The Northern Climate ExChange
Gap Analysis Project

State of Knowledge
Impacts of Climate Change on Human Activity

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2001

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1 Introduction

The possibility of rapid global climate change has raised concerns about the ability of populations to adjust to change. While considerable uncertainty exists about the future climate and its impacts on human activity, there is consensus that climate change will affect high-latitude regions the most. 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 perception of the North as a cold climate land characterized by stable landscapes and unchanging environments.

It is generally accepted that information is an important tool for resource management when dealing with uncertain environments, so consolidating information on climate change and its possible impacts in northern Canada could help increase awareness of current and future trends, identify possible impacts, and provide a sense of information needs.

This report is a critical review of data on climate change and human activity in northern Canada found in a Northern Climate ExChange database. The study was undertaken when the bibliography contained some 456 references, and all references were examined in detail. Over subsequent 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.

It contains some 456 references to papers, books, statistics, and research reports relevant to the question of climate change in northern Canada. The Microsoft Access format allows relatively easy interrogation of the database by keyword search, date of publication, degree of completeness, and geographical area. In addition, summary abstracts of each work provide a fairly detailed sense of content.

This report analyzes the 106 references in the initial database that address some aspect of human activity. While additional references were sought from a wide range of sources, very little new material was found. A request posted on the Internet asking for information from the scientific community yielded no responses.

2 Climate Change and Human Activity

The focus of this work is human activity, defined broadly as economy and land use and identified specifically by a number of descriptors that, in total, describe the range of human activities in northern Canada (see Table 1 for classification and explanation). Discussion of the relationship between climate and human activity is ancient, and the resilience of this debate points to the difficulties of establishing the manner in which climate change may impact on land use and economy.

While it is indisputable that climate provides the context and parameters for human activity, establishing with any certainty the manner in which activities may respond to climate change is fraught with problems.

First, relationships between activities are complex. Change in one activity may affect others through economic multipliers, varying perceptions of decision-makers, and a range of feed-back mechanisms.

Second, the response to physical change may primarily be a function of political and economic contexts. For example, the northward shift of agricultural potential in parts of the Mackenzie basin does not necessarily lead to the conclusion that there will be increased agriculture; this is dependent on markets and the population's acceptance of agriculture as a land-use activity.

Finally, for better or worse, the development of North America has been dependent on innovations that have ameliorated the impact of climate extremes, (such as central heating, irrigation, and air-conditioning)[1], and technological change will play into the way different sectors respond to climate change. Producing the scenarios that become the data and information about the possible impacts of climate change is difficult because one uncertainty is predicated on another, our understanding of the probable future climatic context for human activities depending on the accuracy of physical prognosis regarding the nature of change.

[1] Ironically increased CO2 levels are partially attributable to our endeavours to modify the impact of climate.

3 Database Rationale

The concern that global warming could have a significant impact on northern Canada raises many uncertainties and points to the need for certain types of information. Some of the pragmatic questions at the community level are:

- How will harvesting be affected?
- Will possible changes in winter ice formation affect hunting practices and winter road construction?
- Will melting permafrost affect construction and, if so, what technologies do we have to deal with these problems?
- How will employment be affected?
- Will easier access to northern oil and gas widen the industrial base of some northern communities?
- Will the subsistence base of some communities collapse because adaptation lags behind rapid change?
- How should we modify traditional housing design in the face of a warmer and possibly wetter future?
- Should we prepare for increased flooding?
- Will there be more forest fires?
- Will slope instability and landslides disrupt transportation? Will climate change lead to more catastrophic storms?
- Have communities experienced climate-induced stress in the past? If so, how frequent and severe were these experiences, and how did the communities cope?

It is expected that both the general population and the decision-makers in northern communities will use the information in this climate change database. For example, government agencies may have to respond to a range of issues such as concerns associated with easier navigation through Canadian arctic waters, the dislocation of community economies, or the consequences of extreme events. Given these "user-needs," a climate change information system would have four roles:

1) providing information on possible trends\scenarios and information on approaches for addressing the possible consequences of climate change;

2) enabling users to investigate impacts, responses, etc. of others in similar circumstances. This approach would save both time and money, reducing the need for extensive primary research and allowing users to focus on the most likely approaches or solutions. Given the pace of change, time is an important consideration;

3) providing baseline data that enables users to build scenarios predicting local impacts. For example, detailed information on current populations, ecosystems and economy, and on the relationship between the current climate and human activity, could help a

community anticipate the impacts of environmental changes;

4) identifying research needs. Reviewing current database records and cross-referencing them with areas where information is needed would help identify gaps in research.

