



Using GIS and Web GIS to Visualize the Canadian Arctic Food System

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ABSTRACT

Many First Nation communities in the Canadian experiences the issue of poor food security. Therefore, it is important to study the current condition of the food acquiring and supplying network in this region. In this project, a geographic information system (GIS) was used to investigate the Canadian Arctic food system. Meanwhile, a Canadian Arctic food geodatabase was developed that includes types of foods, key food producers, market destinations, and food industry policies. Principles of GIS and Web GIS were used to visualize and analyze data. The results show that a more sustainable food system is needed in the Canadian Arctic.

1. Introduction

The Canadian Arctic is burdened by high rates of food insecurity (CCA, 2014). Despite producing foods for international markets, arctic communities struggle to maintain a sustainable and nutritional food system.

As defined by the Canadian Constitution (1982), Aboriginal peoples in Canada include First Nation, Metis and Inuit. The traditional economies of Canada's Aboriginal peoples were based largely on the procurement of foods harvested from the 'land'. These foods vary by region but

generally include moose, caribou, small mammals, fish, birds, plants and berries. While these foods continue to make important contributions to the well-being of Aboriginal peoples, Arctic communities are being challenged to satisfy their daily food needs. The causal factors most often attributed to food insecurity within arctic communities include changing dietary preferences within Aboriginal populations, changes in the physical environment, cost and limited household incomes, changing employment patterns, resource extraction, and climate change (Lambden et al., 2006; Natcher et al., 2016).

Food cost and availability have proven to be a challenge of achieving food security in northern Canada. Many Inuit families have difficulty accessing nutritional food due to high food prices. In Nunavut, a kilo of celery costs about \$10. A food basket that would provide a nutritious diet for a family of four for one week costs roughly \$350-\$450 in northern communities, while the same basket costs only \$195-\$225 in southern Canada (CCA, 2014). Yet even at these high prices, the quality of perishable foods is often compromised due to lengthy transportation distances and frequent delays in delivery times to the point of limiting consumer acceptability. Because of these constraints (cost, quality, and acceptability), perishable foods are often replaced by non-perishable and highly

processed foods that lack equivalent nutritional value (Chen and Natcher, 2018). All of the aforementioned problems have led to hunger and poor nutrition for many northerners (CCA, 2014; NAHO, 2004; Boulton et al., 2004).

To address food insecurity in the Arctic, the Government of Canada launched Nutrition North Canada (NNC) in 2011 to help facilitate greater access healthy food to isolated northern communities. Through transportation subsidies, NNC works with retailers across the north and food suppliers in southern Canada to make foods more affordable and more accessible to northern residents. The NNC program spends approximately \$68 million per year to provide subsidies directly to registered northern retailers, southern suppliers, and distributors in an effort to reduce food prices (NNC, 2016). NNC has succeeded in reducing food prices on eligible items, for example dairy, frozen and processed meats, along with select fruits and vegetables. As a result of the NNC program, the cost of a food basket for a family of four has on average been reduced by 5%, or \$94 each month between 2011 and 2015. Notwithstanding this positive outcome, food insecurity remains ever so present in most northern communities. These conditions persist despite the Arctic producing and exporting significant volumes of nutritional and culturally compatible foods (e.g., Arctic Charr, seal). These foods are being exported for international markets yet make virtually no contribution to the northern food value chain.

It was with this imbalance in mind that we used GIS and Web GIS to develop a Canadian Arctic food geodatabase to analyze and visualize Canadian Arctic food data. The geodatabase, maps, and interactive online maps we deployed can help decision makers and northern residents to comprehend characteristics of the Arctic food system. Our results show that a more sustainable food system may be achieved by redirecting the current export of

Arctic foods to those northern communities most in need.

2. Data and Methods

The Canadian Arctic consists of the three



Figure 1 Canadian Arctic and Boundaries Subarctic territorial administrative regions (Yukon, Northwest Territories, and Nunavut) north of 60° latitude, the region of Nunavik, north of 55° in the province of Quebec, and the

Inuit settlement region of Nunatsiavut within Labrador; the study area covers 3,921,739 km² (**Error! Reference source not found.**). Because Statistics Canada classifies import and export data from the Canadian Arctic by province and territory, the study area in this report includes the three territories and two provinces (Newfoundland and Labrador).

