of infectious diseases, and trigger the development of harmful algal blooms, endangering aquatic life. Unsecured hazardous waste may also release contaminants.
The thickness of the lines connecting physical processes, key hazards and consequences represents the relevance of their connection. The least relevant connections are not represented in this graphic.
less relevant
more relevant
CONSEQUENCES
Culture & language
Permafrost thaw affects livelihoods, subsistence, heritage, and identity. For example, food sources can change and intergenerational knowledge transfer can be interrupted.
Health & well-being
Impacts on health and well-being include a higher risk of accidents and insecurity in terms of safe food consumption.
Costs & economy
Repairs, new equipment, reliance on store-bought food, and other necessary adaptation measures financially affect communities, families, and individuals.
Ecosystem
Both extreme and minor disturbances, alterations to biogeochemical cycles and nutrient dynamics, as well as the (bio-)accumulation of contaminants and outbreaks of disease, can all negatively impact ecosystem functions and services.
Recreation & being in nature
Recreational activities and nature experiences are adversely affected by changes in navigable water paths and ground trails, including more difficult access to camps.
Planning & fate control
Increased uncertainties complicate planning and fate control. Communities need to plan around the challenges permafrost thaw poses to, for example, urban planning and connectivity, as well as water, energy and food supply.
ACTIONS NEEDED
Construction measures
Maintenance and construction practices, adapted to (changing) Arctic weather, local permafrost conditions, support infrastructure longevity, stability, and environmental integrity.
Financial investments
Permafrost thaw requires costly risk management and adaptation actions, including hazard prevention and innovative engineering techniques such as foundation upgrades and flood control measures.
Technology & communication means
Improved communication among monitoring entities, scientists, and community members, along with the use of new technology and communication methods, enhances land user safety.
Sociocultural changes
Increased permafrost thaw as a symptom of global warming engenders changes in symbolic culture, social organization, and behaviour, such as adapting knowledge transfer and cultural learning.
Modification of mobility patterns
Thawing permafrost, resulting in increased slumping and riverbank erosion, forces land users to travel longer distances or modify their routes and means of transportation.
Greenhouse gas & contaminant reduction
Mitigation of global warming requires the active reduction of greenhouse gas concentrations and emissions. The release of environmentally active contaminants, especially by industrialized nations, needs to be policed.
Investment in training, education, and capacity
Effective recruitment, retention, and training of medical, engineering, scientific, and administrative personnel strengthens community preparedness for emerging challenges.
Modification of regulatory & planning frameworks
Governance adaptation measures involve, for example, investing in Indigenous and local knowledge, adapting regulatory frameworks, and establishing emergency preparedness protocols.
Modification of energy, food & water provision practices
Supply security in Arctic communities is enhanced by ensuring the availability and quality of imported and country foods, and the diversification of food, water, and energy provision.
Monitoring, testing, and forecasting
Thawing permafrost requires more investment in (community-based) monitoring, disease control, or testing and regulating practices. Forecasting is necessary to decrease uncertainties.