Evaluating the database thus hangs on questions such as: How complete is it? Can it provide a basis for action or decision-making? Is there a reasonable "fit" between the current information on climate change in Canada provided by NCE and the intended users?

4 Methodology

Assessing a database has two components. First, it must be determined whether users can retrieve relevant information easily, and second, the quality of the available information must be assessed. This paper largely concentrates on the second task.

In addition to the NCE database review, the completeness of the existing database was assessed by searching for other sources of information. The value of a database lies as much with its ability to serve the needs of users as it does in the quality of information it contains. Even if all available current information on a topic is captured, such information may fall short of user needs.

The following six steps were used to test the quality of information on climate change in northern Canada:

1) Evaluating how well descriptors in the database matched information needs;

2) Evaluating the extent to which references in the database matched information needs for very specific human activities;

3) Reviewing the quality of information contained in the various references. Is it speculative? Is it informative? Does it tell us about possible responses to change?

4) Assessing currency of data. Is it contemporary? Have prognoses and assessments become outdated?

5) Reviewing the scale and comprehensiveness of geographic coverage.

6) Evaluating the completeness of the database. Is substantial available information missing? (As opposed to desirable information that is unavailable).

5 Identification of Relevant References

The initial step was identifying works dealing with human activity. A key-word search was conducted using the following descriptors for human activity in the North: human activity, harvesting, agriculture, transport, energy, forests, economy, mining, infrastructure, construction, and recreation\tourism. References were found in the following categories:

Table 1: References Relating to Human Activities

Activity	References
Human Activity	93
Land	35
Wildlife	33
Economy	28
Land-Use	17
TEK	15
Transportation	5
Mining	15

Note: The number of valid references exceeds the number of records (106) because many records contained multiple references to different activities.

While the search terms "TEK" and "human activity" helped to identify 106 potentially useful records, the terminology was found to be imprecise as many references did not indicate a clear link to human activity. Subsequently more detailed reference to the range of human activities relevant to the North was sought in the abstract of each of the records.

Users of the database would want to know the possible impact of climate change on well-defined sectors of activity, and consequently a more detailed list of terms was used to describe human activity in northern Canada (Table 2). This included land uses and economy, infrastructure, social aspects of settlement (population, health, well being) and threats to economy and well-being in the form of increased incidence of natural hazards that may result from climate change (floods, landslides etc).

Table 2: References by specific activity

Descriptor	References
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
Economic Impacts	16
Infrastructure \Community	
Transport	12
Water Supply\Sewage	2
Health\Well-being	7
Hazards\Extreme Events	12
Total	**127**

Defining reference material appropriate for inclusion in the analysis was a little

problematic, as a huge amount has been written on climate change in the North over the past thirty years. Arguably all of it could be considered valid as it describes "initial conditions" and could provide baseline information.

Given that the focus of this exercise is the relationship between climate and human activity, all valid references had to contain some discussion of climate change implications. Repetitive works were eliminated, as were general bibliographies (8), and new references added. Table 2 illustrates how the number of valid references decreased as definitions became more specific.

6 Content Analysis

Overview

Formal studies commissioned by government agencies or interest groups have generated much of the focused information on human impacts of climate change in the Canadian North. At the largest scale are works such as IASC's spell out (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. Reports focused at the regional level include the Mackenzie Basin Impact Study (1997), which recognized the complex integrated regional systems framework in which impacts have to be evaluated, and a review of stresses on Hudsons Bay produced by the Canadian Arctic Studies Committee. There are also a plethora of sectoral studies examining the impacts of change on specific aspects of life in the Arctic (for example, Fast and Berkes 1998).

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 detailed data on economy and society necessary for modeling ways in which a predicted change in physical conditions would ultimately impact on way of life at the community level. Anticipated changes such as tree line advance, melting permafrost, or modification of a major ecoregion all have implications for human activity and are generally described at the gross scale. But significant impacts may vary markedly from community to community because of variations in local geography, economy and culture. There are fewer appropriate community level studies.

Individual works often refer to a range of activities, thus diluting what were already highly speculative impacts for any one sector. However, the accompanying analysis was sometimes particularly significant as it centered on the dynamics of land-use change and the ways in which some uses may displace others with climate shifts. For example forests may give way to agriculture and there may be changes in the nature of wildlife harvesting.