Two categories of data were explored to construct the Canadian Arctic food geodatabase and to provide spatial analyses: (1) Canadian Arctic Food data, including the Canadian International Merchandise Trade (CIMT) database; an Internet search for Canadian Arctic food productions; seal and seal products information from Nutrition North Canada (NNC); an annual report from the Government of Canada and (2) Geospatial data, including Geocoder Canada; the GeoGratis Database; and other

open source GIS layers and imagery.

Details of data sources and of data preprocessing are described below:

- 1) Weights and values of food exported from the Canadian Arctic from 1988-2017 were extracted from the CIMT database through the Statistics Canada website. Data from the CIMT database concerning export destinations and food quantities and values were geocoded using a virtual geocode finder (<https://geocoder.ca/>). In cases where the geocoder was not applicable, the coordinates of export destinations were collected using Google Maps. Geospatial data were then mapped using ArcGIS. Online maps showing export products, export destinations, food quantities, and food values were created using Web GIS technology (i.e., JavaScript and PHP languages).
- 2) Online internet searches (December 2016 to May 2017) related to food products and food production in the Canadian Arctic. These searches focused on food resources, commercial food production, and food subsidies that address food insecurity in the Canadian Arctic and were performed by using the Google Search Engine. We collected information about populations, food systems, harvest levels, the commercialization of foods, and related challenges such as governance of the fisheries (e.g. quotas that regulate the harvests of Arctic foods). Other information includes food processing, infrastructure, and relative contributions of food processors were also collected and analyzed to examine employment opportunities in northern communities.
- 3) The basic GIS layers, including boundaries (provincial, territory, and administrative) came from the Statistics Canada 2016 Census of geospatial products.
- 4) International food trade data were taken from the websites of corresponding countries. Due to the accessibility of

data, we focused on six countries besides Canada for the Arctic region, including the U.S. (State of Alaska only), Sweden, Finland, Norway, Iceland, and Denmark.

The Canadian Arctic food data and GIS data were in different formats and from different sources. Therefore, the following five steps were taken: (1) Microsoft Excel and R language was used to clean, organize, analyze, and integrate the original data as tabular data; (2) ArcGIS catalog was applied to develop a Canadian Arctic food geodatabase, along with other geospatial data; (3) Data analysis was performed by combining Excel and ArcMap (4) For the online map, we imported the Canadian Arctic food database into the PostgreSQL server and used PHP and Mapbox to create a Web GIS system (<http://webgis.usask.ca/Arcticfood/>) to interactively map the value and export destinations from the Canadian Arctic; (5) A technical document was prepared for policy makers and northern residents.

The Canadian Arctic food geodatabase includes the types of food harvested in the Canadian Arctic along with trends in harvesting, key Arctic producers, the exported weight and value of food originating from the Canadian Arctic, common challenges in the commercialization of Arctic foods. Other related details, such as the Nutrition North Canada program and industrial policies, is also included in the geodatabase.

3. Results

The Canadian Arctic Food geodatabase and the Web GIS system include tables, charts, PDF maps, and online maps, to help policy makers and northern residents visualize the current status of local food resources and the pathways of Arctic food production and distribution.

3.1 Tables and Charts

The Canadian Arctic food database includes tables and charts with descriptions. Below are several examples.

Error! Reference source not found. shows that exports from the Canadian Arctic increased in value while decreasing in

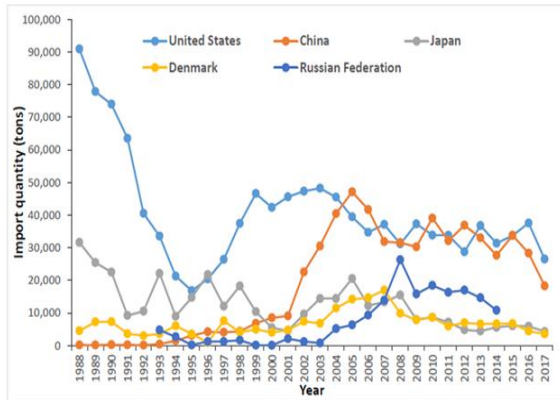


Figure 3 Top five import countries for Canadian Arctic Food

weight from 2013 to 2016.

