Earth Sciences Sector

Permafrost impacts - cost to communities

Overview and Progress

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Reducing Canada's vulnerability to climate change

Introduction

Outcome

ESS S&T used in cost estimates of climate change impacts and adaptation as part of larger efforts to inform new Kyoto debate

Output

Timeframes, options and costs of adaptation of northern community infrastructures to permafrost degradation under different climate change scenarios.

Stakeholders and Partners

-- Climate Change Impacts and Adaptation Program
-- Environment Canada
-- Public Works and Services of the Northwest Territories
-- House Corporation of the Northwest Territories
-- Canadian Mortgage and Housing Corporation

Objectives of the Activity

Infrastructure of northern communities is built primarily on permafrost. Due to global warming, permafrost in the North will degrade or even disappear with rising temperatures.

Given existing and projected trends of climate change, northern community infrastructure is vulnerable to the impacts of climate change. An improved understanding of the vulnerability and associated costs, both with or without adaptation and under different climate change scenarios that are reflective of different levels of greenhouse gas mitigation, is therefore needed as part of larger efforts to inform the upcoming post-Kyoto debate. This understanding is also required for informed adaptation decision-making at the regional and local levels.

Objectives of the project include to estimate the approximate timeframes when remediation/adaptation action could be required and the associated costs, using the Inter-governmental Panel on Climate Change recommended climate change scenarios. The study focuses on infrastructure (houses and buildings) in the Northwest Territories, a region where significant warming has caused damages in recent decades.

Some Facts:

Permafrost: "Soil or rock that remains at or below 0°C (32°F) for at least two years." (NRC, 1988)

Approximately 50% of the Canadian landmass is underlain by permafrost and a significant proportion has an average temperature above -2°C (Smith and Burgess, 1999).

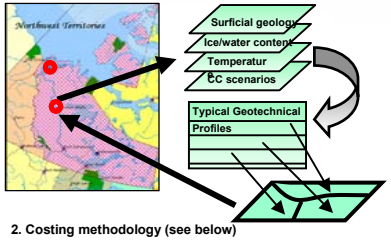
The Canadian Climate Centre General Circulation Model predicts that mean annual air temperature within the Canadian permafrost zone could be between 2 and 7°C warmer than that at present by the middle of the 21st century.

Methodology Highlights

Methodology for Case Study

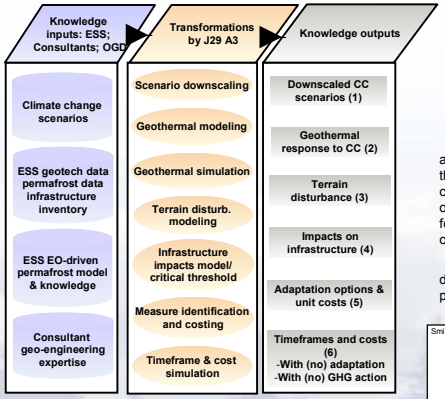
1. **Community selection and stratification**

   Select communities that are vulnerable to climate change
   Identify typical geological profiles based on geotech data



2. **Costing methodology (see below)**
3. **Apply pilot methods to other cases (if needed)**
4. **Upscale from cases to regional level (see Regional Assessment)**

Costing Methodology for Case Study

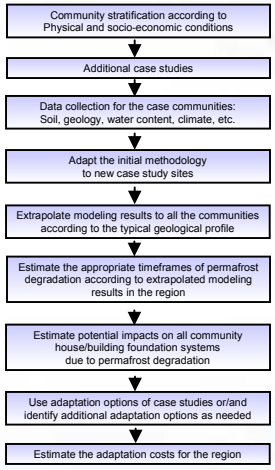


The study uses knowledge from various resources as input for modeling and analysis of permafrost dynamics, and generates knowledge of potential permafrost degradation and its impacts on foundation systems, and estimates the timeframes for adaptation and adaptation costs.