In this interplay between land-uses, behavioral and economic factors determine responses to climate change and may also give rise to land-use conflicts. For example climatic conditions could create new agricultural opportunities in the potentially more arable areas of the southern Yukon and parts of the Mackenzie system, but market conditions may discourage land-use change (MBIS). Northern agriculture would still be a costly proposition, despite relatively low transport costs, and it is difficult to compete with mass production in the south. Significant agricultural expansion could cause conflicts with wildlife harvesting because of land clearance and the notion that "wild" animals constitute pests in domesticated landscapes, exacerbating stresses and ecological modifications that were first triggered by climatic factors.

Sectoral Review

a) Harvesting (hunting, trapping, fishing). Although there are numerous references to harvesting, few detailed studies relate harvesting to climate change. Some

good local studies have provided important information for specific communities (Old Crow, Bathurst Caribou Herd, for example.) Such studies can offer other communities a sense of climate change\subsistence dynamics, but variations in northern geography and community circumstances make interpolation of experiences to other locations questionable.

There is a tendency towards very general works. For example, the Canada Country Series study of climate change impacts on harvesting (Fast and Berkes 1998) provides a generally useful overview. Much of the substantial data on native harvesting was gathered for purposes other than climate change (land claims, regional or community economic studies). Reviews of probable impacts on dietary habits are scant and highly speculative (see, for example, Wein 1995). There is a general understanding of the physical changes that could impact harvesting (ecosystem shifts, shifts in tree-line, permafrost melt, ocean warming, decrease in sea-ice) at the macro-level, but the way in which physical changes would play into population dynamics and mixed economies at the local level is not as clearly understood. The few studies directly linking climate change and harvesting rely on information from widely known studies that sit in the public realm. Considerable baseline information has been gathered at the community level in the course of land claim negotiations or in support of other processes (environmental assessments, planning, etc.), but is not accessible. Overall there seems to be a high sense of awareness that harvesting will be impacted, but the precise nature of the impacts is not known.

b) Human Use of Forests. Forest fires and northward shifts in species habitats could affect human use of forests. Climate change could exacerbate current development pressures in more accessible areas, especially where there is potential for competition from agriculture. Geo-political and economic contexts are seen to be important in assessing the impact of climate change on the use of forests. There is a good sense of potential land-use shifts, and a general understanding of possible physical changes to land-use, but it is not clear how political and economic factors may play into actual land-use changes.

c) Agriculture. Most discussion concerns general land-use and the relationship between agriculture and other land-uses. The northern movement of agriculture could bring conflicts with forest use. An increased need for irrigation may constrain agricultural expansion. Although physical conditions may favour northern expansion of agriculture, a lack of markets and unfavourable local economic conditions may limit its spread. In the Yukon and parts of the Mackenzie Basin, considerable long-term baseline information gives a reasonable sense of how marginal lands would respond to warming. Where studies have focused on specific regions (eg Brklacich and Curran in MBIS, 1997), there is a cautious understanding of the way in which economic factors may constrain land-use change

d) Recreation\Tourism. The very limited amount of available information mainly appears in broad overview works dealing generally with climate change impacts (see, for example, Rothman and Herbert 1997). There is some discussion of emerging issues related to tourism and climate change (Wenzel, 1995, West, 1995).

e) Mining. The most significant questions relate to the ways permafrost melt and increased precipitation may impact

existing mining operations and de-commissioned mines and affect future approaches to de-commissioning. Mining has long been an important industry in northern Canada, but there is little detailed relevant information on associated issues in the database.

f) Energy. (including oil and natural gas). Most references concern the impacts of climate change on energy production. This includes investigating impacts in the Mackenzie-Beaufort region under different climate change scenarios, and the impact of modified hydrology on hydro-electricity generation in Northern Quebec. A minor theme is the use of alternate energy sources in the North to ameliorate global warming through reduction of greenhouse gases.

g) Transport. Impacts vary with location, largely related to landscape changes. Increased landslides and slope instability could affect highway transport, as would the melting of permafrost beneath highway surfaces. Travel related to harvesting may become more difficult because of thinner lake ice (anecdotal evidence for this), more open water and changing shore-ice conditions. Over time northern transport systems have evolved to accommodate a range of climatic conditions, and from a baseline standpoint there is a good sense of current conditions. The literature addresses impacts on land transport from changes such as melting permafrost and increased incidence of landslides, but the prognosis regarding ocean transport is more guarded. Decreasing ice coverage is expected to make navigation on the Arctic Ocean easier, but there is currently considerable controversy among marine scientists about temperature trends (IASC 1999).