Figure 3 shows the top five countries that imported Canadian Arctic food from 1988 to 2017. In the late 1980s the United States was the highest seafood importer, but its imports decreased considerably by the mid-1990s. China, the second highest importer, imported very little before 2000, but its imports increased substantially from the early 2000s. Russia imported a very small weight of seafood during the 1990s, but increased seafood imports from 2005 to 2008.

Figure 4 shows seafood exported from the Canadian Arctic from 1988 to 2017.

3.2 Geospatial Visualizations

The Canadian Arctic food database includes many maps. Below are several examples.

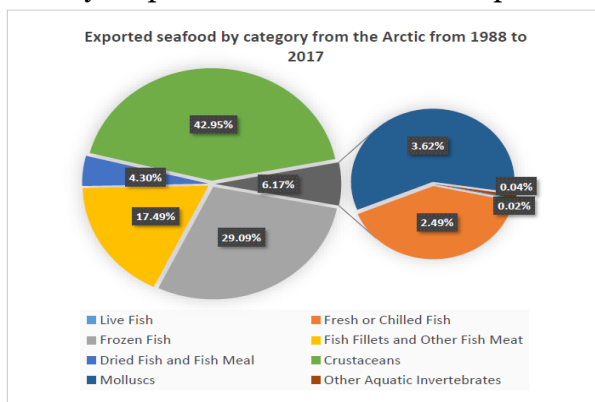


Figure 4 Seafood by category exported from the Canadian Arctic from 1988 to 2017

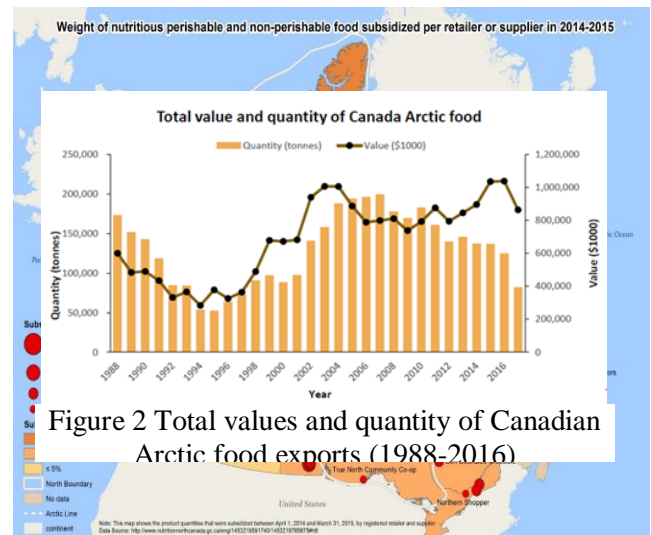


Figure 2 Total values and quantity of Canadian Arctic food exports (1988-2016)

Figure 5 Weight of nutritious perishable and nonperishable products subsidized per retailer or

Figure 5 shows the locations of suppliers of subsidized food in the Canadian Arctic and the weight of subsidies supplied by each retailer from 2014 to 2015. Nunavut received the highest value of subsidies through the NNC program, followed by Manitoba, Ontario, and Quebec.



Figure 6 Seafood exported from the Canadian in 2016

Figure 6 shows that in 2016, the two largest destinations for exports of Canadian Arctic fish, crustaceans, and molluscs were the United States of America and China.

Figure 7 is a map of key Arctic food producers. The main product categories are fish, shrimp, muskox, caribou, crab, egg, and muktuk (whale meat). Different symbols represent different categories of food products in the Canadian Arctic region. These symbols are more attractive and welcoming by the local people as well as the administration executives.

Figure 8 shows seal and seal products exported from the Canadian Arctic from 2004 to 2010. The chart and the table are integrated into this map in order to facilitate the understanding the seal trade around world.

