

ECONOMIC DETERMINANTS OF FOOD SECURITY IN NORTHWEST
TERRITORIES (NWT), CANADA

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ABSTRACT

In recent years, food insecurity, specifically food access and food availability has deteriorated in many parts of the world, including the Northwest Territories (NWT) of Canada. Food insecurity is associated with adverse mental health, obesity, chronic illnesses, and poor academic outcomes. Recent research in NWT aimed at understanding the determinants of food insecurity suggests that high transportation costs, food spoilage, inadequate distribution, and the lack of sales alternatives result in severe food insecurity. These studies, however, are based on small sample sizes from selected communities.

This thesis studies the current trends of food insecurity and its correlation with socioeconomic factors across NWT's six regions and 34 communities. To do so, I gathered secondary data at community level from various sources, including the NWT Bureau of Statistics and Statistics Canada over different time periods. The measurement of food insecurity rests on the indication of what percentage of households per community were worried about not having enough money to buy food in 2018. This indicator reflects food insecurity in the sense of a lack of financial resources to access food and relates to the demand side. The socioeconomic factors considered relate to both the demand side and the supply side as they can affect the percentage of households worried of not having enough money to buy food through factors that affect households' ability to access food and factors that affect food availability, respectively.

The results indicate a north-south divide: In northern regions such as Beaufort Delta, Sahtu, Thcho, and Dehcho, 31%, 31.2%, 55.1%, and 31.5% of households, respectively, are concerned about not having enough money to buy food, while in southern regions such as South Slave and Yellowknife, the percentages are 18% and 17%, respectively. On average, the four northern regions are more than twice as likely to be food insecure as the two southern regions. Also, the results of the descriptive analysis show that regions with more dispersed households, no active mines, and only a few small-sized grocery stores are associated with higher levels of food insecurity. Furthermore, the Ordinary Least Squares (OLS) results show that communities with higher population densities, and a higher percentage of its population participating in traditional activities are associated with higher food insecurity. Also, communities that benefit from Nutrition North Canada's (NNC) food subsidy, as well as communities that have a more educated population, or better transportation facilities such as all-weather roads and airport facilities are associated with lower food insecurity.

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I would like to dedicate this thesis to my beloved parents, Mr Oscar Tetteh and Mrs Theresa Acquah, for providing me with a strong foundation in life. I would also like to dedicate it to Mr Nicholas Mensah and Mrs Edith Mensah, who have been my source of inspiration, support and encouragement. Lastly, I dedicate this thesis to my siblings, Theophilus Oscar Tetteh, Ignatius Oscar Tetteh, and Derron Oscar Tetteh for their unwavering support.

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LIST OF ABBREVIATIONS

AWRs	All – Weather Roads
CCA	Council of Canadian Academies
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
HHs	Households
MRM	Multilevel Regression Model
NNC.....	Nutrition North Canada
NWC	Northwest Company
NWT.....	Northwest Territories
OLS	Ordinary Least Square
RIM	Random Intercept Model

Chapter 1 - Introduction

1.1 Background

The issue of food insecurity is growing rapidly at local, national, and global scales as the world's population grows, world markets become more interconnected, and the implications of climate change become obvious (The Council of Canadian Academies, 2014). The recent global economic crisis and rising food costs have brought attention to the plight of the world's 820 million chronically malnourished people. Out of the total of 820 million people who “go to bed hungry every night”, about 345 million are suffering from acute food insecurity (FAO & WHO, 2019). While food insecurity in developing countries receives a lot of media coverage, food insecurity is also a problem in remote regions in developed countries such as Canada's Northwest Territories (NWT) (Gilmour & Couture, 2015; The Council of Canadian Academies, 2014).

Specifically for the Indigenous population, which makes up 49.6% of the total NWT population (NWT Bureau of Statistics, 2022), the food insecurity rate is more than 3.5 times higher than the food insecurity rate among the non-Indigenous population (Statistics Canada, 2022). For centuries, food systems in NWT have relied on the land, waterways, plants, and wildlife plentiful in northern ecosystems (Lemay, 2021). Traditional foods were taken from the land through hunting, trapping, fishing, harvesting, and other practices that are the foundation of Indigenous groups' traditional economies as well as their culture and social relations (Spring et al., 2019). In recent years, the issue of food insecurity in NWT has been exacerbated by the fact that traditional practices face numerous challenges, including, extreme weather, declining animal population, hunting quota system and limitations, and the increasing costs of hunting equipment and transportation (Gilmour & Couture, 2015; Spring et al., 2019; 2023). At the same time, consumption of marketed food has increased over time and has been challenged by high transportation costs, food spoilage, inadequate distribution, sales alternatives (Burnett et al., 2017; Lemay et al., 2021), and climate change (Spring et al., 2023). Most of the food shipped into NWT is expensive which makes it difficult for lower-income households to afford it, thereby resulting in higher rates of food insecurity in the region (22.2%) relative to the Canadian average (17.8%) (Statistics Canada, 2023).

On the effect of food insecurity, it has also been established that food insecurity is associated with adverse mental health results, obesity, chronic illnesses, and poor academic outcomes, and it is far more intense in low-income and Indigenous homes (Gilmour, & Couture, 2015). A

report by the Council of Canadian Academies (2014) indicates that the current food security problem has long-term ramifications for the health and wellness of people in northern communities. As climate change continues to influence northern ecosystems and communities, there is a need to put the food insecurity situation high up on the research agenda (Porter et al., 2015).

Research on food security in Canada, particularly in the Northwest Territories (NWT), has primarily focused on quantifying the prevalence of food insecurity at the provincial and territorial levels (Kirkpatrick & Tarasuk, 2008; Tarasuk et al., 2020). These studies have also sought to identify the key determinants of food insecurity within specific regions, such as the NWT (Olabiyi & McIntyre, 2014; Guo et al., 2015; Tarasuk et al., 2019; Batal et al., 2021; Shafiee et al., 2022; Pagaduan et al., 2024), as well as the obstacles in promoting food security (Socha et al., 2011; Spring et al., 2018; Kenny et al., 2018; Spring et al., 2023). However, research on the differences in the intensities of food insecurity among different geographical areas such as regions and communities within the NWT is scant. In other words, at present, research has not been able to provide comparative evidence on the intensities of food insecurity across NWT's six regions and 34 communities. The closest study that investigated spatial differences in food insecurity is Tarasuk et al. (2019). They examined the geographical intensity of food insecurity across different provinces and territories of Canada. This means that they treated each province and territory without recourse to potentially varying levels of food insecurity within and among regions and communities of each province or territory. Moreover, despite reports of high food insecurity (Green, 2021; Statistics Canada, 2023; Pagaduan et al., 2024), studies have not adequately examined the regional and community-level intensities of food insecurity to identify potential hotspots of food insecurity in the NWT.

This thesis investigates the level of food insecurity at NWT's community and regional levels and identifies location-specific socioeconomic factors associated with food insecurity. Here, food insecurity is measured by the percentage of households per community worried of not having enough money to buy food and hence relates to the demand side of food insecurity. The socioeconomic factors, however, relate to both the demand and supply side, as they can influence the indicator of food insecurity at hand by affecting the ability of households to access food or the availability of food.

1.2 Research Objectives

The overall goal of this research is to improve our understanding of the state of food security at the regional and community levels in the NWT. More specifically, this thesis aims to:

1. investigate the levels of food insecurity, proxied by the percentage of households in a community who indicated that they were worried about not having enough money to buy food, across the six regions and 34 communities to identify food insecurity hot spots, and
2. identify major correlates of community-level food insecurity related to the (i) market economy such as the availability of grocers, infrastructure characteristics like airport facilities and all-weather access roads, average household income, or employment rate, and (ii) traditional activities such as the percentage of population above 15 years engaged in hunting and fishing, or the percentage of households that eat meat or fish obtained from hunting or fishing. I aim to analyse these correlates of food insecurity, measured as lack of access to food, through the lens of their associations with food availability and food access.

To address the objectives, the thesis uses secondary data gathered from different sources such as Statistics Canada (2017) and NWT Bureau of Statistics (2022). Overall, the data spans several years from 2010 to 2020.

To achieve the first objective of assessing the current state of food insecurity, I generate food insecurity maps that depict the community-level proportion of households worried about not having enough money to buy food. These maps are based on food insecurity data obtained from the 2018 NWT community survey administered by the NWT Bureau of Statistics. In addition, one can differentiate between different severity levels by measuring the percentage of households that answered “Often” or “Sometimes” to a subsequent question once they reported being worried about not having enough money to buy food. To investigate the correlates with food insecurity (objective 2), ordinary least squares (OLS) regression analysis is applied.

1.3 Organization of the Study

The thesis is structured as follows. The next chapter introduces NWT and its food systems while Chapter 3 introduces the conceptual framework. Chapter 4 describes the data, methods, and previous descriptive statistics. Chapter 5 presents the main results and discussion, while Chapter 6 provides concluding remarks.

Chapter 2 – Background

2.1 Introduction

This chapter provides some background information related to the Northwest Territories' (NWT) sociodemographic and economic characteristics, reviews the relevant concepts of food sovereignty, food security, the mixed economy, and lays the foundation for my own conceptual framework.

2.2 The Northwest Territories: geography, demography and economy

The NWT occupies 13% of the country's total land area but is among the three least populated territories with a population of 0.11% of the total Canadian population. Figure 2.1 shows the map of NWT and the neighboring provinces. The territory is located north of the 60th parallel and borders Saskatchewan, British Columbia, and Alberta to the north (NWT HIRA, 2014). The territory also borders Nunavut to the east and Yukon to the west. A significant proportion of NWT's landmass is within the Arctic Circle. NWT has six regions and 34 communities.

Data from the NWT Bureau of Statistics (2022) indicates that the Indigenous people make up about 49.6% of NWT's population while accounting for only 5% of the Canadian population. However, the Indigenous people also comprise different groups with different cultures, beliefs, traditions, languages, and geographic locations. Major groups of the Indigenous people include the Metis, Inuvialuit, and 27 First Nations such as Dehcho First Nations, Gwichya Gwich'in Council among others (James-Abra, 2022). In the NWT, the First Nations represent 32.9% of the total NWT population whilst the Metis and Inuit make up 5.6% and 11.1%, respectively (NWT Bureau of Statistics, 2022). Among the Indigenous population alone, the First Nations make up about 63.2% while the Metis and the Inuit make up 16.3% and 19.6% respectively (Statistics Canada, 2017).

In terms of NWT's market economy, as of 2022, the Gross Domestic Product (GDP) was \$4,396 million with an overall growth rate of 1.5% while Canada's GDP grew by 3.8% (Statistics Canada, 2023). Major contributors to NWT's GDP are public administration, real estate, and mining sectors which accounted for approximately 57% of NWT's GDP in 2022 (NWT Bureau of Statistics, 2023). Among the three sectors, mining (29.5%) is the most important, followed by public administration (18.2%) and real estate (9.5%).



Figure 2.1. Geographical map of Northwest Territories
 Source: Catalyst, (2023)

NWT's employment rate was 67.3% as of 2022 and the finance, agriculture, healthcare, and social insurance industries are the largest employers in the territory and contributed to 79.2% of total employment.¹ Out of the total 25,000 employed people in the NWT, 21,500 (82%) were employed in the services sector alone. The forestry, fishing, mining, oil and gas industries employed about 5.6% while the manufacturing and construction industries employed 1.2% and 6.4% respectively (NWT Bureau of Statistics, 2023). In other words, while sectors such as mining, construction, and manufacturing are important contributors to NWT's GDP, they employ only a small fraction of the available workforce. Employment rates differ between Indigenous and non-Indigenous people, and among regions of the NWT. As of May 2021, about 59.4% of Indigenous people and 75.8% of non-Indigenous people were employed. In terms of spatial differences in employment, the highest employment rate can be found in Yellowknife where 74.3% of the working population is employed as compared to 64% in the rest of the Territory (NWT Bureau of Statistics, 2021).

The annual average household income in the NWT increased from \$136,000 in 2018 to \$140,000 in 2019 which is higher than the Canadian average of \$73,000 (GNWT, 2022). These income figures from the NWT provided above include government transfer payments to workers with low incomes such as tax credits (NWT Bureau of Statistics, 2021). Thus, the relatively higher average income can be attributed to various factors including government transfer payments to persons with low income through the income assistance program, benefits from relatively lower tax rates, and more tax credits (Government of Canada, 2023). The transfer payments or the income assistance program is a cash transfer program to residents of communities in NWT Canada, to enable them to meet their basic needs (GNWT, 2023). The transfers are based on characteristics such as household size, household income, and the community in which the individual lives. It targets individuals who are above the age of 19 years and are believed to have more critical needs such as shelter and utilities which exceed their income (GNWT, 2023). Also, federal workers and service providers like teachers and health workers receive Northern Living Allowance which also supplements the incomes of individuals who live permanently a prescribed northern zone (Government of Canada, 2022).

¹ While these figures provide an idea of the employment rates in the NWT, they do not reflect the participation of individuals in traditional economic activities as traditional activities are not captured in employment (Trovado et al., 2011 as cited by Aylsworth & Filice, 2022).

One of the main forms of food support is the Nutrition North Canada (NNC) food subsidy. The NNC's food subsidy is a federal program that subsidises selected food items such as milk, infant food, vegetables etc. in some isolated communities in the northern part of Canada (NNC, 2024). The eligible communities must also be deemed "a northern community" based on the territorial definitions and have populations all year round and also an airport, a grocery store, or a post office (Naylor et al., 2020). The support given to these communities includes (i) NNC's food subsidy which is aimed at increasing access to perishable food through locally registered retail stores, and (ii) the Harvesters Support Grant which seeks to encourage traditional activities such as hunting, harvesting, and food sharing.

However, income is unequally distributed across and within the regions of the NWT. For instance, Norman Wells, which is the community with the highest median income in the NWT, has an annual income per capita of about \$154,624 while Wrigley which has the lowest income has a median income of about \$42,368 per year (NWT Bureau of Statistics, 2017). These disparities might be a result of the differences in the levels of economic activities such as oil and gas production in Norman Wells, while Wrigley has no such economic activities.

Finally, concerning agricultural activities, only a small percentage of land is suitable for agricultural activities. The region is also faced with adverse weather and climatic conditions such as the presence of permafrost, a relatively shorter growing period, excessive cold, and volatile temperatures which makes cultivation difficult (Pierre et al., 2022).

