

Climate Change and Human Activity in Northern Canada: What We Know; What We Don't Know and What We Need to Know¹

FRANK DUERDEN

Professor, School of Applied Geography, Ryerson University

While considerable uncertainty surrounds the prognoses about the future climate and its impacts on human activity, there is consensus that if change is the new fact of life, high-latitude regions will be among those most affected. Physical changes of the type associated with global warming lie outside the experiences of the contemporary population of the North, and well beyond the popular notion of a land characterised by stable landscapes and unchanging environments. A generally accepted tenet in resource management is that information is an important tool for dealing with uncertain environments. The manner in which human populations will be impacted by climate change has been the subject of an increasing number of studies and reports over the past ten years. In this paper the quality of the "messages" that we get from formal sources of information is reviewed and information needs related to community risk and uncertainty discussed. The assessment of information quality is based on evaluation of the various works that address the impacts of climate change on human activity which were captured in the Northern Climate ExChange database, and as such the primary focus is with formal sources of information, but it is clearly recognised that much valid information lies in the informal realm.

The title of this paper implies movement towards some assessment; some movement towards answering the question "what do we need to know...?" This question is highly pragmatic. At the community level, for example, there is the question of how life and economy will be impacted. How will harvesting be affected? What will happen to winter ice formation? Will it impact on the ability to hunt? Will it create problems for winter road construction? What will be the impact of permafrost melting on construction? How will employment be affected? Will the industrial base of some northern communities widen as it becomes easier to access northern oil and gas? Will the subsistence base of some communities collapse because change is so rapid that adaptation lags? How should we modify traditional housing design in the face of warmer (and perhaps wetter) times? Should we prepare for increa-

sed flooding? Will there be increased incidence of forest fire? Will transport disruptions occur because of slope instability and landslides? Will change be manifested in a greater incidence of catastrophic storms? Have communities had experience of climate induced stresses in the past? How frequently? What magnitude? How did they cope?

The question of response to change is highly complex, a reflection of local conditions, attitudes towards uncertainty, attitudes towards hazards, and the socio-economic character of communities. Information plays an important role in response formulation, and the NCE bibliography, on which the ensuing analysis is based, is a highly comprehensive compendium of references and associated abstracts on all aspects of climate change in the Canadian North. It attempts to capture all relevant publications, papers and data and a review of its contents serves to identify knowledge gaps and information needs.

Climate Change and Human Impacts in the Canadian North

The extreme forecast is that fundamental ecosystems will be modified as the continuous and discontinuous permafrost boundaries move northwards by several hundred kilometres, along with attendant shifts in the tree-line. Moisture loss, resulting from the melting of the currently impermeable permafrost layer underlying northern wetlands, would be exacerbated by increased evaporation resulting in the rapid loss of wetlands, the foundation of complex ecological systems. Shifts in the tree-line may result in species shift as the advent of broad-leaf trees bring with them early succession species such as moose and caribou; on the other hand, such shifts may bring competition between caribou for preferred calving grounds. Sea-ice cover will shrink, substantially affecting the habitat of marine species such as ringed and bearded seals, sea-lions and walruses which require ice for breeding; migratory opportunities for (as an example) High Arctic Peary caribou herds will be reduced. It has been estimated that fresh-water fish will migrate poleward by 150km for every 1C increase in temperature, possibly displacing current resident species. Increases in sea level accompanied by storm surges may inundate parts of the mainland in the Western Arctic.

It is to events such as these, that impact on northern ecosystems, and thus native foods, that Indigenous populations will have to respond. While the general prognosis is that there is potential for considerable changes to, and stresses on, country food and traditional economic activity, projected climate changes may bring some advantages to the wage sector. Reduction of sea-ice cover will result in longer and more reliable navigation through the Northwest Passage and will considerably reduce hazards faced in extracting hydrocarbons that are known to lie in abundance beneath the Arctic Ocean. Reducing engineering and transport costs in the face of sustained energy demand

could lead to expansion of the oil and natural gas industry in the Arctic.

