Assessing Adaptation to Climate Change in Rural High Latitude Regions

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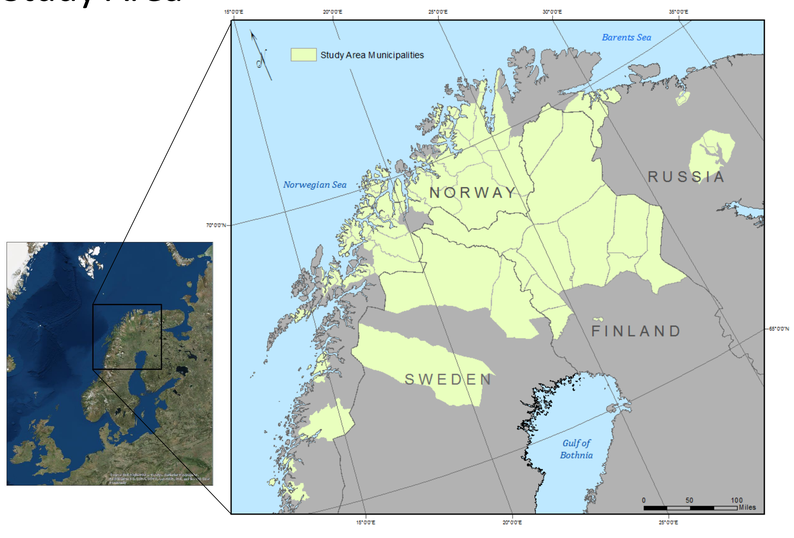
Abstract

Climate change is anticipated to occur most rapidly and with greater impact in Earth's polar regions. This is due in part to a phenomenon known as 'polar amplification'. Projections for these regions include higher temperatures than the global average and high rates of environmental changes. This rapid change in climate circumstances will affect many other characteristics of the region including local biophysical, economic, and social and cultural conditions. Considering these potential changes, many governing bodies are incorporating adaptation in planning decisions. We aimed to uncover the factors that drive adaption to climate change using a regional case study perspective for the development of a multi-scalar regional to local climate change adaptation model. The model can then be applied to other areas as needed to better prepare for a variety of changes that may affect local economies and their development potentials. Our study focuses specifically on municipalities above the Arctic Circle in Norway, Sweden, Finland, and northwestern Russia. Results indicate climate change is a significant factor in the municipalities surveyed but that impacts on local economies and societies vary drastically within the Arctic region. Coast-to-interior and north-to-south perspectives have highlighted these differences. For example, those living along the coast have expressed more concern about climate change and have observed numerous environmental changes, often resulting in the development of climate change plans. By developing a climate change adaptation model, we can showcase how various strategies have enhanced adaptive capacity by incorporating lived experiences and local knowledge into climate model projections.

Study Area



Research Questions

1) Do global circulation models and downscaled projections of climate change match the lived experiences of people in the region?
   a) How have communities adapted to early climate change indicators given their unique opportunities and constraints?
   b) How can we create an adaptive capacity model in relation to climate change for use in other regions of the world?

Photograph of a Sami reindeer herder in northern Norway standing calmly in the middle of the herd on which his livelihood depends. Photograph by Erika Larson, National Geographic, 2011.

Photograph of a *lávut*, a cone-shaped tent used for shelter by Sami herders resting on the tundra. As permafrost melts and food supply (lichens) is compromised by freeze-thaw events and invasive species, populations decline and leave the traditional Sami way of life in peril. Photograph by Erika Larson, National Geographic, 2011.

Photograph of an ice hotel in Jukkasjärvi, Sweden. Many local economies depend on winter tourism from natural amenities, including the *Aurora borealis*, snow for skiing and snowmobiling, and relatively pristine ecological systems. As climate change takes hold, communities have suffered a loss in winter tourism. Photograph by Travel Observers 2016.

Photograph of traditional fish drying in Lofoten, Norway. As temperatures increase it takes longer for the fish to dry and compromises the final product, threatening a long-standing industry and way of life. Photograph by Lisa Hvors, Korydor, 2014.