h) Economic. Impacts tend to be speculative. Improved accessibility in some areas (the Arctic Ocean, for example) could bring new opportunities (increased hydro-carbon development) and cause shifts in community economic bases as the nature of subsistence harvesting changes, possibly declining in some areas. There are virtually no community micro-studies directly related to climate change detailing economic structure and interdependency, or examining the potential for labour to be absorbed into emerging sectors as economies shift. However a number of studies prepared for other purposes (pipeline impacts, planning, land-claims) detail the structure of dual economies that could conceivably provide baseline data. Much of this information is dated; not all of it is easily accessible.

i) Health\well-being. This topic is related to economic development. Climate change is generally viewed as an emerging stress that will exacerbate other factors impacting well-being in the North, such as rapid population increases in the eastern Arctic and the possible release of toxins into the food-chain associated with higher temperatures. It is speculated that people may eat less country food because of changing wildlife regimes, resulting in health problems.

j) Water-Supply\Sewage. While the characteristics of existing infrastructure in individual communities are documented, and some general observations on future scenarios was found, no formal information on climate change impacts in this area was uncovered.

k) Hazards. The range of extreme or catastrophic events associated with warming that may impact human activity is well documented, although there is no detailed

assessment of risk (at the community level for example). Database records identify impacts such as rapid coastal erosion in the western Arctic, increases in run-off leading to flooding, more forest fires, landslides impacting on communications, and permafrost melting potentially affecting built structures and transportation. The MBIS study has the most comprehensive region specific information. With one notable exception (Aharonian, 1994) there is little formal information on the hazard history of northern communities in the contemporary literature. Detailed information on hazard history could be very useful as different experiences of past extreme events would probably be reflected in different responses to events associated with climate change.

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. Agencies, organizations and individuals concerned with climate change and its possible impacts need information that is rigorous (detailed, low on speculation) or prescriptive (suggesting possible adjustments or adaptive strategies). While most works identified in this study have some prognosis regarding climate change, many are speculative in tone. Only slightly more than half the references (55) predict impacts in any sort of a specific or rigorous manner, only eight dealt in any detail with either amelioration of climate change or specific approaches to adaptation. This lack of information partly reflects the fact that a number of works focus primarily on changes in the physical environment, and references to human activity are secondary. The preoccupation with predicting impacts rather than offering ways to react to changes, and the message that the climate may be changing, are both clearly important because they give northerners a sense of the conditions for which they should be preparing.

Is the lack of prescription a cause for concern? It certainly points to a major *formal* information gap on how various sectors should prepare for climate change, but it perhaps understates the extent to which consequences of change are understood. It is highly probably that those employed in various activities in northern communities may have a strong innate sense about the constraints under which particular activities function, and thus the manner in which they may be affected by changing conditions and possible appropriate responses to change. The validation of TEK as a source of information on northern environments over the last several years certainly supports this contention, and local and experiential knowledge may expand way beyond TEK into tertiary and industrial sectors. Thus while the review on page 8 indicates that relatively little is formally recorded about possible impacts on a number of sectors we can surmise that there is considerable reservoir of experience and understanding – local knowledge – that would play an important role in responding to climate change.

The lack of detailed information presents a particular problem for decision-makers in communities that need to address change. Except for those in the Mackenzie region, decision-makers can learn very little of direct application from the database. It is important to note, however, that this is not a failing in the database per se or of NCE's data-collection efforts. The search for additional sources of information yielded few results, and those additional works that were identified displayed the same lack of

specificity as references identified by the NCE. It is perhaps not too crass to characterize 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…….”

7 Spatial Distribution of References

Given that both geography and community settings vary widely in the North, providing information on probable regional or local impacts of climate change is important. However, as Tables 3 and 4 indicate, references tended to be at a gross geographic scale and information in the NCE database displays considerable spatial bias. This is somewhat to be expected when examining the impacts of change on human activity because the North's 90,000 inhabitants are mainly located in the west (the Mackenzie region and the Yukon), characterized by 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 percent of the North's population has more than 40 percent of the place-specific references, and one-third of these were based on one northern community, Old Crow. The numerous references in the database for the Mackenzie valley obviously reflect the rich range of source material produced by the MBIS project. Nunavut per se is very much under-represented.