2.3 Framework of Food Sovereignty and Food Security in Northern Canada

When one intends to understand food security in the context of a region such as NWT, where 49.6% of the population is Indigenous, one can refer to the conceptual framework of food sovereignty and food security of the Indigenous people developed by the Council of Canadian Academies (CCA) and shown in Figure 2.2.² Figure 2.2 provides a comprehensive overview of

² "The Council of Canadian Academies (the Council) is an independent, not-for-profit organization that supports independent, science-based, authoritative expert assessments to inform public policy development in Canada" (Council of Canadian Academies, 2014, p. iii). The council is made up of a Board of Governors which consists of 12 members and is advised by a Scientific Advisory Committee consisting of 16-members. The work of the Council ranges from both natural and health sciences to social and humanities. As a result, the Council conducts independent and multidisciplinary assessments throughout Canada to identify emerging issues in both Canada and globally. These assessments are important as they provide high-quality information to government bodies, stakeholders, and researchers to make informed decisions by serving as a guide to public policy (Council of Canadian Academies, 2014).

the interdependence between food security and food sovereignty and how various factors such as the environment, colonialism, and gender underpin food security and sovereignty among the Indigenous people. More specifically, the wheel represents the complex interplay between the factors that affect the Indigenous people and how these interrelationships influence food sovereignty and food security. Food sovereignty entails allowing individuals to make decisions about their food systems, while food security involves ensuring that all people have access to sufficient nutritious food at all times (FAO, 2006; CCA, 2014). The innermost components of the wheel represent the most important elements.

At the centre of the wheel is the Indigenous people of northern Canada themselves which implies that all the factors within the wheel have either a direct or an indirect impact on their lives. The over-arching goal of food security and food sovereignty is to promote their health and well-being (Council of Canadian Academies, 2014).

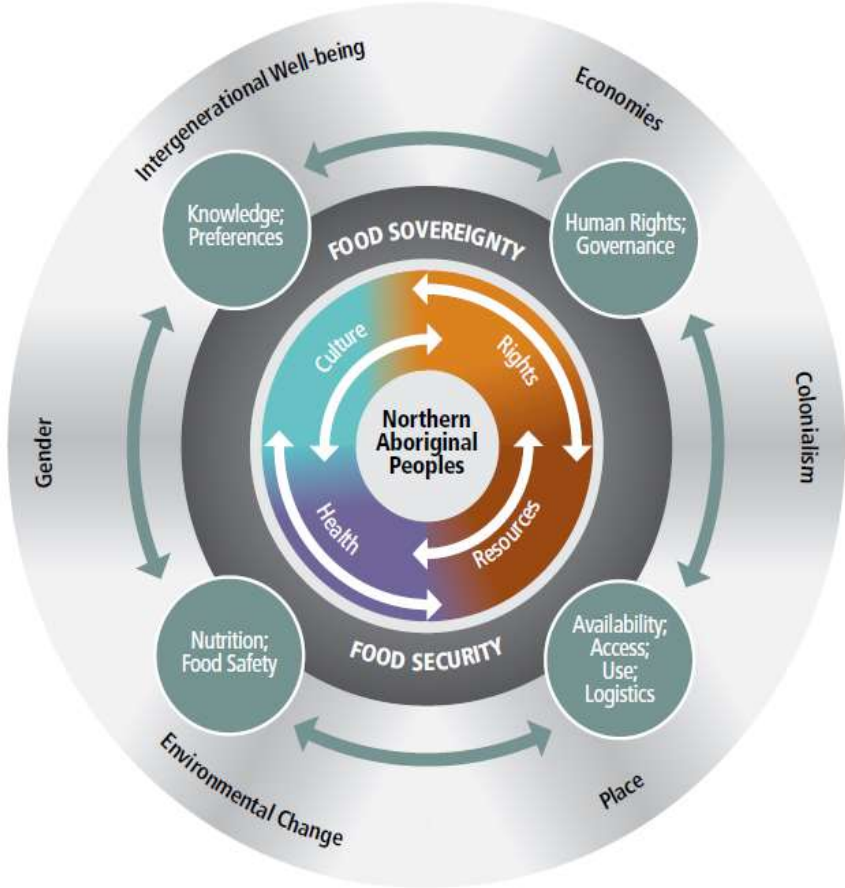


Figure 2.2. The panel’s conceptual framework
 Source: Council of Canadian Academies (2014).

Consequently, the framework centers on the Indigenous people and presents the complexity of the interplay between the Indigenous people and their resources, culture, rights, and health. Apart from the centre, there are four additional layers of factors.

The first layer consists of four factors namely: health, culture, rights, and resources. First, health is considered a very important element of the wheel because it is both an enabler and an outcome of food sovereignty and food security (Dixon, 2014). Good health enables the Indigenous people to access nutritious food from both traditional sources and the market (Pérez-Escamilla, 2017). On the other hand, health is an outcome of food security as being food secure enables good health (Willows et al., 2011). However, among the Indigenous people, good health is not just the physiological well-being and emotional well-being of the individual but also the cultural, social, and environmental well-being of the community in which they live.

Second, culture is also an integral component of the Indigenous people's lives. As defined by Roote (1996, as cited in the Council of Canadian Academies, 2014), culture to the Indigenous people "means a whole way of life — our beliefs, language and how we live with one another and creation". Culture encapsulates the relationships that the Indigenous people have with their communities, clans, spirituality, nations, and the land that sustains them. Therefore, as culture is ingrained in Indigenous people's lives, it influences their activities and hence their livelihoods (Hunter et al., 2021).

The third important aspect of the Indigenous people's lives is their rights. Indigenous rights are distinct from general human rights due to the complexity of land ownership as well as the fiduciary obligations of the State of Canada towards the Indigenous people (Council of Canadian Academies, 2014). As a result, the framework recognizes the importance of Indigenous rights and how it is intricately linked to food security and sovereignty. These rights include land ownership rights, harvesting rights, and provisions in treaties including land claim agreements (Laurin & Jamieson, 2015). Consequently, recognizing these rights and enforcing them is critical to the self-determination of their food systems as well as the achievement of food security.

Finally, resources are an important element of the Indigenous people's economy. Resources include both natural resources such as renewable and non-renewable resources, and capital resources like human capital, financial and social resources. The framework above therefore posits that the presence of these resources facilitates food sovereignty, food security, and good health

(Council of Canadian Academies, 2014). Particularly, considering that traditional activities are important cultural elements, the abundance of natural resources facilitates participation in these activities, which is important to their well-being (Jog et al., 2016). In addition, capital resources play an important role in the mixed economy of northern Canada as it propels market economic activities and allows them to engage in traditional harvest as it enables them to buy equipment (Natcher, 2009). Consequently, the availability of and access to resources influences the well-being of the Indigenous people as it enhances food sovereignty and food security.

The second layer of the wheel contains four outer factors such as nutrition and food safety, human right governance, knowledge and preferences, as well as availability, access, use, and logistics. These factors also have linkages with other factors and with one another as well. First, nutrition, as an integral component of food security, is necessary to ensure good health and well-being (Hwalla et al., 2016). This entails the kind of nutrients that make up the food as well as the ability of the individual's body to effectively utilize these nutrients for healthy living (CFS, 2012).

For Indigenous people, nutritious food is not just important for the body but for the soul as well (Cone, 2005). Therefore, accessibility to and effective usage of nutritious food is important in ensuring food security as the lack of it may lead to obesity and hence lead to negative health outcomes. Consequently, in understanding the nature of food security and food sovereignty, it is important to understand the nutritional deficits that the Indigenous people experience. In addition to nutrition, it is explained by CCA (2014) that food safety is a critical component of the framework which targets the complex food safety risks that Indigenous people in northern Canada face especially in the consumption of traditional food which is obtained from areas that might be affected by contaminants. Also, food safety is necessary as the process of food preservation, storage, and preparation might be unsafe (Spring et al., 2018). The framework also highlights the importance of food supply related to food transportation to the northernmost part of the territory. Consequently, ensuring food security and sovereignty among the Indigenous people requires ensuring food safety as unhealthy food might lead to health impairments.

Second, knowledge, and preferences about traditional food and cultural practices are important in ensuring food sovereignty and food security (Islam et al., 2017). Sufficient knowledge about the cultural practices and understanding preferences makes it possible for the Indigenous people to determine the kind of food they eat, and how to obtain and prepare it. The Indigenous people have had traditions for centuries and the knowledge of the role of food in these cultural and

spiritual activities among young Indigenous people is important. Also, recognizing that Indigenous people have tastes and preferences that might differ from other people and among the different Indigenous groups ensures that food security and sovereignty are not focused on only availability and accessibility, but cater to the complexity of traditions and the connections between the people and their lands (Council of Canadian Academies, 2014).

Third, human rights and governance are important elements as they largely influence the extent to which food sovereignty and security are attainable. Even though the right to food is enshrined by the United Nations Sustainable Development Goals ensuring food sovereignty, the extent to which human rights are attainable is influenced significantly by the nature of the governance structure in the area (Council of Canadian Academies, 2014). Governance structures include the federal, provincial, and territorial structures which play a major role in either facilitating or inhibiting food sovereignty. Thus, the framework indicates that enforcing human rights through good effective governance structures at all levels is necessary to ensure food security (Council of Canadian Academies, 2014). The fourth component of this layer is the availability, accessibility, and use which are the dimensions of food security according to the FAO (2006) and are explained in detail below in section 2.5.

The outermost layer of the wheel contains the framing factors such as well-being, economies, environmental change, intergenerational, colonialism, place and gender (Council of Canadian Academies, 2014). First, intergenerational well-being is both a factor and an outcome of food security. Wellbeing ensures the continuity of traditional knowledge, values, and skills as individuals in the communities can pass them down to the next generation. On the other hand, intergenerational well-being implies that individuals in the communities are food secure. This factor ensures connection and continuity across various generations and hence enables the Indigenous people to understand contemporary problems and how to solve them using local strategies (Council of Canadian Academies, 2014). Second, economies illustrate the mixed nature of economic activities in that part of the country as they combine traditional subsistence activities and market activities (Natcher, 2009). Details of how the mixed economy framing factor is important in food sovereignty and food security are explained in subsection 2.4.

Third, place relates to the unique characteristics of the location in relation to the rest of the country. Place includes unique histories, politics, and geographical as well as cultural activities that inextricably coexist and, hence, influence food sovereignty and security. The framework

implies that there is a strong connection between the Indigenous people and the place where they live which significantly influences their overall wellbeing (Wilson, 2003). Fourth, the dynamics of food sovereignty and food security occur differently among the different genders. Women are often more likely to be food insecure than men as shown by Matheson & McIntyre (2013) and Broussard (2019). Therefore, gender is believed to influence the food security of the Indigenous people (Ford & Berrang-Ford, 2009). Fifth, the history of colonialism led to various struggles, including the loss of their ancestral lands, and civic rights, and has affected the culture and traditions of the Indigenous people (Crosby & Monaghan, 2012). These threats continue to exist in different forms today and affect food security and sovereignty.

Finally, environmental changes have led to the extinction of some animals which traditionally serve as a source of food for the Indigenous people. According to the CCA (2014) framework, environmental changes are very rapid in the north and has many implications on the elements of the framework as well as on food sovereignty and security. Increases in temperature, and chemical and biological pollution of fresh water, terrestrial and marine waters in many areas of the NWT have significant impacts on the biodiversity of the ecosystems (Ford et al., 2018). These environmental changes affect the availability, accessibility, and quality of the natural resources that the Indigenous people depend on. Also, higher temperatures led to rapid changes in ice, and an increase in bushfires, which contributed to the movement of birds, mammals, and insects further north (Jacques & Sauchyn, 2009). Consequently, NWT's future generations may be at a higher risk of reduced traditional activities.

2.4 The Concepts of Food Sovereignty and Food Security

As introduced in section 2.3 and as shown in Figure 2.2, food sovereignty is influenced by the characteristics of Indigenous people, their environment, histories, and traditions. The CCA indicates that “food sovereignty is based on the principle that decisions about food systems, including markets, production modes, food cultures, and environments, should be made by those who depend on them” (p. xix). Given the Indigenous people's characteristics, food sovereignty requires that each of these groups have the ability and the right to produce and eat food in their own way which defines their unique traditions and cultures. This means that it is important for each of these groups to be able to make their decisions about the kind of food to grow, and how to grow it, whilst having access to sufficient quantities of food (Grey & Patel, 2015).

A related concept of food sovereignty is food security. The concept of food security has been defined differently by various organizations and academics. The Food and Agriculture Organization (FAO) defined food insecurity in 1974 as “Availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices” (FAO, 2006, p.1). This definition at the time was inspired by increasing food prices which created the need to increase the production and hence supply of food through the adoption of technology (Upton, et al., 2016). Subsequent studies revealed that the issues of food insecurity were not just about availability but also accessibility to food and the stability of the supply and demand for food over time (Clapp et al., 2022). This informed a new definition of food security as stipulated by the FAO. “Food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 1996, rev. 2009).

This redefinition reveals the four dimensions of food security, i.e., availability, accessibility, utilization, and stability (Myers et al., 2004; FAO, 2006), and each of these four dimensions must be fulfilled to achieve food security (Anema et al., 2014; Ike et al., 2015). Each dimension is explained in what follows.

First, food availability, also regarded as the supply aspect of food security, is defined by Ogot (2021) as “the situation where food is made to exist for consumption at local levels where local individuals or households can locate their needed foods. It depicts the production and supply of varieties of foods” (p.147). Food availability is based on whether there are sufficient quantities of food either through local or domestic production or imports (Vermeulen et al., 2019). The availability of food means that there is food present in community stores and supermarkets, homes of people, and reserve banks. Consequently, it is not sufficient to increase the production of food through the use of technology, and modern methods of food production (Naeem & Malana, 2016). However, an increase in the production of food must lead to improvement in storage and transportation to local communities. Thus, the location of the food, variety, and quality of the food, as well as the availability of both core and traditional foods to the local people, is essential in determining food availability.

Second, food accessibility which is regarded as the demand side of food security, is the ability of individuals to have adequate income or resources to purchase or obtain food (USAID,

1992). According to Pinstrip-Anderson (2009), food availability alone is insufficient to determine food security as the presence of food in sufficient quantities does not imply that individuals can access it (FAO, 2008). The dimension of food accessibility is important in ensuring food security because, even though food may be available at various locations, individuals may not be in a position to purchase this food. This tends to impede food security even when food is available.

Third, food utilization is "the proper biological use of food, requiring a diet providing sufficient energy and essential nutrients, water, and adequate sanitation" (FAO, 2006). The utilization of food is largely dependent on the nature of the extent of knowledge within the household (Shafiee et al., 2022). Households with sufficient knowledge of the methods of food storage, processing, and the fundamental principles that guide good nutrition will be able to utilise food for maximum nutritional benefits. This implies that various non-food factors contribute significantly to the quality of the utilization. Some of these non-food factors include cultural practices that are observed in the preparation of food, the practices of feeding as well as intra-household allocation of food (Alonso et al., 2018). Consequently, even in the presence of food availability and accessibility to adequate food, non-food factors such as the cultural practices and beliefs of the people can significantly influence the level of malnutrition among households (UNCTD, 2016).