Results

Notable Changes to Biophysical Systems

Increase
- Sea level rise, storm waves, winds
- Fish migration northward to cooler waters, temperature stress
- Surface temperatures (>2^{0}C)
- Agricultural production and expansion (mostly hay and potatoes)
- Permafrost thawing and freeze-thaw
- New insect/plant populations (threaten trees and other native species)

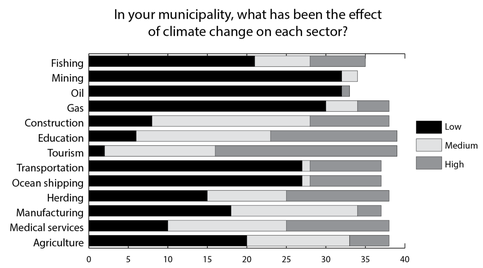
Decrease
- Length of winter (30 day delayed arrival compared to recent decades)
- Reindeer migration and population (reduction of food supply due to freeze-thaw events, invasive species replacing native vegetation, and increase in bothersome insect species)
- Snowfall has turned to icy rains
- Weather predictability

Notable Changes to Economic, Cultural, and Social Systems

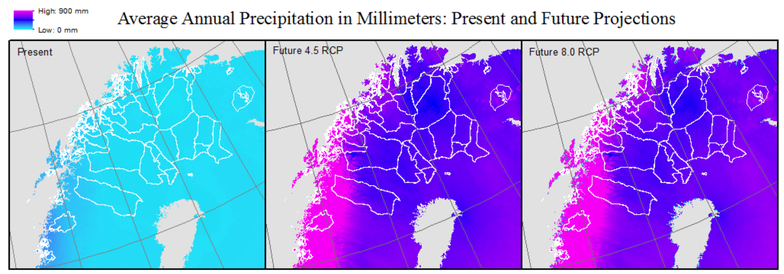
Increase
- Summer tourism
- Port operation and use
- Ground slippage and mudslides causing damage to roadways and other infrastructure
- Mental illness and substance abuse primarily due to darker winters (snow loss leading to less light reflectance)
- Climate refugee populations

Decrease
- Winter tourism (less snow)
- Traditional cod fishing industry
- Reindeer herding and husbandry
- Energy use for heating
- Timber harvesting (due to muddiness and permafrost thaw preventing machinery from functioning)
- Population (due to brain drain and disruptions to sense of place)

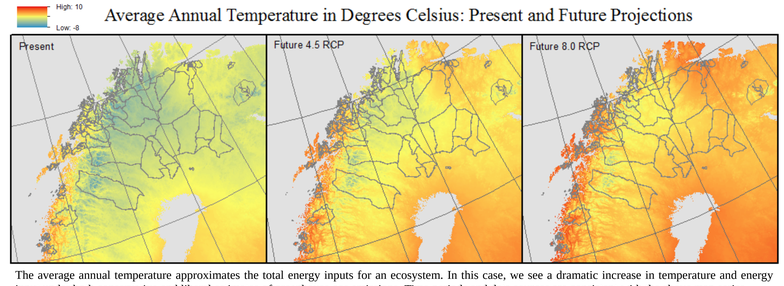
Word cloud showing the top 40 words (or their word equivalents) used during survey questionnaire interviews.



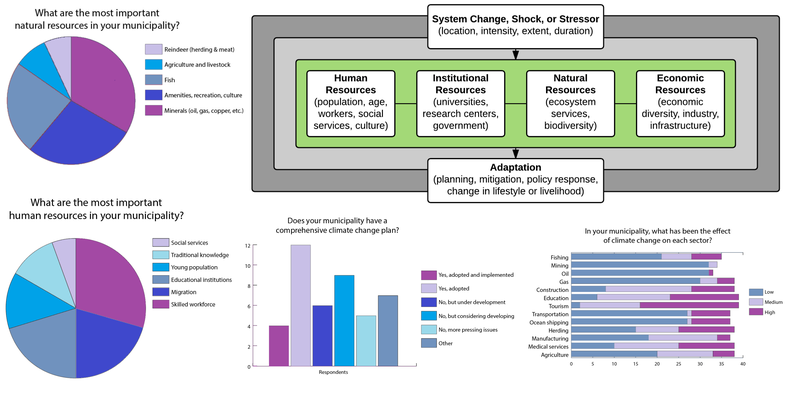
Stacked column graph showing responses to a survey question which asked how climate change is currently affecting each of the municipalities economic sectors.



'Present' represents the average for 1960-1990 and 'future' represents the average for 2041-2060. This pilot comparison uses outputs from three Global Circulation Models (GCMs): ACCESS1-0, BCC-CSM1-1, and CCSM4. GCM runs with Representative Concentration Pathways (greenhouse gas concentration trajectories) of 4.5 and 8.5 W/m^2 are shown. In the future, eight more GCMs will be included to further minimize biases.



The average annual temperature approximates the total energy inputs for an ecosystem. In this case, we see a dramatic increase in temperature and energy input under both conservative and liberal estimates of greenhouse gas emissions. Time periods and data sources are consistent with the above map series.



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