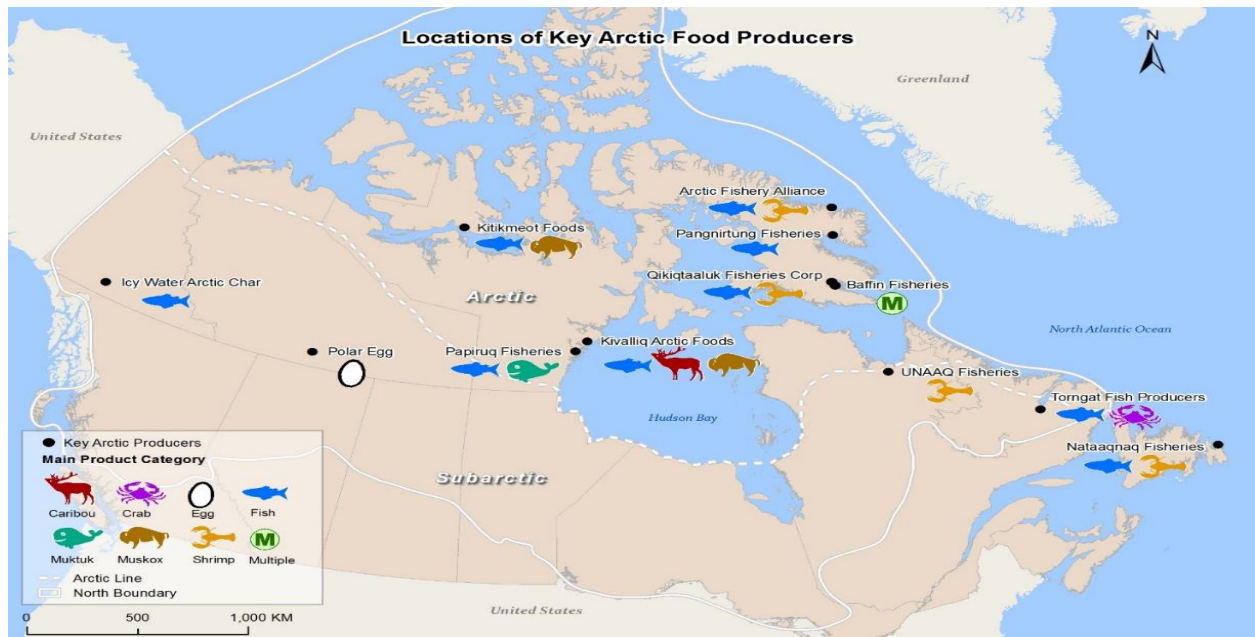


Figure 7 Locations of key Arctic food producers (symbols were shifted to avoid the overlap)