Regional Assessment

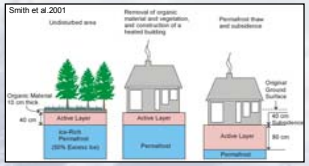
Regional assessment will upscale the case studies to regional and territorial levels.

Conceptual Framework – Regional Assessment



The two key components of regional assessment are the community stratification and the development of the method to extrapolate case study results to all the communities based on geological profiles, climate conditions, foundation systems, and socio-economic conditions.

The study will explore the spatial and time distribution of adaptation and the costs of permafrost degradation impacts in regional level.

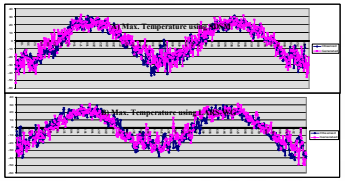


Initial Results

Climate Change Scenario Downscaling

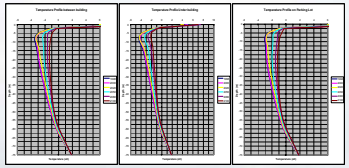
Downscaling of GCM model output for our case study has been conducted. For scenarios with monthly data, we used the LARS-WG model. For scenarios with daily data, we use SDSM to downscale TMAX, TMIN and precipitation. The following two graphs compare the downscaled data to the corresponding observed data. The downscaled and observed data match well. More detailed information on downscaling of climate change scenarios can be found in the poster "Permafrost Modelling for Norman Wells".

Comparison of downscaled Scenario to observed data



2D Permafrost Modeling and Simulation

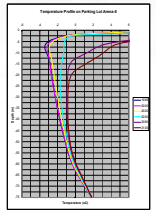
Permafrost modeling by TEMP/W software is applied to a typical geotechnical profile in Norman Wells. A base model was constructed under an arena parking lot. Results from the modeling have been extracted for three locations for Sept. 15 of the years 1998, 2000, 2020, 2050, 2080 and 2100. These locations are: a) 6m; b) 16m; c) 26m. The following figures show the temperature profiles for these three locations of the selected years. The model results show that soil temperature will increase with time – an indicator of potential permafrost degradation. More details about the modeling and simulation can be found in the poster "Permafrost Modelling for Norman Wells".



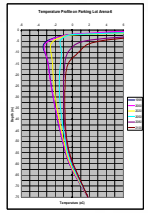
Comparison on Permafrost Modeling Results using GCM-based scenarios

Different GCM models and different SRES scenarios predict quite different air temperatures. Changing the scenario data for model input resulted in very different modelling results. The following figures demonstrate different soil heat regimes with two different scenario data sets. These results will be used to estimate cost differences with different scenarios. More results and discussion can be found in the poster "Permafrost Modelling for Norman Wells".

scenario data, NIES-A1FI



scenario data, NIES-B1



Sensitivity Study of Modeling

Sensitivity studies on various model inputs, such as N-Factor and water content, have been conducted.

It is found that N-factor is very sensitive to modeling results. However, N-factor is an empirical data set and it is very difficult to get 'correct' values for different surface materials. The study plans to integrate the CC program's permafrost model of surface dynamics into the sensitivity modeling to replace the N-factor method.

Remedial/Adaptation Measures and Unit cost:

Differential terrain disturbance caused by thaw or frost heave, can be transferred from the foundation system directly to structure, Typically, such movements cause deformation to the structure and damage to many of its components.

Various remedial/adaptation measures have been identified by the study. For each measure, there is an indicator of the effectiveness of different foundation systems for coping with permafrost degradation and corresponding cost. The study will estimate the regional costs of taking appropriate measures to adapt community houses/buildings to global warning and the timeframe in which the action should be undertaken.

Remedial/Adaptation Measures for Houses and Buildings

Insulation	Removable Insulation	Foundation Reinforcement with Piles and Beams	Cooling Tubes	Capillary Porous Materials	Mechanical Refrigerator System and Thermosyphon	Latent Heat of Melting Water

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