Human activity is the end of a chain that starts with Global Circulation Models (GCMs).² It is a process in which uncertainty is compounded at every step (Diagram 1). There is considerable debate about the accuracy of GCMs and the story they tell. The prognoses from these models are subsequently

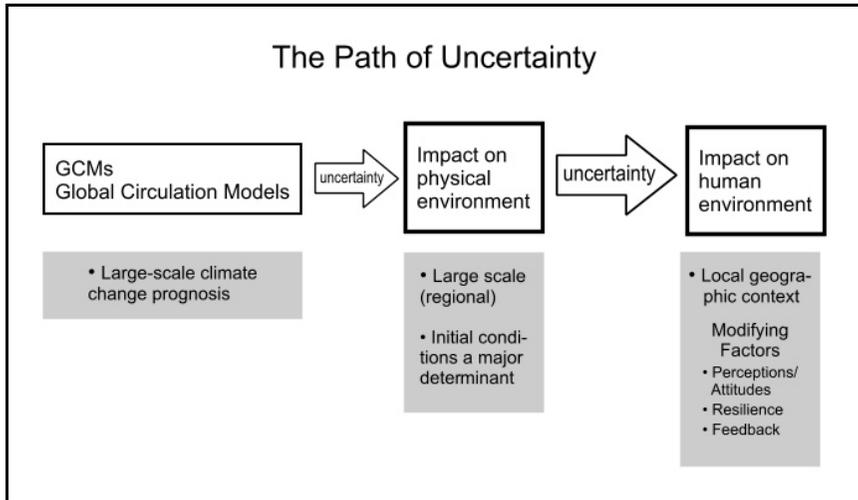


Diagram 1. The path of uncertainty. Uncertainty is compounded at every step.

translated into regional and local physical/biophysical impacts (conditioned by initial conditions, global location etc.), and finally into impacts on human activity (conditioned by initial conditions, relationship to the biosphere, attitudes, perceptions, feedback, resilience). While there is a strong and informed sense that change is taking place there is tremendous uncertainty about the exact nature of change. At the International Arctic Science Committee meetings in Tromsø in 1999 (for example), there was considerable debate about ocean temperature trends in the Arctic Ocean and the nature and implications of apparent differences in trends between the eastern and western Arctic Ocean. If there is uncertainty about this fundamental determinant and indicator of Polar climate, then such uncertainty is amplified through biophysical systems to human impacts. Uncertainty is further compounded by the fact that, while the circumpolar world is a large region, and historically data have been captured at the gross scale, human activity takes place at the highly localised scale where local geographic contexts and regionally peculiar land-use practices create a wide range of unique conditions.

What do we know about climate change impacts from formal sources?

Assessment of what we know about impacts on human activity was based on review of the data/bibliographic references on climate change and human activity in northern Canada found in the database developed by the Northern Climate Exchange. At the outset, this contained some 456 references to papers, books, statistics, and research reports of relevance to the question of climate change in northern Canada.³ The database is in MicroSoft Access format and has a field structure allowing searches in critical areas of investigation (keyword search, date of publication, degree of completeness, geographical area) to take place easily. Additionally, abstracts of each work provide a fairly detailed sense of content. The analysis in this report is confined to those references in the database that address some aspect of human activity. Searches revealed 106 relevant references. Diagram 2 depicts the range and orientation of relevant references.

Diagram 2:
References Linking Human Activity and Climate Change

1) Sector/Land Use	
• Harvesting (Hunting/Trapping/Fishing)	19
• Forest Use	12
• Agriculture	12
• Recreation	6
• Energy/Oil and Natural Gas	13
• Mining	3
• Construction	3
2) Economic Aspects	16
3) Infrastructure/Community	
• Transport	12
• Water supply/Sewage	2
• Health/Well-being	7
4) Hazards/Extreme events	12
	Total 127

Evaluating the Data Base

In order to assess the currency and quality of climate change impacts, references in the database were reviewed and evaluated against criteria describing focus, factual content, currency, and scale. The evaluation contained the following components:

- a) Evaluation of the extent to which references in the data-base match information needs for very specific human activities.
- b) Review of the quality of information contained in the various references. Is it speculative? Is it informative? Does it tell us about possible responses to change?
- c) Assessment of currency of data. Is it contemporary? Are prognoses and assessments rendered obsolete by the passage of time?
- d) Review of the scale and comprehensiveness of geographic coverage. How good is geographic coverage? Are data spatially spotty or spatially lumpy?
- e) Evaluation of the completeness of the database. Is substantial available information missing? (As opposed to information it would be desirable to have that is not available).