Finally, food security requires that its availability, accessibility, and utilization remain stable over time (FAO, 2006; García-Díez et al., 2021). Consequently, in ensuring food security, it is not sufficient for food to be available, accessible, and utilized, at one point in time, but sustainable over time (Shafiee et al., 2022). The sustainability of food security includes promoting innovative and sustainable agricultural practices and food production, especially in the presence of climate change which affects traditional methods of food production (Thornton et al., 2014).

2.5 Mixed Economy System in NWT

As mentioned above, NWT's mixed economy consists of the traditional economy and the market economy which are intricately linked with the components of the framework displayed in Figure 2.2. The traditional economy involves harvesting wild food through hunting, gathering, and fishing and hence is linked to the four other factors of the wheel including the environment, resources, and knowledge of the Indigenous people. These activities in addition to the market activities provide income and food to households of NWT. The market economy entails the wage

earners. The traditional economy and the market economy interact through social networks of families, friends, and communities as shown in Figure 2.3.

Many Indigenous households have a diverse set of income sources including subsistence activities like handicrafts, government transfers, and wage employment such as the mining industry (Natcher, 2009). Household members engage in subsistence harvesting, receive government transfer payments, or work full-time or part-time jobs that pay a wage (Wenzel, 2017). Community members frequently shift along this continuum depending on a range of factors, with the majority of households engaging in numerous activities at the same time (Natcher, 2009).

In this mixed economy, community members share food especially food obtained from traditional activities such as hunting and fishing among their kin. The northern mixed economy is distinct in that most households successfully combine wage labour and commercial production with hunting and gathering (Hall, 2021). Over time, the traditional economy has not disappeared due to increasing industrial and market development. Rather, activities such as harvesting, distribution, and consumption of wild foods by the Indigenous people continue to contribute to the well-being of the people of NWT (Proverbs et al. 2020). The subsistence economy in the regions has generally developed and endured because people have incorporated it with market activities into their everyday lives.

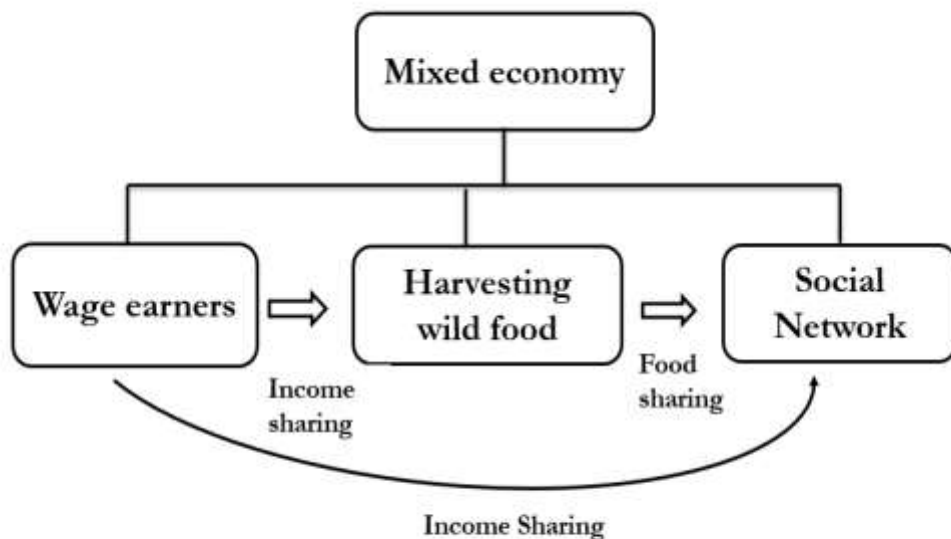


Figure 2.3. The mixed economy in northern Canada

Source: Adapted from Usher et al. (2003).

For instance, according to Natcher (2009), wage work is commonly utilised to assist family members who are harvesting. Households with high wage income—and thus the capacity to buy the tools required for efficient harvesting—tend to generate, consume, and share a notably greater quantity of wild foods than households with little to no access to wage-earning opportunities (Natcher, 2009). This characteristic of high-wage-earning households implies that cash or wage-earning is used as a fundamental means of stimulating traditional activities in the NWT. In some instances, money from government transfers also supplement the wage income of households (NWT Bureau of Statistics, 2022b)

Studies have indicated that traditional activities including hunting, fishing, gathering, and arts making play a vital role in NWT's economy (Prieto et al., 2022). Generally, all food that is locally obtained or harvested from land and water is regarded as traditional food, and these traditional food includes food with distinct acquisition and processing methods as well as sociocultural connotations (Batal et al., 2021). As defined by Kuhnlein and Receveur (2007), traditional food refers to “all food within a particular culture available from local natural resources and culturally acceptable” (p.418). It also includes the sociocultural meanings, acquisition, processing techniques, use, composition, and nutritional consequences for the people consuming the food. In the northern part of Canada, traditional food plays a significant role in promoting both health and food security. Apart from its spiritual and nutritional significance, there is evidence from other studies linking traditional food to food accessibility and availability (CCA, 2014). For example, Morton et al. (2021) showed that 60.7%, 77.5%, and 66.4% of individuals interviewed indicated that they had consumed traditional food during the past seven days in NWT, Nunavut, and Yukon, respectively. Similarly, Ford and Berrang-Ford (2009) discovered that in Igloodik, Nunavut, individuals whose diet consisted of at least 50% rural food never reported missing a day of meals during the previous year. Conversely, 46% of respondents whose diet contained 49% or less traditional or rural sources said they had gone without food for the full day. These figures highlight the important dietary role that traditional food plays in the lives of the Indigenous people in northern Canada.

The traditional food system in the NWT is important for not just the food it provides, but also the opportunity it provides for the people to build relationships. Participating in harvesting, hunting, or gathering food represents strength, unity, and cohesion among the Indigenous people (Hansen et al., 2008). Islam and Berkes (2016) found that households that engaged in traditional

activities such as fishing and hunting shared their food with their social networks including household members. The results from Islam and Berkes (2016) confirmed those of Lambden et al. (2006) who observed that accessibility to traditional and market food in Arctic Canada played a major role in promoting food security in the region.

Many other studies such as Lambden et al. (2007), Barbeau et al. (2015) and Ryan et al. (2019) observed that the consumption of traditional foods is important in ensuring food security among Canada's Indigenous people. It has been identified by Huet et al. (2012) and Collings et al. (2016) that households with active hunters are more likely to be food-secure than households without an active hunter. They explain that households with active hunters are likely to have higher access to traditional food through food-sharing networks which enables food obtained from fishing or hunting to be shared among one's kinsmen (Shafiee et al., 2022). One of the essences of food sharing is to minimize the burden of any misfortune on any household or individual (Nelson et al., 2008). Also, families, towns, and regions become more cohesive and form social links when they exchange food and equipment (Wheelerburg, 2008). As a moral requirement grounded on concepts of communality and gifts from the land, food sharing is a fundamental component of northern Indigenous culture and identity (Collings et al. 2016; Tod-Tims, 2020). Furthermore, Gombay (2010), indicated that the Indigenous people believe that reciprocity promotes social networks and interpersonal ties while making it easier to distribute food for economic reasons. Similar results which indicate that social networks among Indigenous people promote food security were obtained by Gendron et al. (2016).

However, the role of traditional food activities in ensuring food security is increasingly threatened by various factors including inaccessibility to fishing, lack of equipment, climate change, government policies and laws that prohibit or limit harvests, and loss of traditional knowledge and skills (Ross & Mason, 2020; Spring et al., 2023). These factors have led to a shift in consumption over time from traditional food to market food, especially among younger generations (Ramirez Prieto et al., 2022).

Some empirical studies have observed the manifestation of the above factors in a declining rate of consumption of traditional food. For example, Little et al. (2021), observed a nutritional shift occurring among Inuit people living in the Canadian Arctic, marked by a shift away from traditional foods and toward market foods. The authors proposed that colonial processes, poverty,

socioeconomic issues, shifting food choices and knowledge, and climatic change are the main forces behind this transition. According to a dietary survey done in two different Inuit communities, there has been a noticeable rise in the intake of market foods and a notable fall in the energy contribution of traditional foods over time (Sheikh et al., 2011). This transition implies that the Indigenous people are moving away from the consumption of nutritious food to the consumption of food that has a lower nutritional value.

A report by Kuhnlein and Receveur (2007) about the consumption of market food among adult Metis, Dene, and Inuit indicated that market food items such as sweets and fats, meat, and grains made up about 15% of their daily meals. The rate becomes higher with children who consumed more market food than the adults in the areas. Some of the major market food items consumed by the Indigenous people include soft drinks, eggs, white bread, biscuits, tea, evaporated milk, sugar, coffee, and cornflakes. Other food items that are consumed less frequently include rice, cheese, and meat products (CCA, 2014).

2.6 Summary

The chapter provided a detailed overview of the NWT. This overview was done by examining the concepts of food security and food sovereignty in light of the framework introduced by the Council of Canadian Academies (2014). The chapter also explored the dimensions of food security and the concept of the mixed economy, which will be applied in the conceptual framework introduced in the next chapter.

Chapter 3 - Conceptual Framework

3.1 Introduction

From the concepts of food sovereignty and food security introduced in the previous chapter, it is established that the two concepts are intricately linked with the characteristics found in the Northwest Territories (NWT). In this chapter, I provide the conceptual framework underpinning the community-level analysis of food insecurity in NWT. Given data availability, I focus on the two dimensions of food security, namely food availability and food accessibility, and how food security is related to various factors associated with economic activities and traditional activities prevalent in the NWT.

3.2 Major Determinants of Food Security in NWT

Figure 3.1 summarizes the different characteristics and their expected relationship with food insecurity at the community level that are assumed to work through the supply side of food, i.e., food availability, or through the demand side, i.e., food access. For the purpose of this thesis, food insecurity is measured by the percentage of households worried about not having enough money for food.

On the supply side, I consider community-level characteristics such as the number of grocery stores weighted according to size, and the availability of infrastructure such as airport facilities and all-weather roads. On the demand side, I include community-level characteristics such as average income of households, employment rate, food price index, percentage of households with six or more people, percentage of households that are married, percentage of population above 15 years with at least a high school diploma, percentage of households that live in their own house, number of active mines, percentage of population above 15 years that is engaged in hunting and fishing, percentage of households that eat meat or fish obtained from traditional activities, and whether the community receives the Nutrition North Canada (NNC) subsidy. Community-level characteristics such as population density, participation in traditional activities, and country food consumption which are expected to work through either the food availability or the food access dimensions are displayed between the two categories. I provide detailed explanations of the expected directions of correlations between these characteristics and food insecurity in what follows. Note that the list of variables shown in Figure 3.1 is not exhaustive, but includes those factors that are proxied by available data.

Food availability

In the context of NWT, I assume that the state of food availability is a result of several factors. These factors include the weighted number of large and small grocery stores in the community and the presence of airport facilities and all-weather roads, (Spring et al., 2020; Shafiee et al., 2022). To calculate the weighted number of grocers, I considered grocers such as Northmart store, Walmart Supercentre, Center Square Mall, and Independent Grocer as large and weighted them with 0.7, while all other grocers are considered small and weighted with 0.3. The weights were chosen arbitrarily and represent the relative variety of available food products of larger vs. smaller grocers.

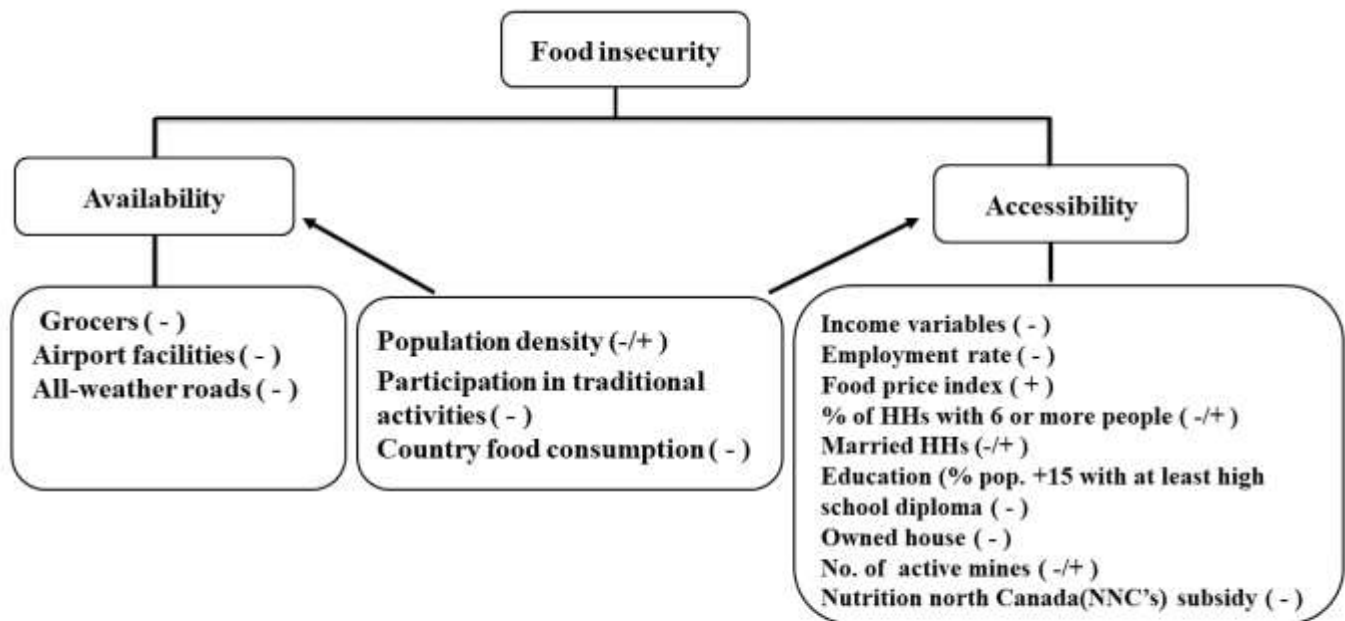


Figure 3.1. Determinants of food insecurity in NWT

Note: (a) “no”, “pop.”, “HHs” are abbreviations for the words “number”, “population”, and “households”, respectively. (b) Income variables consist of family, personal, employment, and income assistance from the government. (c) “(-)”, “(+)”, and “(- / +)” indicate the expected direction of the relationship between the variable and food insecurity, i.e., a negative relation, a positive relation, and an ambiguous relation, respectively

.Source: Authers’ own illustration (2023).

For instance, Cambden et al. (2018) observed that larger grocery stores are often associated with lower and more favorable food prices and Shafiee et al. (2022) indicate that the presence of many grocery stores promote the availability of varieties of food and enhances competition.

Therefore, I expect communities with many and larger weighted numbers of grocers to be less food insecure relative to communities with a fewer grocery stores and and lower weighted score.

