

A Probabilistic Model to Estimate the Value of Alaska Public Infrastructure at Risk from Climate Change

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1. INTRODUCTION

In 2004, the Arctic Change Impact Assessment (ACIA), a report produced by experts across many fields of study, concluded there was a clear need to study the socioeconomics related to climate change in the Arctic. Given the general shortfall in the literature about the economics of climate change, economists and policy analysts at the Institute of Social and Economic Research (ISER) began thinking of ways ISER could contribute to the local, national, and international debate on this timely topic.

This paper (and policymaking tool) represents our first attempt at estimating the risk to public infrastructure from rapid Arctic climate change. The paper can be boiled down into three sections. First, we assemble and map a database of Alaska's public infrastructure. Second, we show that the climate will continue to change in Alaska. Third, we demonstrate that as the Alaska climate continues to change (i.e., temperatures and precipitation increasing in general), the increased rate at which public infrastructure depreciates into the future will have significant cost implications.

2. MAPPING ALASKA PUBLIC INFRASTRUCTURE

Man-made as well as natural systems are at risk from climate change. Infrastructure throughout Alaska—including buildings, transportation systems, and utilities—is likely to be affected. One example is the village of Shishmaref, subject to erosion from Bering Sea storms. Community leaders

say moving the entire village is the only way to avoid catastrophic losses. The U.S. Army Corps of Engineers estimates that relocating this village (and two others) in the next 10 to 15 years will cost more than \$450 million.¹ Many other communities are also facing substantial effects of climate change and have requested emergency funds to help maintain their infrastructure. For example, roads built on melting permafrost near Fairbanks require additional (and costly) maintenance. Harbors exposed to rising sea levels and water treatment plants damaged by abnormal freezing and thawing cycles may depreciate more quickly. These problems increase maintenance costs and shorten the life of infrastructure.

2.1 Public Infrastructure Data Sources

In this model, we compiled data on both the location of public infrastructure and the topographical profile of the Alaska community where the infrastructure is located. For example, Barrow is an “exposed coastal community” built on “continuous permafrost.” To understand the distribution of public infrastructure in Alaska, ISER has been collecting community-level information from various sources, including the Alaska Department of Commerce, Community, and Economic Development; the State Office of Risk Management; the Denali Commission; the Federal Aviation Administration; the Department of Transportation and Public Facilities; and

¹ The other communities the Army COE says will need to be moved are Kivalina in northwest Alaska and Newtok in southwest Alaska.

many others. The most recent version of the database contains nearly 10,000 individual pieces of public infrastructure organized by 19 categories.



Fig. 1. Documented Location of 19 Types of Alaska Public Infrastructure

2.2 Useful Lifespan and Replacement Costs of Public Infrastructure

For the lifecycle model, we estimated replacement costs and baseline useful life for various types of infrastructure. These estimated average replacement costs are used as inputs to our model.

Infrastructure Type	Replacement Cost	Units	Baseline Useful Life (years)
Airport	\$ 5,664,812	Whole	10
Bridges	\$ 10,000	Per foot	40
Courts	\$ 16,150,618	Whole	40
Defense	\$ 305,441	Whole	40
Emergency Services	\$ 467,110	Whole	20
Energy	\$ 31,570	Whole	30
Grid	\$ 100,000	Per mile	15
Harbor	\$ 162,050	Whole	30
Hospital	\$ 44,772,750	Whole	40
Law Enforcement	\$ 3,917,245	Whole	30
Misc. Building (govt)	\$ 1,030,578	Whole	30
Misc. Building (health)	\$ 1,631,781	Whole	30
Railroad	\$ 2,795,717	Per mile	30
Roads	\$ 3,000,000	Per mile	10
School	\$ 2,486,167	Whole	40
Sewer	\$ 30,000,000	Whole	20
Telecommunications	\$ 299,576	Whole	10
Telephone Line	\$ 50,000	Per mile	15
Water	\$ 5,000,000	Whole	20

Table 1. Preliminary Estimates of Replacement Costs and Baseline Useful Life of Public Infrastructure

3. CLIMATE PROJECTIONS FOR ALASKA REGIONS

The Institute for the Study of Society and the Environment at the National Center for Atmospheric Research (NCAR) generously provided ISER with climate

change projections (monthly temperature and precipitation) for the years 2030 and 2080 for six Alaska regions—Anchorage, Barrow, Bethel, Fairbanks, Juneau and Nome. NCAR provided ISER with output from 21 climate models, all of which were based on the “A1B” emissions/growth scenario as defined by the Intergovernmental Panel on Climate Change (IPCC).^{2 3} ISER, along with outside experts, selected three representative models for our preliminary investigation.

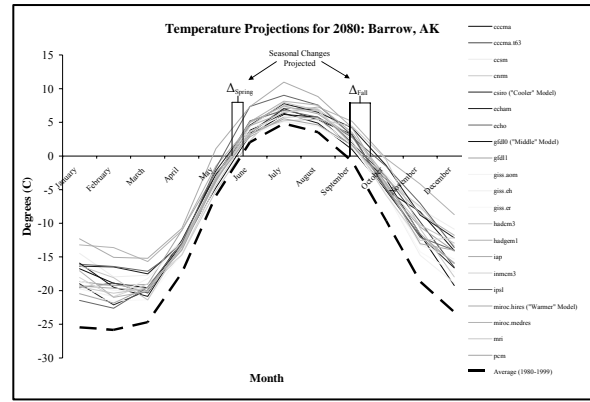


Fig. 2. Projected Temperature for Barrow (Alaska, USA) to 2080

3.1 Notes on Conveying Uncertainty

Including uncertainty in model estimates is a daunting but necessary task. We have constructed the model in a way to facilitate examining the range of possible outcomes associated with different input and parameter assumptions.