Critical Review of Formal Information

Much of the information that focussed on human impacts of climate change in the Canadian North is in the form of formal studies commissioned by government or interest groups. At the largest scale are works such as IASC's (1999) systemic overview of infrastructure and land-use, and broad studies of possible changes in the Yukon (1998) and the Arctic (1998) produced as part of the Canada Country Study series. Spatially focussed studies have been in the form of Mackenzie Basin Impact Study (1997), which recognised the complex integrated regional systems framework in which impacts must be evaluated, and a report produced by the Canadian Arctic Resources Committee reviewing possible stresses in Hudson Bay. There are also a plethora of sectoral studies examining impacts of change on specific aspects of life in the Arctic (for example, Fast and Berkes 1999). Overall, however, many of these studies are (inevitably) highly speculative and are often dogged by both uncertainty about the physical nature of changes and a lack of the detailed data on economy and society that is required to model ways in which a predicted change in physical conditions would ultimately impact on way of life at the community level. While anticipated changes, such as tree-line advance, permafrost melting, or modification of a major eco-region, all of which have implications for human activity are generally described at the gross scale, significant impacts may vary markedly from community to community as a reflection of variations in local geography, economy and culture. There is a paucity of appropriate community-level studies.

How Spatially Comprehensive Are the Data?

Given that the North is characterised by widely varying geographies and communities have markedly different locational contexts, it is important that there be information on probable regional or local impacts of climate change. However, references tended to be at a gross geographic scale, and the information in the database displays considerable spatial bias. To some extent, this is to be expected if we are examining impacts on human activity, because the North's 90,000 inhabitants are not evenly distributed across the region. The demographic bias is towards the West—Yukon and Mackenzie, where there is the most complete infrastructure (roads, pipelines, mining, oil and natural gas) and relatively large non-Native populations. Even making allowances for these variations, the West is over-represented in the database. The Yukon, with only 30% of the North's population has in excess of 40% of the place-specific references, and there was even further bias inasmuch as one third of these were based on one northern community. The other clear area of bias is the Mackenzie valley, an obvious reflection of the rich range of source material produced by the MBIS project. Nunavut, per se, is very much under-represented. The scale of representation is also highly generalised with many references, focussing on "Yukon," "Arctic," "Western Arctic," or "the North."

From the preceding review, a general picture emerges of our knowledge of the ways in which climate change may impact on different aspects of human activity. From the standpoint of agencies, organisations and individuals for which understanding prognoses about climate change and its possible impacts is important, this knowledge has utility if it is rigorous (i.e., detailed, low on speculation) or if it is prescriptive (suggesting possible adjustments or adaptive strategies). While most works in the information base reviewed in this study have some prognoses regarding climate change as a theme many are speculative in tone and only slightly more than half the references (55) could be said to deal with impact prediction in anything like a specific or rigorous manner, and only 8 dealt in any detail with either amelioration of climate change or specific approaches to adaptation. This paucity is partly a reflection of the fact that a number of works refer to human activity, but not as their central theme, their primary focus being changes in the physical environment. The preoccupation with impact prediction (as opposed to reaction) and the message that the climate may be changing is clearly important because it provides consumers of the information a sense of what they should prepare for.

Is the lack of prescription a cause for concern? If anything it reflects the general uncertainty about the future (in other words, we cannot say with any precision how to react). Does it point to an important information gap? (How should sectors prepare for climate change?) Quite possibly. It certainly does in terms of formal recorded information, but we should consider that there

is a vast amount of informal information vested in northerners, managers, entrepreneurs, decision makers, who have vital first-hand long-term experience of a wide range of activities, land-use and resource management practices. They understand their activities best, and may have a good sense of appropriate action in the light of climate change.

The paucity of detailed information presents a particular problem if the objective is to reach into communities and assist decision makers in addressing change. The reality is, that with the exception of the Mackenzie, there is very little of direct application they can learn from existing information. It is perhaps not too crass to characterise the message of many works as being "climate change is coming, there could be some considerable impacts, we really don't know what they are but you should be ready for them. . . ."