However, this expectation might be misleading as smaller communities with fewer people do not necessarily need larger grocery stores. Also, Shafiee et al. (2022) explained that distance to grocery stores is one of the main barriers to food security in Indigenous communities. The presence of many larger grocery stores located in strategic places of a community makes food available to households in a more convenient manner while few poorly located grocery stores which are far from residential areas will impede food availability. As argued by Socha et al. (2011), grocery stores often have a monopoly for the most part of the year especially in communities that are remote and difficult to reach. This monopoly makes it easier for grocery stores to impose higher prices on food items in these communities. Finally, due to the distance perspective, Shafiee et al. (2022) classified grocery stores as a demand side variable. However, this study looks at the number of small and large grocery stores in the community and classifies it as an availability dimension because more grocery stores imply more availability of varieties of food.

Similarly, I expect a negative relationship between food insecurity and the presence of infrastructure such as airport facilities and all-weather roads in the community. As indicated by Prentice and Russell (2009) and Kristin et al. (2017), some communities of the NWT can only be accessed by air, especially in winter which is expensive to operate and hence contributes to rising food prices (Prentice, 2012). In addition, air cargo is limited as it can only supply smaller quantities of food at a time, which is consequently associated with higher food prices in NWT communities (Socha et al., 2011). At the same time, the presence of all-weather roads in a community makes it easier for food to be supplied throughout the year, thereby stabilising the availability of food. Although Shafiee et al. (2022) classified people's access to transportation as an accessibility dimension. I, hence, capture the infrastructure conditions as an availability dimension because it enhances the movement of food from other parts of Canada to the NWT or from one community to another.

Furthermore, I expect that community-level population density, participation in traditional activities, and the consumption of country food can work through both the availability and access dimensions of food security. In terms of community-level population density, I expect an ambiguous relationship (+/-) with food insecurity. First, higher population density can influence food

availability given that a rise in population levels may spur economic activities, creating higher food demand and attracting higher food supply through grocers (Collard et al., 2013). On the other hand, however, higher population density implies higher demand for food in communities. If this higher demand is not met, then food insecurity may be higher in those communities relative to communities that are less densely populated. Shafiee et al. (2022) also linked population growth with a decrease in food-sharing networks, thereby leading to increased food insecurity.

Participation in traditional activities such as hunting and fishing is expected to have a negative association with food insecurity. This is because a higher levels of participation in traditional activities implies a lower dependency on marketed food. Considering that traditional foods are not legally for sale in the NWT, food obtained from traditional activities is either shared or consumed within the household. This means that individuals are likely to depend less on money to buy food and hence are likely to be less worried about not having enough money to buy food. Also, from the supply perspective, traditional activities contribute to the availability of traditional food in the NWT for consumption. Particularly, food sharing with kin or friends promotes the availability of traditional food and enriches consumable food varieties (Ready, 2018a). From the demand perspective, participating in traditional activities such as fishing and hunting improves the immediate accessibility of food especially through food-sharing networks. To illustrate the importance of traditional activities in the NWT, according to the NWT Bureau of Statistics, in 2018, about 21.6% of the entire population of NWT engaged in arts making, 36.3% went fishing or hunting, 26.4% gathered bears whilst 4.7% engaged in trapping (NWT Bureau of Statistics, 2018).

Similarly, I expect the consumption of country food as measured by the percentage of households that eat meat or fish obtained from traditional activities to have a negative association with food insecurity. This variable also works both through the supply and demand side because it indicates both the quantity of country food available and how much of it is consumed by households. Country food has significant cultural, historical, and spiritual importance among the Indigenous people of the NWT (Lambden et al., 2006). Aside from the cultural connections associated with consuming country food, it is perceived to be more nutritious (Morton et al., 2021). However, country food consumption has been challenged by the rising cost of hunting, declining interest in traditional activities, and rapid changes in social relations which weaken food-sharing networks as

well as climate change which has led to the disappearing of birds and other animals (Socha et al., 2011; Panikkar & Lemmond, 2020; Shafiee et al., 2022).

Food Accessibility

Food accessibility explains the demand side of food security. It is influenced by several community-level factors including, average household income, employment rate, the food price index, household size, the marital status of households, educational levels of households, ownership of a house, the presence of active mines and NNC's food subsidy (Tarasuk et al., 2015; Grimaccia & Naccarato, 2018; Shafiee et al., 2022).

I expect the average annual household income in a community to have a negative association with food insecurity. Having adequate income is a means to access specifically market food. (Olabiyi & McIntyre, 2014). Communities with relatively more stable and higher average family incomes are likely to be more food secure than communities with fluctuating and lower average family incomes (Shafiee et al., 2022).

Similarly, I expect the community-level employment rate as measured by the percentage of the population of 15 years or older in a community who are employed to have a negative relationship with food insecurity. Employment serves as the main source of income for households. As a result, being employed means that individuals obtain regular incomes which enables them to buy food. Thus, communities with a higher percentage of their working population being employed will be more likely to have lower levels of food insecurity (Shafiee et al., 2022; Men et al., 2021; Uppal, 2023). Shafiee et al. (2022), however, also argued that employment could have a positive association with food insecurity since Indigenous persons who are employed could have less time for traditional food activities.

Next, the percentage of the population above 15 years old with at least a high school diploma in the community is expected to have a negative association with food insecurity. As households with higher levels of education are more likely to secure well-paid jobs, they are also more likely to better access food (Anila & Adiq, 2011; Mango et al., 2018). However, the migration of young, educated people to other parts of the country for work opportunities might erode the impact of education on food security in the NWT. Other studies have found that educational status has no significant impact on food accessibility (Asghar & Muhammad, 2013; Gebrehiwot & van der Veen,

2014). Notwithstanding, I expect communities with a more educated population to be relatively more food secure than communities with lower educational levels (Shafiee et al., 2022).

In terms of the percentage of households that live in their own house, I expect a negative relationship with food insecurity. The variable can be seen as an indicator of wealth (Geyer et al., 2014), and hence being in a better position to access food. At the same time, house ownership by Indigenous people may be acquired through the Northwest Territories Housing Corporation (Collings et al., 2016) This program hence may enable Indigenous people to save liquidity for accommodation and re-direct it to access food.

I expect that Nutrition North Canada's (NNC) food subsidies will be negatively associated with food insecurity. Although there are concerns that the program is not able to pass on the subsidy to the consumers as indicated by the Auditor General of Canada (2014) and Weber (2016), an empirical investigation by Naylor et al. (2020) showed that most of the subsidy is passed onto the consumer through a reduction in food prices. Thus, it can be inferred that the subsidy reduces food prices and makes it affordable to households in the benefitting communities. However, there have been concerns about increasing dependence on subsidised store-bought food which is highly processed and has health implications such as obesity among beneficiaries (Christopherson, 2015; Pagaduan et al., 2024).

Next, in terms of the community-level food price index, I expect a positive association with food insecurity in the NWT. Economic theory posits that higher inflation levels reduce the purchasing power of individuals especially fixed-income earners (Halim et al., 2022). The food price index variable in this study is the average price of items in a given community which means that increases in prices require individuals and households to commit a higher proportion of their incomes towards the purchase of food (Wichelns, 2011). It is identified by Wendimu et al. (2018) that prices of fresh food in Indigenous communities are high and hence compromise the accessibility of food. The high level of prices has been found to be a result of transportation challenges and the low level of competition among grocery stores in the NWT (Socha et al., 2011) as northern communities depend on the Northern Store (Northwest Company) for food (Fiddler, 2012).

Unlike the food price index, I expect the percentage of households in a community with more than six people to have an ambiguous relationship with food insecurity. On the one hand, larger households with more dependents such as children and the elderly are more likely to

experience lower levels of food security (Findlay et al., 2013; Ningi et al., 2021). It has been found in some studies that larger household sizes are often associated with overcrowding and food insecurity (Ruiz-Castell et al., 2015; Shafiee et al., 2022). However, it can be argued that larger household sizes with a majority of the members actively participating in the labor market are likely to have higher levels of food security since each of these members generates income to cater for the essential needs of the household including food.

Similarly, I expect the percentage of households in a community who are married and live together to have an ambiguous relationship with food insecurity. The marital status might influence the food security level of a household in various ways depending on the composition of the household. For instance, a single parent who is a low-income earner is likely to be more food insecure as compared to a married couple who are both low-income earners as they can leverage their combined resources. Studies such as Delormier et al. (2017) and Collings et al. (2016) argued that a single-parent household with young children is more vulnerable to food insecurity. As mentioned above in the discussion of household size, households with children are more likely to have a higher level of food insecurity than households without children (Domingo et al., 2021). However, married couples with children have an advantage over single parents with children since larger numbers of kin from both the husband's and the wife's families, with whom they engage in food sharing, form a system of support for one another (Ready, 2018a). On the other hand, married couples with only one wage earner will be more likely to experience food insecurity as compared to single households with no children in which the individual is gainfully employed (Ready, 2018b).

Finally, I expect that the number of active mines in a community has an ambiguous relationship with food accessibility. Active mining activities in the NWT primarily consist of gold, diamond, and zinc and provide employment to many people (NWT & Nunavut Chamber of Mines, 2016). On the one hand, active mining companies provide employment opportunities and hence means to access food. On the other hand, the presence of mining activities in the communities may disrupt traditional activities including hunting, or fishing which may harm the ability to access food.

3.3 Summary

The chapter introduced the conceptual framework and the underlying hypothesis that will be tested in Chapter 5. More specifically, this chapter included an assessment of the context of the NWT, the relationship between various factors of the NWT, and how those factors relate to food security. As stated above, it is expected that grocery stores, availability of airport facilities, all-weather roads, education, employment, income, participation in traditional activities, consumption of country food, and food subsidies will have a negative association with food insecurity. Also, it is expected that food price index will have a positive correlation with food insecurity. However, I expect household size, house ownership, marital status, and mining will have ambiguous relations with food insecurity. The next chapter of the thesis describes the data sets and methods used in this study.

Chapter 4 – Data and Methods

4.1 Introduction

This chapter presents the data, methods, and descriptive statistics used to address the research objectives in this thesis. Specifically, section 4.2 describes the data and variables used in the analysis, while section 4.3 provides a descriptive analysis of food insecurity in the Northwest territories (NWT). Finally, section 4.4 presents the econometric method used.

4.2 Data Sources

This thesis uses secondary data to investigate the level of food security across NWT's 33 communities and six regions.³ As shown in Table 4.1, data was compiled from various sources, including Statistics Canada (2017), the NWT Bureau of Statistics (2022), and Google Maps (2023). Information regarding communities' food insecurity, population density, average household income, household size, food price index, education, marital status, housing tenure status, participation in traditional activities, employment rates, the breakdown of employment rates by gender, and the comparison of employment rates between the Indigenous and non-Indigenous populations, and consumption of country food comes from the NWT Bureau of Statistics (2018).⁴ Furthermore, I consulted Statistics Canada (2018) to identify what community received the NNC in 2018. Finally, geo-locations on grocery stores and mines are obtained from Google Maps (2023). I grouped the grocery stores into small and large based on size, whereby I consider Walmart, the Real Canadian Superstore, Independent Grocer, and Costco to be large grocery stores and all others to be small. I then assigned a weight of 0.7 to the larger grocery stores and 0.3 to the smaller ones implying that the variable, number of grocers is a function of the sum of 0.7 multiplying the number of large grocers and 0.3 multiplying the number of small. Similarly, data on the presence of mining sites were grouped into active and inactive mines, i.e., mining sites that are still in operation, and non-active mines, i.e., mining sites that are either temporarily or permanently closed. In the following, I briefly describe the main dependent variable used in this study.

Food insecurity is measured as the percentage of households per community worried of not having enough money to buy food as of 2018. In addition, the percentage of households that

³ Though the total number of communities was originally 34, N'dilo a community in the Yellowknife region was removed from the analysis due to missing observations.

⁴ The NWT Bureau of Statistics is a section under the government of the NWT responsible for the collection, compilation, development, and dissemination of statistics.

indicated “Often” or “Sometimes” worried of not having enough money to buy food allows me to differentiate between two severity levels of food insecurity. The community-level aggregation of these variables is based on three questions where households were asked i) whether they are worried not having enough money to buy food; and if “Yes”, ii) whether they are “Often” or iii) “Sometimes” worried not having enough money to buy food (NWT Bureau of Statistics, 2018).

Measuring food insecurity in this manner differs from the approaches used by previous studies on food insecurity in Canada (Tarasuk et al., 2019; Olabiyi & McIntyre, 2014) which rely primarily on data from the Household Food Security Survey Module (HFSSM) developed in the United States but implemented by Statistics Canada (Jessiman-Perreault & McIntyre, 2017). “The HFSSM is a standardized and validated scale of food insecurity severity that measures inadequate or insecure access to food due to financial constraints” (Proof, 2018, p.2). The HFSSM has a set of 18 questions to determine whether a household is food insecure or not. The questions include asking households to affirm or deny if they and their households could not afford balanced diets or if they ever had to skip or cut down on the size of meals (Foster et al., 2019). Households that respond affirmatively to at least one of the questions is considered food insecure.

The main advantage associated with the approach used in this study is that it allows individual households to self-assess whether the monetary means are sufficient to secure food. In addition, it allows to understand whether the self-assessment of not having sufficient means to buy food happens only sometimes or often. Consequently, households that answer “often” or “sometimes” to the question can be regarded as severely or moderately food insecure, respectively. This approach implies food security is not quantified on just the amount of money a household spends on food but on the household’s own perception of having enough money to afford food. However, the main disadvantage of this approach is that it is subjective and does not provide a standardized measurement of food insecurity since different households will interpret having “enough money to buy food” differently. Also, the measure relates only to the food security dimension of access. Besides, the measurement does not take into consideration the quality of food that households consume which is an important metric of food security (Kortright & Wakefield, 2011; Riediger et al., 2021).

Table 4.1. Description of variables, data sources, and years of observation.