² We acknowledge the Program for Climate Model Diagnosis and Intercomparison (PCMDI) for collecting and archiving the model output and the JSC/CLIVAR Working Group on Coupled Modeling (WGCM) for organizing the model data analysis activity. The multi-model data archive is supported by the Office of Science, U.S. Department of Energy.

³ The A1 storyline, in general, assumes strong economic growth and liberal globalization characterized by low population growth, very high GDP growth, high-to-very high energy use, low-to-medium changes in land use, medium-to-high resource availability (of conventional and unconventional oil and gas), and rapid technological advancement. The A1B scenario represents a “balanced” development of energy technologies. It assumes that no one energy source is relied on too heavily and that similar improvement rates apply to all energy supply and end use technologies.

4. METHOD

We formulated algorithms to estimate the additional replacement costs, when melting permafrost, flooding, and erosion reduce the life of public works. Our results report the present value of these costs as the difference between a base case and climate change scenario (see Fig. 3).

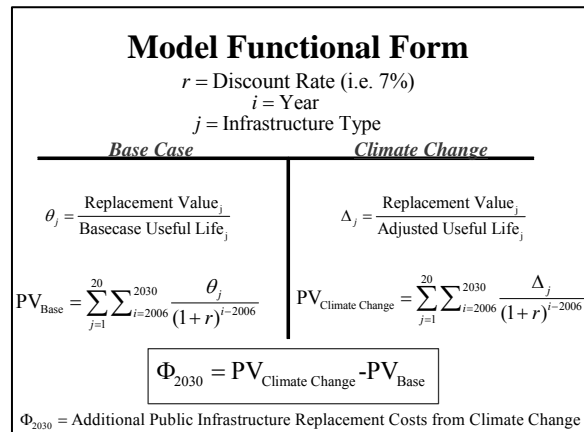
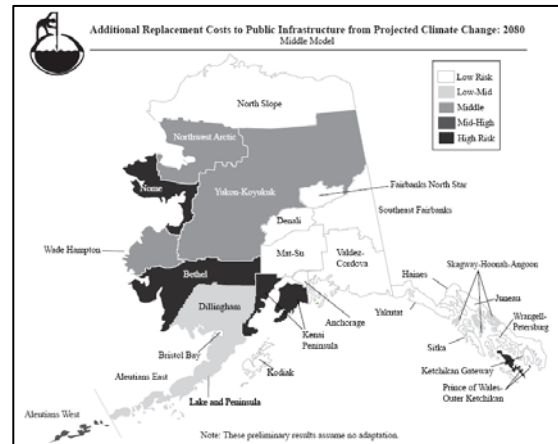
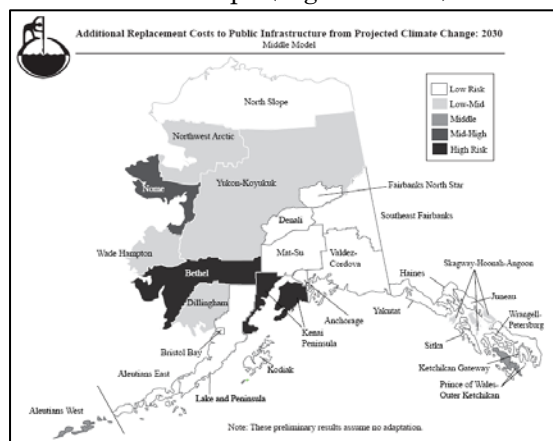


Fig. 3. Lifecycle Model Functional Form

5. RESULTS

Our preliminary estimates show that climate change could increase infrastructure replacement costs by tens of billions of today's dollars to 2080 (assuming little adaptation). Replacing bridges, buildings, and other structures with long lives will have the largest public costs. Roads, airport runways, and other public works with shorter lives are not as vulnerable, since routine use requires more frequent replacement regardless of climate change. We report results with preliminary probabilities of likelihood by type of infrastructure and location along with detailed maps (Figs. 4 and 5).



Figs. 4 and 5. Preliminary Financial Risk to Alaska Public Infrastructure, by Area, from Projected Climate Change (2030 and 2080)⁴

6. CONCLUSION

The results of this research, although preliminary, introduce more questions than provide answers. It is clear that we need to make significant refinements in this probabilistic lifecycle model, if it is to be taken seriously as a policymaking tool. However, what we can say now is that the magnitude of the economic effects of climate change on Alaska's public infrastructure will be in the many billions of dollars—certainly enough to warrant more socioeconomic research on this critical topic.

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⁴ **Preliminary Results- Do Not Cite or Quote.** Assumes little or no adaptive behavior. Algorithms are currently in development to offset these costs with assumed learning and technological improvements.

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