What We Need to Know

It is evident from analysis of the database that there are considerable gaps in our understanding of the ways that climate change may impact human activity in the North and the way in which northerners may respond to change. While the ultimate value of knowledge is a function of the needs of the user, there are deficiencies in information quality, scale, and focus, which have important implications for approaches to information capture and policy. Major concerns include,

- i) A reoccurring theme in climate change literature (either directly, or implied through generality of discussion) is uncertainty about the nature and impact of climate change in the North. It is difficult to prescribe anything approaching reasonable responses to change if the real nature of that change is unknown. While information, such as that contained in the reviewed literature, may allow us to narrow down possible scenarios for different sectors and for affected populations, the prevailing message is one of uncertainty. There is virtually nothing in the literature reviewed that explicitly addresses the question of strategies for dealing with uncertainty. Resource management literature addresses this question, and some consideration should be given to putting it into frameworks appropriate to northern Canada.
- ii) While there is a paucity of formal material (i.e., in the public realm) relating climate change and human activity there is probably extensive grey literature of relevance, and there is considerable local scale information on land and environment produced over the past twenty years, largely in support of land claims. This type of information (if it were made accessible) could serve as base-line data for scenario building.
- iii) There is a need to find out what the expectations and level of knowledge are of those who are involved in decision making. Traditional Ecological

Knowledge is accepted as a way of encoding knowledge and understanding processes and change for aboriginal populations. Is it not also reasonable to expect that there is much detailed and useful informal knowledge regarding ways of responding to change held by long-time practitioners and decision makers in the North involved with different aspects of human activity, such as transport, construction, or community infrastructure systems? Their experiences, expectations and perspectives on adaptation to changing environments are perhaps the most valid, but are also the least likely to enter the world of print.⁴

- iv) Much more hard, geographically precise information is required as the basis for scenario building. Human impacts will be felt at the community level. Widely differing geographic contexts and economies mean that as a consequence of initial conditions and local context individual communities will react to change in different ways. Dedicated community-specific databases are required, detailing initial conditions and locational factors that would have bearing on climate change impacts (susceptibility to hazards, extreme events), land-uses, structure of economic base, etc.
- v) There is a paucity of information on community risk. Catastrophic events (floods, landslides, rupture of communications) could be the most visible and immediately costly impact of climate change. While there is some decent regional prognosis regarding hazard impacts (e.g., MBIS), well-organised data are sparse, both temporally and spatially, for the North. Ideally, data need to be consolidated to identify possible risks associated with climate change at the community level.
- vi) As the volume of information produced through MBIS illustrates, studies that are integrated and have a regional focus have tremendous value, as long as the region has underlying physical unity. They provide a systemic basis for tracing/modelling physical impacts, and, from the human activity perspective, address both the political/economic context and the dynamic relationship between different activities. They have immediate practical relevance to subject populations for addressing issues arising from the probability of climate change. Further integrated regional impact studies should be encouraged.
- vii) It may be useful to investigate other regions that represent the types of physical environments that may emerge in the North. The value of this may perhaps be limited because the immediate problem will be one of dealing with the process of change (which could be protracted, and characterised by unpredictable events) rather than with emergent stable environments.

Ultimately what we know about possible human impacts of climate change in northern Canada falls far short of what we need to know, and this

paper has gone some way towards identifying some of the more significant knowledge gaps. While we clearly cannot know everything, and uncertainty prevails, accumulated knowledge narrows the range of uncertainty, allowing us to focus on the most likely or the most probable outcomes. Given the apparent rapidity of climate change in the North, a key component in narrowing the knowledge gap would be the development of a focussed strategy to seek, consolidate and organise information that is functionally relevant and spatially appropriate to the needs of a wide range of community level decision makers.

Endnotes

1. This work was funded in part by the Climate Change Action Fund and prepared for the Northern Climate Exchange's "Knowledge Assessment Project."
2. Those who see anthropogenic factors as the major determinant of climate change would perhaps argue that human activity is both the starting and the end point because release of greenhouse gases triggered the problem initially.
3. The study was undertaken when the bibliography contained some 456 references, and all references were examined in detail. Over the past two months the number of citations has increased markedly, and consequently the analysis and discussion of information quality is based on a very highly representative sample of works that collectively describe our state of knowledge regarding climate change in the Canadian North.
4. The number of references to "personal communication" in the database indicates that there is a wealth of experience to be drawn on from those involved in the day to day business of running the north in both the public and private sectors.

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