Variable name	Explanation of variables	Source	Years of Observations
Food insecurity			
Yes	Percentage of households who responded “ Yes ” to worried about not having enough money for food		
Often	Percentage of households who responded “ Often ” to worried about not having enough money for food		2018
Sometimes	Percentage of households who responded “ Sometimes ” to worried about not having enough money for food		
Population density (people/km ²)	The total number of people per square kilometer		2011 & 2018
All-weather road (Binary)	Binary variable equal to one if community and region has all weather access road, zero otherwise		2013
Airport facilities (Binary)	Binary variable equal to one if community and region has airport facilities, zero otherwise		
Average Income: Family Income	The average family income of households for each community and region	NWT Bureau of Statistics	
Personal Income	The average personal income of households for each community and region		2011 & 2018
Employ. Income	The average employment income of households for each community and region		
Income assistance (% of pop.)	Percentage of population that receive income assistant from the government		
Employment rate (% of labor force)	Percentage of the population of 15 years and above that are employed		2011 & 2016
Employment rate: Male	Percentage of male population employed		
Female	Percentage of female population employed		
Indigenous	Percentage of indigenous population employed		2019
Non-Indigenous	Percentage of non -indigenous population employed		

Table 4.1. Continued

% of households with 6 or More People (% of HHs)	Percentage of households in a community with more than 6 people		2011 & 2014
Owned house (% of HHs)	Percentage of households in a community that live in their own house		
Food price index	The average prices of food items per community		2010 & 2015
High diploma or higher (% of pop.)	Percentage of the population of 15 years & older in a community with at least a high school diploma	NWT Bureau of Statistics	2011 & 2016
Married households (% of HHs)	Percentage of households in a community who are married and live together		2016
Country food consumption (% of HHs)	Percentage of HHs that eat meat or fish obtained from hunting or fishing in the community		2018
Participation in traditional activities (% of pop.)	Percentage of the population of 15 years & older in a community that engaged in hunting and fishing		2018
NNC subsidy	The volume of subsidy, measured in kilograms, and the monetary value of the subsidy in Canadian dollars that communities receive from the government. It serves as a binary variable, distinguishing communities that benefit from governmental subsidies (with a value of one) from those that do not receive subsidies (with a value of zero)	Statistics Canada	2018
Number of grocers	The number of small and large grocery shops in a community	Google maps	2023
No. of active mines	The number of active mining sites in a community		

Note: “no”, “pop.”, “HHs” are abbreviations for the word’s “number”, and “population”, “households”, respectively. All variables are measured at community level.

4.3 Descriptive analysis of food insecurity in NWT

In this section, I provide descriptions of the variables and the food security characteristics of the regions and communities of the NWT. This description includes maps which identify food insecurity hotspots in the NWT and how they relate to characteristics such as the availability of mines, grocery stores, etc. I also provide a tabular description of regional-level characteristics such as income, population sizes, household size, participation in traditional activities, among others. Details of these are provided below.

First, to understand the regional level distribution of food insecurity, Figure 4.1 shows the average percentage of households per region who responded “Yes”, “Often” and “Sometimes” to the question of being worried about not having enough money to buy food. One can note a northsouth divide in terms of food insecurity across all three panels in Figure 4.1.

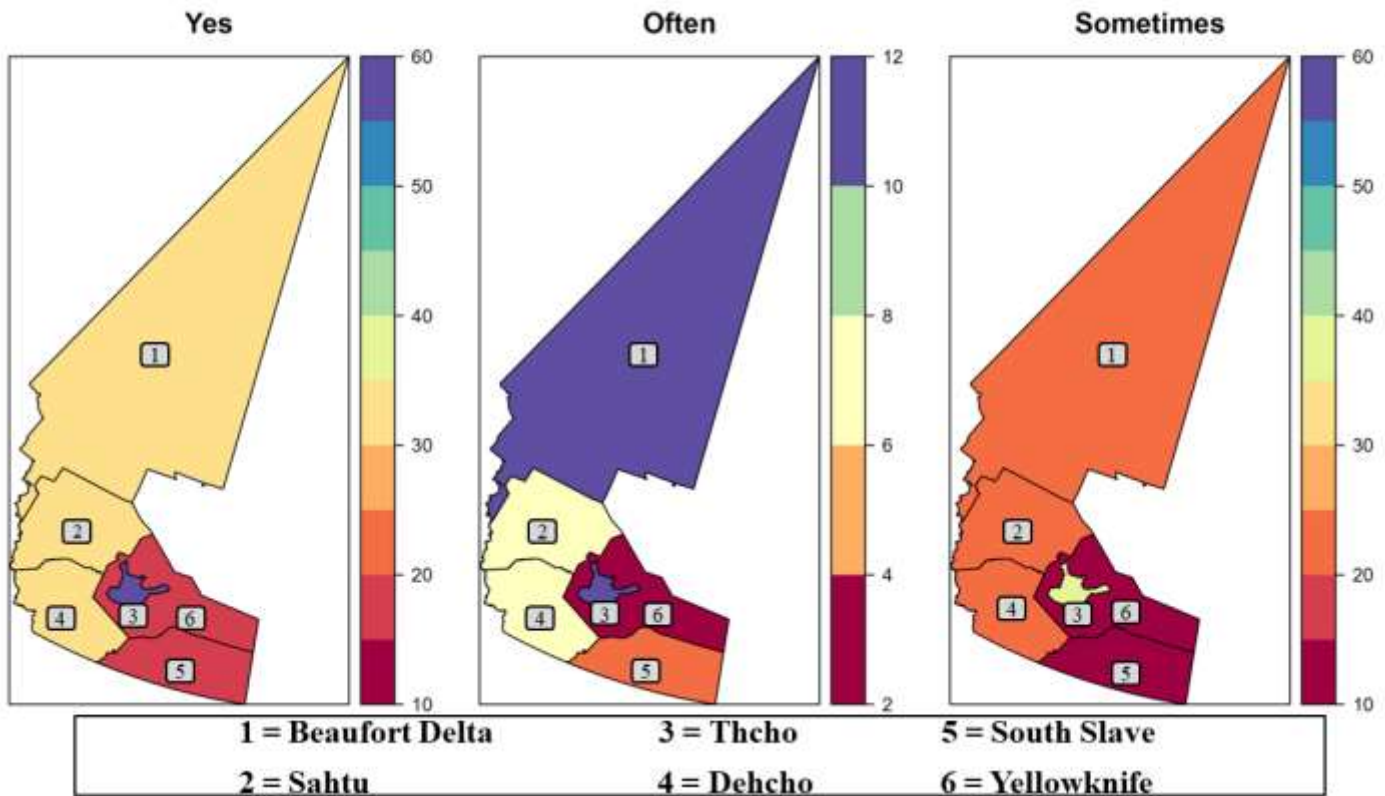


Figure 4.1. Food insecurity at the regional level as of 2018

Note: These maps represent three levels of food insecurity in NWT’s six regions. “Yes”, “Often”, and “Sometimes” are the responses of households to whether they have enough money to buy food. Increasing depths of the colour represent higher food insecurity.

Source: NWT bureau of Statistics website (2022) and Google Maps (2023), own illustrations

Yellowknife and South Slave in the south exhibit 17% and 18.7% of households that indicated being worried about not having enough money to buy food, respectively, while the northern regions range on average between 31% and 31.5%.⁵ Thcho, however, is the exception to this pattern, as it belongs geographically to the southern regions, but it shows the highest share, namely 55.1% of households being worried about not having enough money to buy food.

Differentiating between the two severity levels of being “Often” or “Sometimes” worried of not having enough money to buy food, shows that the majority of those who indicated that they do worry, worry sometimes. In the southern regions, Yellowknife and South Slave, the percentage that “Sometimes” worry about not having enough money to buy food is approximately 13%, while it ranges between 20.6% and 24.4% in the three northern regions. In Thcho it is 44.2%. Finally, it is noteworthy that Thcho and Beaufort Delta are the two regions with the highest share of households that worry “Often” of not having enough money to buy food, which is 11% and 10.4%, respectively.

Before I discuss potential reasons for this spatial pattern of food insecurity, let us look at the within-region distribution of food insecurity, its association with the spatial distribution of large and small retailers, active and inactive mining sites, and other characteristics as introduced in Table 4.1 aggregated at a regional level. To further examine food insecurity within the six regions, I map the community-level share of households that worried of not having enough money to buy food in Figure 4.2.

Figure 4.2 shows that food insecurity varies within regions, with higher levels observed among dispersed communities such as Wrigley, Lutselk, Dettah, and Benchoko in the Dehcho, South Slave, Yellowknife, and Thcho regions respectively, are geographically isolated and exhibit elevated food insecurity levels compared to other communities. Conversely, food insecurity is lower among communities that are closer to each other, as seen in communities like Inuvik and Fort McPherson, Norman Well and Tulita, Fort Simpson and Fort Providence, Enterprise and Hay River in the Beaufort Delta, Sahtu, Dehcho, and South Slave regions respectively. Additionally, communities surrounded by water bodies, such as Dettah, Benchoko, and Coville Lake in Yellowknife, Thcho, and Sahtu regions respectively, demonstrate high levels of food insecurity.

⁵ Appendix A shows the respective regional averages in table format.



Figure 4.2. Food insecurity at the community level as of 2018

Note: These maps identify the hotspots of food insecurity at community level. It is percentage of households in community who responded “Yes” to whether they are worried about not having enough money to buy food. Increasing depths of the colour represent a higher severity of food insecurity.

Source: NWT Bureau of statistics website (2022) and Google Maps (2023), own illustrations.

Notably, despite Yellowknife being the most populated NWT region, it comprises only two communities (NWT Bureau of Statistics, 2021), indicating a concentration of the population compared to other regions.

I also map the locations and sizes (large or small) of grocery stores in regions of the NWT to observe spatial patterns between grocery stores and food insecurity shown in Figure 4.3. The map on the right represents the locations and sizes of grocery stores while the map on the left represents the food insecurity levels in the corresponding regions. A distinct feature of the map from the right is that the grocery stores are concentrated in the south, especially in the Yellowknife region. Also, all of the large grocery stores except one, are found in one region, the Yellowknife region. Thus, apart from Beaufort Delta which has only one large grocery store, the rest of the regions have only small grocery stores.

Relating the map on the right to the map on the left, it is evident that Yellowknife, the region with the highest number of large grocery stores, is also the most food-secure region in the NWT, alongside South Slave. Interestingly, the most food-insecure region, Thcho, is found within the Yellowknife region. In addition, it can be noted that the regions with sparsely located grocery stores are more food insecure relative to regions with more concentrated grocery stores.

Figure 4.3 maps food insecurity at a regional level and the location and size of grocery stores.

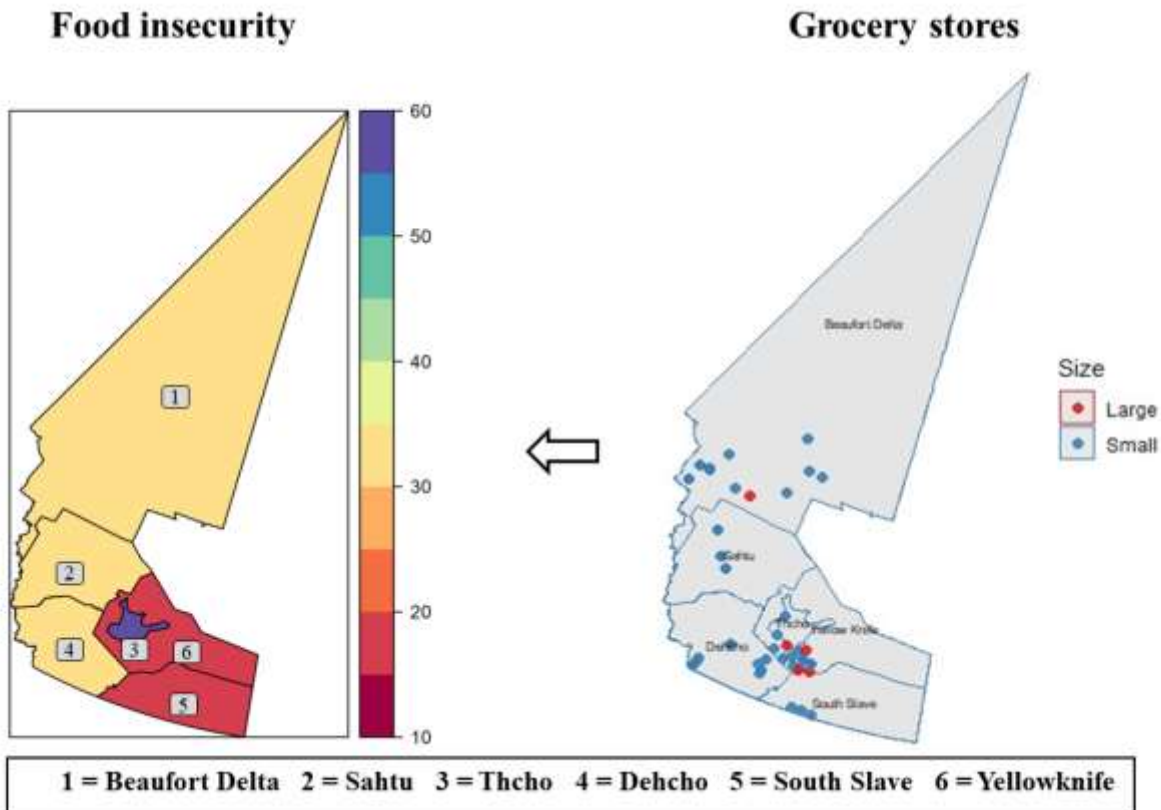


Figure 4.3. Relationship between food insecurity (“Yes”) and grocery stores

Note: This map relates the numbers and size of grocery stores in a region to the percentage of households in the region who responded “Yes” to worried about not having enough money to buy food. Increasing depths of the colour represent increasing severity of food insecurity.

Source: NWT Bureau of Statistics website (2022) and Google Maps (2023), own illustrations.

The siting of these grocery stores could be influenced by the spatial distribution of settlements and the population densities of each region such that regions with more sparse settlements would exhibit sparsely sited grocery stores. Thus sparsely sited grocery stores could reduce access to a variety of food items especially when the grocery stores are small in size. Therefore, it can be inferred that the number, size, and location of grocery stores in regions and communities could indicate the level of food insecurity as it implies the availability of food.

In addition to the above, I map the presence of mining sites in the regions in the NWT to understand the spatial relationships between the availability of an active mine and food insecurity. Figure 4.4 presents the two maps with the map on the right representing the availability of both active and inactive mines while the map on the left represents food insecurity across the regions of NWT.

From the map on the right in Figure 4.4, one can note that Beaufort Delta is the only region that does not have any mining sites. In addition, the mining sites are concentrated in the southern part of the NWT, and more than half of these sites are in just one region, i.e., Yellowknife.