Many references are at a very general scale, examples include "Yukon", "Arctic", "Western Arctic" etc, or "the North." While this is a reflection of the fact that changes will be wide ranging, to a large extent it results from the paucity of sub-regional or local scale information about the north.

Table 3: Geographic Focus of Database References

Location	Occurrences
1) Arranged by Frequency	
Not Specific	44
Mackenzie Basin	19
Yukon	18
Yukon North	11
Alaska	6
N. Provinces	6
Arctic Ocean	5
N. Quebec/Labrador	3
Nunavut	2
Central Arctic	1
Yukon Central	1
2) Arranged by Location	
Not Specific	44
Yukon	18
Yukon North	12
Central Yukon	1
NWT	7
Mackenzie Basin	19
Nunavut	2
Western Arctic	3
Central Arctic	2
Northern Provinces	6
Alaska	6

Note: This table depicts the apparent spatial imbalance in the available information relating to climate change and human activity. This is attributable both to focused studies in the west examining climate change impacts and to the range of scales at which references have been classified. More than one-third of the references are not region-specific, and many relate to more than one region. Overall only 36 are affiliated with a single region, and some of these regions are vast (Alaska, for example), pointing to the need for more locally focused small-scale studies.

However impacts on human activity will be felt locally. Every community is unique with its own geography, culture and economy, so even identical changes in broad conditions such as advancing treelines, melting permafrost, retreating sea-ice and storm surges may impact any two communities in markedly different ways. For example, at the aggregate (or systemic) level we can make gross estimates of food harvests and relative dependency on country food, and thus perhaps model how depleting one species may impact on this part of the economy. But harvests vary in both type and volume, as does the local ecological context for the harvest. Local economies also vary, and communities with stronger or emerging industrial economies may be better able to tolerate change by offering alternate employment.

As a consequence of these various factors, communities will probably react in different ways to changes in environment or productivity of the land. In order to get a realistic sense of probable impacts, detailed information on initial (baseline) conditions in individual communities is required along with a sense of the ways that their local physical environment could be impacted by events associated with climate change, such as melting permafrost and changes in forest characteristics.

The numerous relevant references drawn from the Mackenzie Basin Impact Study (MBIS) come closest to providing an integrated and geographically useful database. MBIS recognized that the physical environment provides a context for human activity and that different activities are related and interdependent. The works associated with MBIS provide a multi-facetted and fairly well integrated perspective on climate change impacts in a large physical region defined by one unifying feature, its watershed.

To a large extent MBIS is a good model for a climate change information base in terms of the types of information provided and appropriate geographic scale. (The Wolf Creek study performs the same function at a somewhat smaller scale, as did CARC's Hudson's Bay study.) Much of the information in MBIS is only useful for application in its own geographic area. This is not a weakness; rather it reflects the strengths of a regionally important information base. But it also underlines the general need for more geographically specific data collection throughout the North. [2]

[2] While MBIS is by far the best regional integrated source on climate change impacts it was a relatively low budget exercise, and to some extent this is reflected in its speculative nature and relative paucity of primary data.

8 Currency

While the NCE database captures information ranging back over thirty years, the more specific analyses linking climate change to human activity or to defined regions have been conducted in the last decade. This reflects the fact that concerns about climate change are relatively new.

Table 4: References by date of completion

Date of Completion	References
1990 and before	19
1991-95	40
Since 1996	54

While these trends are not unexpected, they do indicate that the number of studies linking human activity and climate change in the North is increasing. The recent studies are region or sector specific and have the greatest relevance, and continuation of this trend may help ameliorate the current substantial information deficiencies.

9 How Good is Our Formal Knowledge of Human Impacts of Climate Change in Northern Canada?

From the preceding analysis, conclusions can be drawn about the specific structure of the NCE database and the state of knowledge regarding climate change impacts in northern Canada. In the first instance, the NCE bibliography is a good (if not quite complete) inventory of books, papers, data and reports on the impact of climate change on human activity that clearly sit within the public realm. As it stands, the database architecture could perhaps be improved to better reflect both the content of works related to human impacts and their geographic context. The addition of more key words (such as the ones used in this report) to describe specific activities would be very useful. More precise regional definition would also be appropriate, although it is conceded that this is rather problematic given that there is no precise geographic focus for many works.