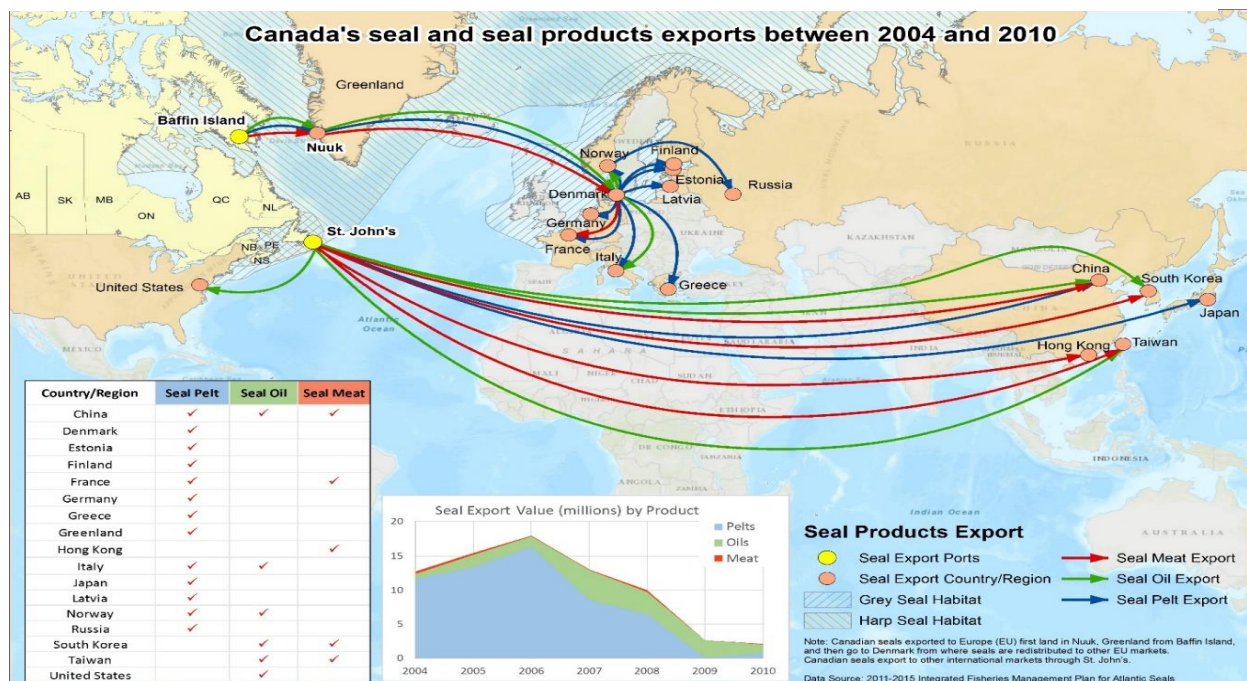


Figure 8 International exports of Canada's seal and seal products (2004-2010) (the curves do not represent the real ship routes)

3.3 Web GIS System

Currently the Web GIS system at <http://webgis.usask.ca/Arcticfood/> contains food export data from the Canadian Arctic, five other countries, and one region: Alaska, Norway, Denmark, Finland, Iceland, and Sweden. More countries and regional data will be available in the future.

The interactive online map allows a user to select an arctic food category (e.g., fish, crustaceans, molluscs, aquatic invertebrates), and a year from 1988 to 2017 (Figure 9). When the map button is clicked, an animated map will show the flow details based on the selection (Figure 11). When you hover over a destination, an information window will pop up to show the specific export information for the country (Figure 10)

Trader: Canada Arctic
 Product: Live Fish
 Year: 2017
 Data source
 Print Map Help

Figure 9 Trader, product and year



Figure 10 Popup information window



Figure 11 Animated destination flow map showing fish exported from the Canadian Arctic in 2017

4. Conclusion

It is widely agreed that the Canadian Arctic community faces acute food shortages. As there are limited food processing facilities available in the north, the Arctic community must buy food originating in the south, entailing high shipment costs. This study used GIS and Web GIS to investigate the Canadian Arctic food system. We developed a Canadian Arctic food geodatabase and a Web GIS system to help policy makers and Northern residents visualize the current status of local food resources and the pathways of Arctic food production and distribution. Our results suggest that the current commercial food system in Canadian Arctic is failing to meet the economic and nutritional needs of northern residents. While NNC has succeeded at making nutritional foods more accessible to northern residents, food insecurity continues to be experienced by a large percentage of Aboriginal households.

Our results also indicate that within the Arctic region there are considerable opportunities for commercial food production, both for export and for meeting local food needs. Food industries are producing large volumes of food commodities that are culturally compatible with indigenous local food preferences and also have high export value. For example, in 2017, Canada's Arctic regions exported in excess of 75,163,383 kg of fish and other marine products to international markets. This export had an estimated value of \$797,960,562 CAD. The production and distribution of these products involves a complex value chain involving domestic and international actors, including producers, processors, transportation services, and wholesalers. Yet Canada's Arctic foods value chain is challenged by a host of social, economic, logistical, and political obstacles that limit north-to-north distribution and continuing over-reliance on raw export. If advances are to be made in alleviating northern food insecurity, changes in the Arctic food value chain may be required,

where a greater proportion of northern foods are produced and made available to satisfy northern food needs.

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