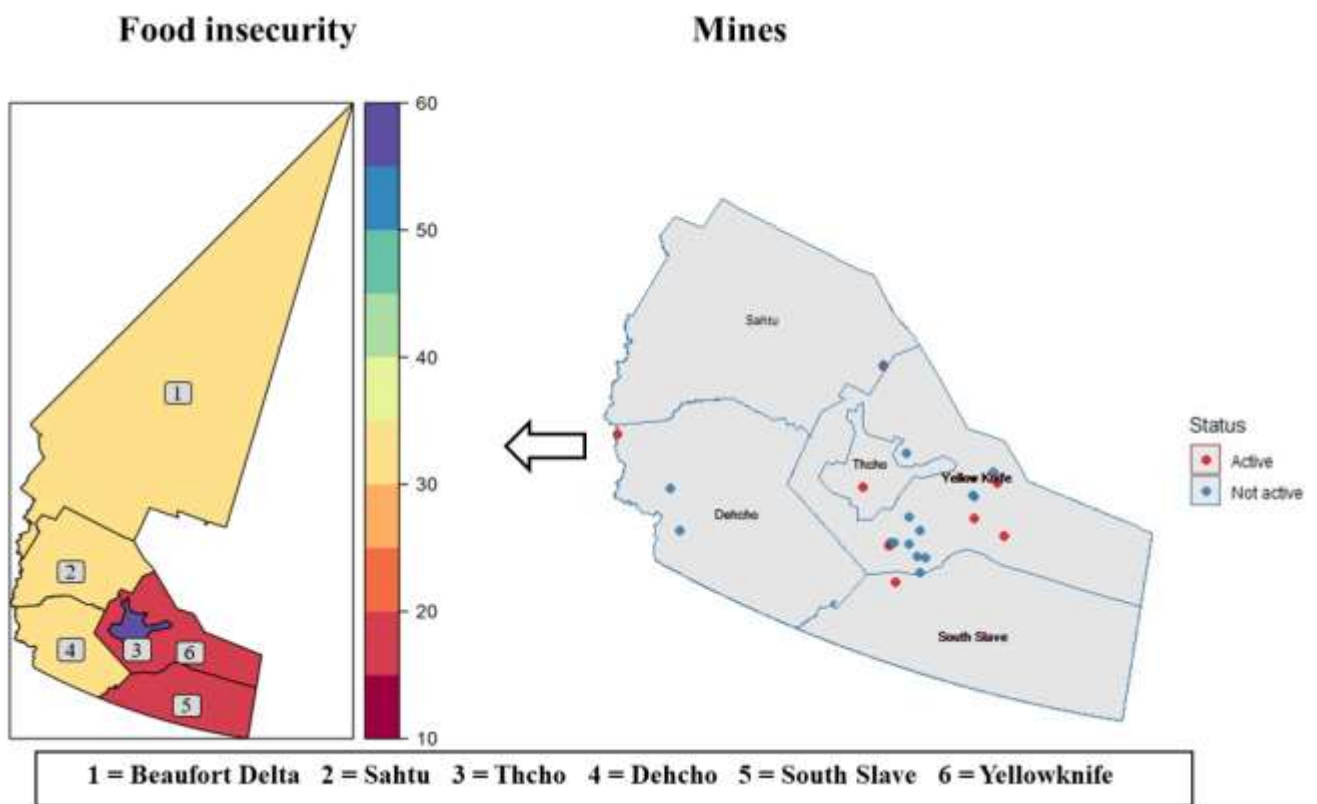


Figure 4.4. Relationship between food insecurity (“Yes”) and mines

Note: This map relates the location of a mining site, whether active or not, in a region to the percentage of households in region who responded “Yes” to worried about not having enough money to buy food. The increasing depths of the colour represent the increasing severity of food insecurity.

Source: NWT Bureau of Statistics website (2022) and Google Maps (2023), own illustrations.

Approximately, two-thirds of the mining sites are inactive, and more than half of the active mining sites are located in Yellowknife. In relating the presence of mining sites in the regions to food insecurity, it is observed that Yellowknife, the region with the lowest food insecurity level in the NWT, has more than half of all the mining sites and more than half of the active mining sites

in the NWT. In contrast, Beaufort Delta, one of the regions with the highest level of food insecurity, has no active mines while which is the most food-insecure region has only one active mine.

Moreover, just as in the case of the large grocery stores, the majority of the active mining sites are located in the southern regions of NWT, particularly Yellowknife which is the most food-secure region. The location of these mining sites and their associations with food insecurity could imply that active mining activities in a region might contribute to the reduction in food insecurity through the provision of employment opportunities.

Next, I report the average region-level characteristics in Table 4.2 to understand how regional characteristics are spatially related to food insecurity in the NWT. These characteristics include average income levels, average employment rates, home ownership, marriage, educational levels, food price index, presence of mining sites, NNC food subsidy, participation in traditional activities, country food consumption, all-weather road, airport facilities, population density, and availability of grocery stores.

From Table 4.2 one can note that the average family income in the southern regions i.e. Yellowknife and South Slave is higher than the average family income in the northern regions i.e. Beaufort Delta and Thcho. Also, Yellowknife has the highest family income level in the NWT, which could explain the lower level of food insecurity in the region. While Thcho and Beaufort Delta which are noted as the most food insecure regions have the lowest income levels in the NWT. This observation is the same for all forms of income in the NWT, including personal and employment income. As a result, regions with lower income levels such as Beaufort Delta and Thcho receive the highest income assistance as a percentage of their populations while regions with the highest income such as Yellowknife and South Slave, receive the lowest income assistance.

Similar to the income pattern, the employment rate in the NWT is highest among the southern regions, Yellowknife and South Slave, which have the lowest food insecurity rate. The most food-insecure regions, Thcho and Beaufort Delta have the lowest employment rate in the NWT. In terms of sex, the employment rate among females is higher than males in all the regions of the NWT. Also, the employment rate among Indigenous people is lower than the employment rate among non-Indigenous people throughout all regions of the NWT.

Table 4.2. Average region-level socioeconomic characteristics associated with food insecurity.

	Regions							
	Years of obs.	Pooled sample	Beaufort Delta	Sahtu	Thcho	Dehcho	South Slave	Yellowknife
Average Income:								
Family income (CAD)	2011	85463.70	73600.67	92866.38	81123.33	81158.33	87279.25	145706.10
	2018	101618.20	87864.58	118526.70	97703.05	86265.93	107790.20	163373.40
Personal income (CAD)	2011	40750.86	35027.00	44334.98	35444.59	38516.52	44688.45	67628.86
	2018	46945.92	40783.42	54621.28	42823.93	39925.14	51430.59	74871.49
Employment income (CAD)	2011	39861.91	34741.82	42395.92	33934.31	38287.30	44168.25	65727.66
	2018	45388.71	40186.95	50440.38	40508.59	41117.31	49269.07	73527.41
Income asst (% of pop.)	2018	7.18	14.34	6.64	18.79	10.77	5.24	3.40
Employment rate (% of pop.)	2011	48.99	46.56	51.12	42.43	46.31	53.38	64.10
	2016	51.49	52.20	55.64	47.95	45.56	54.72	61.00
Employment rate: Male		47.74	50.30	51.91	28.05	47.41	50.87	58.45
Female		54.06	55.03	60.04	51.50	47.74	55.08	62.50
Indigenous	2019	49.10	49.10	49.60	40.30	41.10	55.30	59.20
Non-Indigenous		81.65	84.10	85.80	81.40	83.20	75.70	79.70
Owned house (% of HHs)	2011	52.21	33.70	44.40	57.00	59.00	66.35	52.80
	2016	52.11	33.30	44.40	54.60	61.90	62.28	56.20
Married HH (% of HH)	2016	71.91	68.07	69.24	74.09	73.80	74.68	75.17
% of HHs with 6 or more People (% of HHs)	2011	10.41	10.21	10.80	23.78	4.94	10.30	5.65
	2014	9.46	7.80	12.20	20.65	7.50	5.82	5.60
Education (% pop. 15+ with at least high school diploma)	2011	45.64	43.31	43.28	38.73	42.13	54.00	63.60
	2016	51.67	52.10	52.70	42.05	51.38	54.02	60.80
Food price index (Yellowknife=100)	2010	152.25	173.05	182.56	138.75	135.57	128.50	100.00
	2015	152.31	170.37	173.00	139.50	140.29	137.25	100.00
No. of active mines	2023	9	0	0	1	1	2	5
No. of inactive mines		16	0	1	2	0	3	10
Number of communities		33	8	5	4	8	6	2

Table 4.2. Continued

	Years of obs.	Regions						
		Pooled sample	Beaufort Delta	Sahtu	Thcho	Dehcho	South Slave	Yellowknife
NNC subsidy value		\$239,034.10	\$241,456.40	\$359,143.00	\$153,883.00	0	\$201,654.00	0
NNC subsidy volume (kg)		88,230	71,370	146,008	57,595	0	77,947	0
NNC subsidy (% of pop. in a communities)	2018	42.42	62.50	100.00	75.00	0.00	16.67	0.00
Participation in traditional activities (% of pop.)		36.29	45.40	45.60	39.40	51.70	40.80	27.80
Country food consumption		63.19	78.00	84.42	86.91	87.66	70.34	47.38
All weather road (Binary)	2013	54%	30%	0%	25%	75%	83%	100%
Airport facilities (Binary)		78%	88%	100%	75%	88%	67%	50%
Population density (people/km ²)	2011	13.46	10.750	6.233	18.543	4.091	6.551	196.890
	2018	13.917	10.580	6.731	19.008	4.120	6.770	206.967
Total number of grocers		50	13	8	4	9	5	11
Large grocers	2023	6	1	0	0	0	0	5
Small grocers		44	12	8	4	9	5	6
Grocers per communities		1.52	1.63	1.6	1	1.13	0.83	5.5
Number of communities		33	8	5	4	8	6	2

Note: “No”, “pop.”, “HHs” are abbreviations for the word’s “number”, and “population”, “households”, respectively. Income assistance represents the percentage of population receiving income support from the government. Income assistance is expressed as a percentage by dividing it by the total population. The food price index is measured using the Yellowknife region as the base price. NNC subsidy binary variable. If a variable = 1, it indicates that a community receives a subsidy from the government, otherwise, it is zero. Airport facilities, all weather road, are binary variables. If a variable = 1, it indicates that a community has access to corresponding facility, otherwise, it is zero. Participation in traditional activities refers to the percentage of the population of 15 years and above that engages in hunting and fishing. The values and quantity of subsidies represent the averages of communities within a region that receive subsidies from the government. Country food refers to the percentage of households that eat meat or fish obtained from hunting or fishing in the community. Grocers per communities are calculated as the total number of grocery stores divided by the number of communities. Population density is determined by dividing the total regional population by the total land area of communities within a region.

Source: NWT bureau of statistics website (2022), Statistics Canada (2018), and google maps (2023), own calculations

Thus, the differences in employment rates across regions, sex, and race also account for the disparities in food insecurity rates in the NWT.

In terms of ownership of homes, the north-south divide once more becomes apparent. Southern regions such as South Slave and Yellowknife have a higher percentage of their households that own houses relative to the northern regions, Beaufort Delta and Sahtu. More specifically, more food-secure regions like South Slave and Yellowknife have home-ownership rates of 62.28% and 56.20% respectively as compared to the northern and more food-insecure regions like Beaufort Delta and Sahtu with 33.3% and 44.4% respectively. Again, the divide between southern regions and northern regions is manifest in the percentages of married households. The more food-secure regions which are in the south have higher percentages of married households relative to less food-secure regions in the north.

The educational levels in the NWT also differ significantly across regions and geographical locations. From Table 4.3 one can note that the percentage of the population of 15 years or above with at least a high school diploma is the highest among the regions in the south relative to the north. However, the food price index is higher among the northern regions such as Beaufort Delta and Sahtu than in the southern regions like Yellowknife and South Slave. For instance, food inflation in South Slave is 37.25 percentage points higher than in Yellowknife but 70.37, and 73 percentage points higher in Beaufort Delta and Sahtu than in Yellowknife. These differences in food prices suggest that despite having a lower average family income, northern regions pay more for the same basket of food items than southern regions.

Out of the total of 9 active mines in the NWT, 7 are in the southern regions, namely Yellowknife and South Slave with 5 and 2 active mining sites respectively. However, northern regions such as Beaufort Delta and Sahtu do not have active mining sites. Also, out of the 16 inactive mining sites in the NWT, 13 are in the southern which are also the most food-secure regions. More specifically, Yellowknife and South Slave have 10 and 3 inactive mining sites respectively. The lack of active mining sites in the northernmost parts implies that the southern regions are more likely to benefit from mining activities such as employment as compared to the Northern regions.

Finally, the differences between the northern and southern regions are shown once more in the level of participation in traditional activities and the consumption of country food. Yellowknife and South Slave, which are the regions in the south and the most food-secure regions of the NWT

have only 27.8 percent and 40.8 percent of their populations participating in traditional activities. On the other hand, Dehcho, Beaufort Delta, and Sahtu which are regions in the south and are more food insecure have 51.7 percent, 45.4 percent, and 45.6 percent of their populations participating in traditional activities. Also, in terms of country food consumption, only 47.38 percent and 70.34 percent of the populations of Yellowknife and South Slave respectively consume country food while 87.66 percent, 64.42 percent, and 78 percent of the populations of Dehcho, Sahtu, and Beaufort Delta respectively consume country food. The statistics above show that regions with a higher percentage of their populations participating in traditional activities and consuming country food are more food insecure. Also, regions in the north are relatively more food insecure as compared to regions in the south of NWT.

Overall, one can note from the trend that the descriptive statistics present a clear pattern of disparities between the north and the south in which regions in the south are characterised by better conditions such as higher average family incomes, higher employment rates, higher percentages of home ownership, higher percentages of married households, a higher percentage of educated populations, lower food price index and higher number of both active and inactive mines. These indicators explain the north-south disparity in food insecurity in which northern regions such as Beaufort Delta, Sahtu, and Thcho are more food insecure as compared to southern regions such as Yellowknife and South Slave.

4.4 Empirical strategy

In modeling the association between food insecurity and community characteristics, I apply ordinary least square (OLS) and estimate the following model:

$$FI_i = \alpha_0 + \beta X_i' + \varepsilon_i, \quad (1)$$

where FI_i represents one of the three food insecurity measures of (i) the percentage of households worried about not having enough money for food in the i th community, and among those who did, (ii) the percentage of those that reported “Often”, and (iii) the percentage of those that reported “Sometimes”. X_i' is the vector of community-level characteristics introduced in Table 4.1 as observed in the most recent year, and ε_i is the error term that captures unexplained variability in the i th community. The error term is normally distributed, and it follows a $N(0, \delta^2)$. Finally, β are the coefficients of interest to be estimated and will be compared against the hypotheses introduced

in Figure 3.1. The OLS approach provides estimates of the coefficients that best fit the observed data and allows for inference about the relationships between the explanatory variables and food insecurity in the NWT.⁶

The OLS estimation can provide unbiased and efficient estimates of the relationship between food insecurity and community characteristics if the following assumptions are met:

- **Linearity:** The relationship between the explanatory variables (community characteristics) denoted as X_i , and the response variable (food insecurity), denoted as FI_i , is assumed to be linear. This relationship means that changes in the response variable are linearly related to changes in the explanatory variables.
- **Independence:** The observations (community characteristics) are assumed to be independent of each other. This independent relationship can be denoted as $\text{Cov}(\varepsilon_i, \varepsilon_j) = 0$ for $i \neq j$, indicating that the error terms for different communities are uncorrelated.
- **Normality:** The error term (residuals), denoted as ε_i , is assumed to follow a normal distribution with a mean of zero and constant variance for each community, i.e., $\varepsilon_i \sim N(0, \delta^2)$.
- **Homoscedasticity:** The variance of the error term is constant across all levels of the explanatory variables. In other words, the spread of the residuals is consistent across different values of the community characteristics. Mathematically, this constant variance is expressed as $\text{Var}(\varepsilon_i) = \delta^2$ for all i .
- **No perfect multicollinearity:** There should be no exact linear relationship between any pair of explanatory variables, denoted as X_i .