Regarding the overall state of knowledge, there is a real lack of quality information relating human activity and climate change impacts in northern Canada. The 106 citations identified dwindle significantly if their relevance and currency are considered. After adjusting for duplication, 91 records clearly referred to human activity, and a number of these were references to different activities in the same article or paper. Only 45 citations could be considered current, meaning produced in the last five years, and these also are the most relevant references, yielding practical focused information on climate change impacts. They are largely products of projects centered on climate change impacts (MBIS, the Canada Country Studies, for example).

Given the large size and geographic diversity of northern Canada, there is little formal information available on human activity and climate change. This situation is made worse by the fact that most of the information is specific to the western Arctic, and many works are at a broad scale. Understanding the impacts of change with any certainty is perhaps not a reasonable expectation at this stage, given that there is considerable uncertainty about what is happening to the North's physical environment upon which most human activities are based. Section 6 of this report summarizes the state of formal knowledge regarding climate change impacts and human activity in the Canadian North.

Different users require information at different scales, so a useful report provides the right information at the appropriate scale. While much work remains to be done in obtaining, consolidating and presenting information, a number of works exemplify ways of conveying climate change information at different scales that would be useful to specific users. Information can be classified at four distinct scales:

- large scale sectoral (IASC,1999 for example)
- regional\sectoral (Canada Country series)
- regional\integrated (MBIS)
- community level (Kofinas, 2000).

The value of these studies lies in their utility to different user groups. The IASC analysis, for example, has its greatest immediate value in providing a scientific overview to

federal-level decision-makers charged with responsibility for broad sectors of the northern environment (inland waters, Arctic navigation, regulation of non-renewable resources) and a need to be aware of concerns that could arise from extreme events. The regional level analyses serve as a tangible basis for planning and drawing affected land-use interests together in contemplating climate change impacts, while community level studies recognize the fact that impacts and responses will depend very much on local geography, economy and community attitudes.

10 Information Needs

1. A reoccurring theme in climate change literature (either directly, or implied through general discussion) is uncertainty about the nature and impact of climate change in the North. Prescribing anything approaching reasonable responses to change is difficult 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 *possibl*e scenarios for different sectors or affected populations, the prevailing message is one of uncertainty. Virtually nothing in the literature reviewed explicitly addresses the question of strategies for dealing with uncertainty. Resource-management literature does address this question and some consideration should be given to putting it into frameworks appropriate to northern Canada.

2. While there is a lack of formal material (i.e., in the public realm) relating climate change and human activity, there is probably extensive "grey literature" of relevance. Also considerable local-scale information on land and environment has been produced over the past twenty years, largely in support of land claims. If this type of information were made accessible, it could serve as baseline data for building scenarios.

3. The expectations and levels of knowledge of those involved in decision making need to be identified. TEK is an accepted way of encoding knowledge and understanding processes and change for aboriginal populations. Is it not also reasonable to expect that long-time northern practitioners and decision makers involved with different sectors (such as transport, construction, or community infrastructure systems) would hold much detailed and useful informal knowledge regarding ways of responding to change? 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.[3]

4. Much more hard, geographically precise information is needed for building scenarios. Human impacts will be felt at the community level. Widely differing geographic contexts and economies mean that individual communities will react to change in different ways. Dedicated *community-specific* databases are required that include factors such as initial conditions, land uses, economic structures and locational conditions that could have bearing on climate change impacts. Examples of the latter include susceptibility to hazards and extreme events.

5. There is a lack of information on community risk. Catastrophic events such as floods, landslides, and communication ruptures could be the most visible and immediately costly impact of climate change. While there is some decent regional prognosis regarding hazard impacts (MBIS), generally in the North well-organized data are sparse, both temporally and spatially. Ideally data need to be consolidated to identify possible risks associated with climate change at the community level.

[3] 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.

6. As the volume of information produced through MBIS illustrates, integrated studies with a regional focus have tremendous value, as long as the region has underlying physical unity. They provide a systemic basis for tracing\modeling 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. More integrated regional impact studies should be encouraged.

7. While investigating other regions that represent the types of physical environments that may emerge in the North may be useful, its value may perhaps be limited because the immediate problem will be one of dealing with the process of change rather than with the emergent stable environment. This process could be both protracted and characterized by unpredictable events.

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