To ensure the estimates are unbiased and efficient, I test the assumptions of OLS estimation. The results of these tests show that the model adheres to the assumptions of OLS, and you can find the detailed results in Table A4 in the Appendix.

In addition to estimating equation (1) for each of the three food insecurity measures using the most recent observations of right-hand side variables, I estimate a modified model, where I take the temporal change of these variables – as the data allows. Furthermore, I perform two

⁶ As one may be concerned about the hierarchical structure of the data and the appropriateness of estimating OLS vs. multilevel model, I tested whether regional level variation contributes to the overall level of food insecurity. Table A2 in the Appendix indicates that the random effect is statistically insignificant and hence, multilevel approach is not supported using the data at hand.

sensitivity tests. First, since the descriptive analysis showed Yellowknife to be the most food-secure region, I excluded it and re-estimated equation (1). Second, albeit the regional variation does not seem to contribute to the overall level of food security as shown in Table A2 in the Appendix, it may be of interest how different the results of a random intercept model are from the results obtained in estimating equation (1).

4.5 Summary

This chapter described the underlying data including the measurement of main variables of interest, methods, and descriptive statistics used in this study. The descriptive statistics showed that food insecurity is more severe in the northern regions, with Beaufort Delta (31%), Sahtu (31.2%), Thcho (55.1%), and Dehcho (31.5%) having notably higher percentages of households answering “Yes” to the question of whether they were worried about not having enough money to buy food. In contrast, the southern regions of South Slave (18%) and Yellowknife (17%) exhibit lower levels of food insecurity. While the average food insecurity rate among the four northern regions is 37.2%, the average between the two southern regions is 17.85%. Also, regions with more dispersed communities and households, no active mines, and only small grocery stores were more food insecure. In the next chapter I will further investigate these relationships using OLS.

Chapter 5 – Results and Discussion

5.1 Introduction

Following the discussion of the methods and a description of the variables as well as the characteristics of the NWT, this chapter presents the results of the estimation. More specifically, section 5.2 provides the ordinary least square results, hereby, I consider all characteristics of food availability and food access simultaneously. Section 5.3 discusses the findings of the study and compares them to the relevant literature Section 5.4 tests the robustness of results, while section 5.5 is a summary of the chapter.

5.2 Ordinary Least Square Results

Table 5.1 reports the OLS results of the association between community-level food insecurity and the different community-level characteristics as specified in equation (1). Columns (1), (2), and (3) indicate the three different dependent variables, i.e., percentage of households in the community who responded “Yes” to the question about whether they were worried about not having enough money to buy food”, the percentage of households that indicated “Often”, and “Sometimes”, respectively.

Focusing on Column (1), one can note that communities’ population density and participation in traditional activities are statistically significant at the 5% level and positively associated with the percentage of households per community worried about not having enough money to buy food. This positive association observed in the results contradicts my expectation of a negative relationship between food insecurity and traditional activities. Nevertheless, a potential explanation is that traditional food sources are not reliable as they depend on seasons. For instance, while fishing and hunting may take place throughout the year, in winter, these activities become less viable (CBC, 2021) implying that communities with a higher percentage of their population participating in traditional activities might have less access to food. Another potential explanation for the negative association between traditional activities and food insecurity is that when households spend more money in traditional activities, less is available to buy food. Also, communities with higher population density are likely to experience a strain on resources and access to food holding all other factors constant. In the NWT, due to food supply challenges, a higher population suggests that many people have to depend on the limited quantity of food supplied. This strain on resources could be linked to the positive relationship between food insecurity and participation in traditional

activities in which highly populated communities with a larger share of their citizens participating in traditional activities are likely to be constrained by the limited stock of hunted food such as fish, and game among others.

Table 5.1. OLS estimation of the association between food insecurity and socioeconomic characteristics at community level.

	Yes	Often	Sometimes
Grocers (weighted sum of small & large grocery stores)	-2.082 (2.478)	-0.070 (1.217)	-2.170 (2.179)
Population density [ln (people/km ²)]	3.984** (1.849)	0.472 (0.908)	3.801** (1.626)
Country food consumption (% of HHs)	7.650 (7.320)	4.938 (3.594)	-0.082 (6.436)
Airport facilities (binary)	-16.530** (7.559)	-10.350** (3.711)	-4.914 (6.646)
All-weather roads (binary)	-25.292** (10.840)	-9.198 (5.322)	-20.561** (9.531)
Family income [ln (CAD)]	-1.772 (9.887)	-1.293 (4.854)	-2.958 (8.693)
Food price index	0.167 (0.143)	0.102 (0.070)	0.041 (0.126)
% of HHs with 6 or more people (% of HHs)	0.402 (0.476)	-0.379 (0.234)	1.016** (0.418)
Married HHs (% of HHs)	0.478 (0.264)	0.448 (0.130)	0.008 (0.232)
Education (% pop. 15+ with at least a high school diploma)	-0.350* (0.176)	-0.192** (0.086)	-0.018 (0.154)
Owned house (% of HHs)	0.063 (0.213)	0.155 (0.105)	-0.137 (0.188)
No. of active mines	-2.888 (8.567)	-6.700 (4.206)	5.329 (7.532)
Participate in traditional activities (% of pop.)	0.477** (0.229)	0.247** (0.112)	0.250 (0.201)
NNC subsidy (binary)	-25.579** (10.886)	-9.908* (5.344)	-20.699** (9.571)
Constant	-1.475 (128.264)	-19.909 (62.973)	52.225 (112.774)
Observations	33	33	33
Adjusted R²	0.523	0.390	0.418

Note: (a) The dependent variable is food insecurity measures the percentage of households in the region who responded “Yes”, “Often” and “Sometimes” to worried about not having enough money to buy food. (b) Airport facilities, all-weather roads are binary variables, if a variable = 1, it indicates that a community has access to the corresponding facility, otherwise, it is zero. Subsidy is a binary variable, if a variable = 1, it indicates that a community receives a subsidy from the government, otherwise, it is zero. (c) ***, **, and * indicate 1, 5, and 10 percent significant levels respectively. (d) Standard errors clustered at the community level in parentheses. (e) “no”, “pop.”, “HHs” are abbreviations for the words “number”, and “population”, “households”, respectively. Source: NWT Bureau of Statistics website (2022), Statistics Canada (2018), and Google Maps (2023), own calculations.

This limited traditional food might be exacerbated by the increasing challenges of climate change which has influenced to the migration of birds among others wildlife species (GNWT, 2022). Finally, better infrastructure such as airport facilities, all-weather roads, and NNC subsidies are statistically significant and negative at the 5% level.

Unlike the participation in traditional activities and population density, better educational outcomes such as a higher percentage of adolescents and adults with at least a high-school diploma are statistically significant at a 10% level. These are also associated with lower shares of reporting being worried about not having enough money to buy food.

Differentiating between the two severity levels of food insecurity being “Often” or “Sometimes” worried of not having enough money to buy food in columns (2) and (3) reveals similar associations. From column (2) and considering the percentage of households that reported often being worried of not having enough money to buy food, most of the statistically significant correlations stay robust, yet the magnitude of the coefficients decreases. For example, the association between food insecurity and the percentage of people in a community who participate in traditional activities is reduced by half but stays positive and statistically significant at the 5% level. Similarly, the negative correlation coefficient with airport education and NNC reduces significantly, but remains statistically significant at the 5% and 10%-level, respectively. However, the variables measuring population density and airport facilities become insignificant.

For column 3, population density and household sizes are statistically significant and positively related to food insecurity while all-weather road and NNC subsidy are negatively associated with food insecurity. As explained in Chapter 3, household size could be negatively or positively related to food insecurity. Therefore, the positive association, in this case, suggests that larger households or households with at least six people in the NWT could be characterised by more dependents such as children and elderly people than individuals participating actively in the labour market. Thus, higher dependency levels among larger households increase the chances of food insecurity among households.

Before I compare the findings of Table 5.1 with the findings from comparable studies in the literature in section 5.3, let us look at Table 5.2, where I regress the three dependent variables of food insecurity on the changes in community characteristics. The essence of this was to observe if changes in the community-level characteristics had any association with changes in food

insecurity. From Table 5.2, one can note that the relationship between the changes in the variables and food insecurity measured as “Yes”, “Often”, and “Sometimes” are not statistically significant.

Table 5.2. OLS estimation of the association between food insecurity and temporal changes in socioeconomic characteristics at community level.

	Yes	Often	Sometimes
Grocers (weighted sum of small & large grocery stores)	-3.938 (2.816)	-1.293 (1.267)	-2.850 (2.281)
Δ Population density [ln (people/km ²)]	1.103 (4.909)	0.378 (2.208)	0.604 (3.976)
Δ Country food consumption (% of HHs)	-23.308 (119.050)	-4.098 (53.541)	-10.543 (96.417)
Airport facilities (binary)	-9.372 (8.716)	-4.454 (3.920)	-4.977 (7.059)
All-weather roads (binary)	-17.337 (15.002)	-9.123 (6.747)	-13.443 (12.150)
Δ Family income [ln (CAD)]	23.965 (49.008)	0.485 (22.041)	10.725 (39.691)
Δ Food price index	0.170 (0.203)	0.009 (0.091)	-0.165 (0.165)
Δ % of HHs with 6 or more people (% of HHs)	0.291 (0.382)	0.097 (0.172)	0.191 (0.309)
Δ Married HHs (% of HHs)	0.065 (0.358)	0.249 (0.161)	-0.133 (0.290)
Δ Education (% pop. 15+ with at least high school diploma)	-0.832 (0.787)	-0.226 (0.354)	-0.651 (0.638)
Δ Owned house (% of HHs)	0.118 (0.662)	0.100 (0.298)	0.204 (0.536)
No. of active mines	2.561 (10.555)	-0.399 (4.747)	1.524 (8.548)
Δ Participate in traditional activities (% of pop.)	0.385 (0.587)	0.134 (0.264)	0.101 (0.475)
NNC subsidy (binary)	-6.654 (18.280)	-4.703 (8.221)	-8.281 (14.805)
Constant	49.053** (21.854)	2.513 (9.829)	51.519*** (17.700)
Observations	33	33	33
Adjusted R²	0.402	0.358	0.381

Note: (a) The dependent variable is food insecurity, measures the percentage of households in region who responded “Yes”, “Often” and “Sometimes” to worried about not having enough money to buy food. (b) Airport facilities, all weather roads are binary variables, if a variable = 1, it indicates that a community has access to corresponding facility, otherwise, it is zero. Subsidy is binary variable, if a variable = 1, it indicates that a community receives a subsidy from the government, otherwise, it is zero. (c) ***, **, and * indicate 1, 5, and 10 percent significant levels respectively. (d) Standard errors clustered at the community level in parentheses. (e) “no”, “pop.”, “HHs” are abbreviations for the word “number”, and “population”, “households”, respectively. Δ represent a change.

Source: NWT bureau of statistics website (2022), Statistics Canada (2018), and google maps (2023), own calculations

This result could imply that while some of the variables are significantly related to food insecurity, the variations in community and household characteristics do not significantly determine the level of food insecurity in the NWT. Therefore, since the results of the “Yes”, “Often” and “Sometimes” models do not differ significantly, I discuss the findings of this study in detail below by interpreting them in the context of the NWT and in terms of the literature. These are provided in the section below.

5.3 Discussion

Overall, the results from the estimations show that food insecurity is associated with population density, airport facilities, all-weather roads, household size, education, participation in traditional activities, and food subsidies. While airport facilities, all-weather roads, education, and food subsidies have negative associations with food insecurity, household size, population density, and participation in traditional activities have positive associations with food insecurity.

As stated earlier, it is observed that airport facilities and all-weather roads have significant and negative associations with the level of food insecurity. This result confirms my expectation and emphasises the important role that transportation infrastructure plays in ensuring food security in the NWT. As explained in previous chapters, the low level of food production in the NWT implies that food is transported from various parts of the country to serve the regions and communities of the NWT. However, in winter, the supply of food to some of these regions and communities is constrained by the lack of good roads as some of the roads become unmotorable (Sladden et al., 2020). This result resonates with the findings of Deaton et al. (2020) and a cross-sectional survey by Domingo et al. (2021) among First Nations living on Canadian reserves. As explained by Domingo et al. (2021), the positive association between rising levels of remoteness and food insecurity in communities lacking year-round ground transportation indicates the role of transportation in food security. Therefore, the construction of all-weather roads and airport facilities enables the transportation of food to these regions and communities which increases the availability of food and reduces food insecurity. This observation corroborates the remark by DeBoer et al. (2022) that good transport infrastructure is associated with an improvement in food security especially in rural communities where the costs of transportation are high and are a major barrier to food security.

From the estimations, the percentage of the population who are above the age of 15 years and have a minimum of a high school diploma has a negative association with food insecurity. This result is in line with my expectations and confirms the results of many studies in the literature (Egeland et al., 2011; Huet et al., 2017; Javadi et al., 2023). The negative relationship between education and food insecurity is probably because education enhances the employment of individuals and increases their income levels. Notwithstanding, the association between education and food insecurity in the NWT might be underestimated by the continuous migration of the Indigenous people out of the area in search of job opportunities and education opportunities in other cities of Canada (Norris & Clatworthy, 2011).

I find that food insecurity is negatively associated with the NNC's food subsidies as I expected. The result implies that the NNC's food subsidy helps to improve the food insecurity situation in some communities of the NWT. According to the criteria of the program, beneficiary communities should be located in the NWT, have inhabitants throughout the year, and should not have access to roads or marine. However, the communities should have an airport that serves as the main medium of food transportation (Nutrition North Canada, 2024). These requirements are based on the lack of transportation networks which impede food transportation to these communities and since air transport of food is expensive, the prices of food become relatively more expensive. Thus, the provision of subsidy through Nutrition North Canada aims at subsidizing the prices of some selected food items to the inhabitants of these communities. However, while the program has had positive impacts on food security, there are growing concerns about the quality of the food which is deemed to be highly processed and hence presents implications for the health of the beneficiaries (Pagaduan et al., 2024).

The positive association between household size and food insecurity suggests that communities with a higher percentage of households that have more than 6 members are more likely to be food insecure as compared to communities with a lower percentage of households with more than 6 members. This result confirms the findings of Findlay et al. (2013) and Ruiz-Castell et al. (2015) but contradicts the findings of Bhawra et al. (2021) that household size in Canada has no significant association with food insecurity. On one hand, many household members could imply more income if the majority of the household members are within the working population and are employed. However, the positive association between household size and food insecurity in this

study suggests that households with more than six members in NWT are characterised by higher dependency on a few actively working members. These dependents could be children within age groups less than the working age, sick persons, unemployed persons, or elderly persons who are retired. In this case, the higher dependency in larger households means the share of food per person becomes lower due to relatively lower family income. For instance, Ruiz-Castell et al. (2015) explain that larger households increase the possibility of a reduction in the portions of children's meals. Thus, communities with a majority of households having fewer members will be less likely to worry about not having enough money to buy food.

My results also show that population density has a positive association with food insecurity in the NWT. This result is similar to the finding of Kousar et al. (2021) and Panikkar and Lemmond, (2020) that population growth has a positive relationship with food insecurity. As the supply of food in the region is constrained by transportation challenges, an increase in the population is likely to decrease the availability of food per household if transportation networks are not improved to make food readily available. The relationship between population size and food insecurity can thus be explained by the idea that an increase in the population of the NWT (Northwest Territories) suggests a higher need to allocate food resources among a larger number of people than in the past. As argued by Panikkar and Lemmond, (2020), in addition to other factors, population growth results in a reduction in country food sharing among First Nations.

Finally, regarding traditional activities, the regression results indicate that participation in traditional activities such as fishing and hunting has a positive relationship with food insecurity. In other words, an increase in the percentage of a community's population who engage in fishing or hunting is associated with an increase in food insecurity. This finding is surprising and contradicts my expected outcome considering that traditional activities like fishing and hunting contribute significantly to the nutrition of Indigenous people (NWT Bureau of Statistics, 2018). However, the outcome of the traditional activities variable might be explained by the following reasons: First, households that spend more money on traditional activities might have less money available to buy food though this does not mean that these households are necessarily food insecure. Secondly, hunting and fishing are not reliable throughout the year since there is no guaranteed outcome for hunters and fishermen. Therefore, households that engage and depend on traditional activities might have lower incomes since food from these traditional activities is not for sale in the NWT.

Thus, considering that the dependent variable measures the percentage of households worried of not having enough to buy food, households that offset wage employment with more traditional activities are likely to be classified as being food insecure. Also, the unreliability of hunting and fishing suggests that communities with more members depending on traditional activities will be more likely to be food insecure, especially during seasons when traditional activities are less viable. This situation is particularly likely to worsen in winter and also due to climate change which has led to the migration of birds and animals (GNWT, 2022). The result on traditional activities therefore contradicts the findings of Lambden et al. (2007) and Kenny et al. (2018) that traditional activities such as hunting and fishing enhance long-term food security.

5.4 Sensitivity tests

This section implements two sensitivity tests. First, to the robustness of the OLS estimation, it is important to investigate the behaviour of the models when regions that have significantly lower food insecurity rates are eliminated from the study. In this study, the Yellowknife region is the most food-secure region in NWT and hence might influence the outcomes of the estimation. Thus, I rerun the OLS estimation by eliminating the Yellowknife region from the data set to observe the behaviour of the model.⁷ The result of this estimation for the community-level characteristics and food insecurity is provided in Table A3 in the Appendix. From Table A3 which shows the robustness of all characteristics associated with food availability and accessibility, it is observed that population density, airport facilities, all-weather roads, education, participation in traditional activities, and NNC subsidy remain significant after excluding Yellowknife. In addition, the coefficients of airport facilities, all-weather roads, education, and NNC food subsidy remain negative while the coefficients of population density and participation in traditional activities remain positive, as observed in the estimation including Yellowknife. These results corroborate the findings of the full model which combines the food availability and food accessibility variables as shown in Table 5.1 above. Therefore, the results from Table A3 suggest that the previous OLS estimation results for many of the variables are robust.

Lastly, I use the multilevel regression model (MRM), specifically the random intercept model (RIM) to determine the association between food insecurity and community-level characteristics. The essence of this estimation is to determine the behavior of community-level

⁷ The number of regions and communities reduced from 6 to 5 and from 33 to 31 respectively.

characteristics on food insecurity when MRM estimation is used instead of OLS. The main purpose of running the RIM is that I suspect that the regional variation contributes to the overall level of food insecurity, and the OLS will not capture this layer of variability. Thus, I test the significance of the random effect in RIM using the likelihood ratio test in Table A2 in the Appendix. The p-value of the test is greater than a 5% significance level, hence there is enough evidence to say that adding the random intercept to the model does not significantly improve the fitted model compared to the model without random effect (OLS). In other words, including the random effects in the estimation does not statistically improve the model fit. The result of this estimation is presented in Table A5. When the RIM is used in the estimation of the community-level characteristics associated with food insecurity, population density, airport facilities, all-weather roads, education, participation in traditional activities, and NNC subsidies are significant. This result, in addition to the likelihood ratio test, suggests that the results of the OLS are robust and hence confirm my decision to use the OLS in estimation because the regional variability does not influence the overall level of food insecurity.

5.5 Summary

In addressing the research objectives, results from the OLS results suggested food security is associated with better transportation infrastructure such as airport facilities and all-weather roads, lower population density, better education, and government subsidies. In the next subsection, I discuss the implications of these findings.

Chapter 6 – Summary and Conclusion

6.1 Introduction

This chapter provides a summary of the main findings of the thesis and also provides recommendations for potential policy options and programs that could improve the food insecurity situation in the NWT, Canada. The chapter also discusses the limitations of this research and provides suggestions for potential future research.

6.2 Summary of Findings

This thesis investigated the level and determinants of food insecurity across 33 communities in the NWT and identified potential hot spots of food insecurity. Secondary data was gathered for the period between 2010 to 2020 across the 33 communities and six regions of the NWT. The methods involved spatial mapping of food insecurity to identify communities and regions of high food insecurity risk as well as an empirical estimation using an OLS model.

The results of the spatial analysis and the OLS indicate that food insecurity is more severe in the northernmost regions (Beaufort Delta (31%), Sahtu (31.2%), Thcho (55.1%), Dehcho (31.5%)) than in the southern regions (South Slave (18.7%), Yellowknife (17%)). More severe food insecurity implies a higher percentage of households responded “Yes” to the question about whether they are worried about money to buy food in a given region relative to another. The spatial analysis shows that regions with more dispersed communities, no active mines, and only small grocery stores were more food insecure. Also, from the OLS estimation, food insecurity is associated with no access to good transportation especially in winter such as all-weather roads and airport facilities, lower education, higher population density, inadequate access to large grocery stores, larger household sizes with many dependants, and higher participation in traditional activities such as hunting and fishing.

Some of the results of this study confirm the findings of earlier literature on the determinants of food insecurity in Canada. For instance, these findings are related to the findings of Anila and Adiq (2011) and Tarasuk et al. (2019) that households with education were associated with higher levels of food insecurity. However, studies such as Gebrehiwot and van der Veen (2014) found no significant relationship between education and food insecurity. Also, the results corroborate the findings of Shafiee et al. (2022) that lack of transportation facilities such as airport

facilities, and all-weather roads in northern Canada is associated with food insecurity. The results also show that higher population density and higher participation in traditional activities such as hunting and fishing in a community are associated with higher food insecurity which is contrary to the findings of Wesche et al. (2016) and Kenny et al. (2018). This outcome of the traditional activities is explained by the unreliability of traditional activities such as hunting and fishing. Also, households that spend more money on traditional activities might have less money available to buy food though this does not mean that these households are necessarily food insecure. Secondly, hunting and fishing are not reliable throughout the year since there is no guaranteed outcome for hunters and fishermen. Therefore, households that engage and depend on traditional activities might have lower incomes since food from these traditional activities is not for sale in the NWT.

6.3 Limitations and Potential Future Research

The results from this study largely confirm the factors that relate to higher levels of food insecurity in the NWT as observed in previous studies (Tarasuk et al., 2019, Council of Canadian Academies, 2014). However, the identification and comparison of food insecurity levels across the regions of Canada using spatial mapping provides more information about the hotspots of food insecurity in the NWT. Considering that one of the objectives of this study was to identify hotspots of food insecurity in the NWT, a spatial regression analysis would be appropriate to complement the results from the spatial mapping and the OLS estimation. However, the nature of the data used in this study is not suitable for spatial regression. This is because, estimating spatial regression requires information about the spatial relationships among the various regions and communities of the NWT known as the spatial weight matrix (Otto & Steinert, 2023). However, the data used in this study did not include information about how the communities and regions in the NWT are connected to each other or the distance between communities and regions in the NWT. This data structure is a major limitation of the analysis as spatial regression is appropriate for establishing spatial dependences of variables.

Secondly, it is explained in this study that food sharing is a major practice among the Indigenous people of the NWT. Through the market and traditional activities, households engage in mixed economic activities whereby traditional food obtained from trapping, hunting, or gathering is shared with a network of family, friends, and neighbours. This important role of food-sharing networks implies that a study of food insecurity should entail an estimation of the role of these

food-sharing networks and the consumption of wild foods (which is different from country food) in enhancing food security among the Indigenous people of the NWT. However, this important feature of the mixed economy of the NWT was not included in this analysis due to data paucity on the food-sharing networks. Consequently, the results obtained from this study might not completely explain the food security issues of the Indigenous people of the NWT.

Furthermore, there are measurement issues especially related to the self-reported nature of the dependent variable. Specifically, responses to the question whether a household has not enough money to buy food could be biased as respondents may not reveal the truth. Second, feel ashamed. Second Furthermore, it should be noted that the food insecurity measure exclusively relates onto money and hence access to food and not food availability rather than food. This situation may lead to households that offset wage employment with traditional activities being classified as being food insecure even though they are not necessarily deprived of food. However, a dependent variable that asks households if they worry about not getting enough food to eat might be able to explain the lack or insufficiency of food among the households.

6.4 Policy Recommendations

Based on the result, the following policy initiatives are recommended to reduce the level of food insecurity in the communities and regions of NWT. First, since the food subsidy program has a statistically significant negative relationship with food insecurity, efforts should be made to improve the efficiency of the food subsidy program particularly by ensuring that subsidies reach the intended beneficiaries. Second, due to the increasing concerns of low food quality associated with the NNC food subsidy program, it is important that supervision and effective implementation of the program are enforced. This is necessary to promote good nutrition and health among beneficiaries.

Furthermore, improving educational opportunities in the Northwest Territories (NWT) is crucial for enhancing food security and overall community well-being. Higher educational attainment is directly linked to better employment opportunities and higher income levels, which in turn can alleviate food insecurity. Therefore, it is essential for the government to invest in schools, vocational training, and adult education programs. This investment should include modernizing educational infrastructure, providing scholarships, and facilitating access to remote learning technologies. Additionally, the NWT government should implement policies that incentivize and

attract residents to pursue educational and vocational courses. These policies could include financial incentives, such as grants and bursaries, as well as career support services to help individuals transition into the workforce. By enhancing educational opportunities and making them more accessible and appealing, the NWT government can empower residents with the knowledge and skills necessary for informed decision-making about nutrition and food procurement, ultimately leading to improved food security and socioeconomic outcomes in the region.

Lastly, considering the paucity of data on critical variables such as wild food consumption, which is different from country food and traditional activities, it is recommended that investments are made into data collection. Comprehensive data would be essential to understanding the intricacies of food security in the regions and communities of the NWT through research. The outcome of these studies would enhance the development of targeted policies and interventions towards food insecurity reduction in the NWT.

References

- Alonso, E. B., Cockxs, L., & Swinnen, J. (2018). Culture and food security. *Global food security*, 17, 113-127
- Anema, A., Fielden, S., Castleman, T., Grede, N., Heap, A., & Bloem, M. (2014). Food security in the context of HIV: Towards harmonized definitions and indicators. *AIDS and Behavior*, 18, 476-489. <https://doi.org/10.1007/s10461-013-0659-x>.
- Batal, M., Chan, H. M., Fediuk, K., Ing, A., Berti, P. R., Mercille, G., ... & Johnson-Down, L. (2021). First Nations households living on-reserve experience food insecurity: prevalence and predictors among ninety-two First Nations communities across Canada. *Canadian Journal of Public Health*, 112(Suppl 1), 52-63.
- Batal, M., Chan, H. M., Fediuk, K., Ing, A., Berti, P., Sadik, T., & Johnson-Down, L. (2021). Importance of the traditional food systems for First Nations adults living on reserves in Canada. *Canadian journal of public health*, 112(Suppl 1), 20-28.
- Bhawra, J., Kirkpatrick, S., & Hammond, D. (2021). Food insecurity among Canadian youth and young adults: insights from the Canada Food Study. *Canadian Journal of Public Health*, 112, 663 - 675. <https://doi.org/10.17269/s41997-020-00469-1>.
- BodnarukR. (n.d). Canada City. Available at: <https://www.pinterest.ca/pin/438397344952598117/>. Accessed on: 15/03/2024.
- Broussard, N. (2019). What explains gender differences in food insecurity? *Food Policy*. <https://doi.org/10.1016/J.FOODPOL.2019.01.003>.
- Burnett, K., Skinner, K., Hay, T., LeBlanc, J., & Chambers, L. (2017). Retail food environments, shopping experiences, First Nations and the provincial Norths. *Health promotion and chronic disease prevention in Canada: research, policy and practice*, 37 (10), 333-341. <https://doi.org/10.24095/hpcdp.37.10.03>.
- Camden, A., Levy, J., Bassil, K., Vanderlinden, L., Barnett, O., Minaker, L., Mulligan, K., & Campbell, M. (2018). A census of midsize to large supermarkets in toronto: a cross-

- sectional analysis of the consumer nutrition environment. *Journal of Nutrition Education and Behavior*, 50, 573–581. <https://doi.org/10.1016/j.jneb.2017.12.002>.
- Canadian Broadcasting Corporation (2021). Warm winter weather making it a difficult hunting season in N.W.T. Available at: <https://www.cbc.ca/news/canada/north/warm-winter-weather-making-difficult-hunting-season-1.5878344>. Accessed on: 22/05/2024
- Che, J., & Chen, J. (2001). Food insecurity in Canadian households. *Health reports*, 12 4, 11-22.
- Christopherson D. (2015). Chapter 6, Nutrition North Canada — Aboriginal Affairs and Northern Development Canada, of the Fall 2014 report of the Auditor General of Canada: Report of the Standing Committee on Public Accounts. Available at: https://www.oag-bvg.gc.ca/internet/english/parl_oag_201411_06_e_39964.html. Accessed on 15/03/2024
- Clapp, J., Moseley, W. G., Burlingame, B., & Termine, P. (2022). The case for a six-dimensional food security framework. *Food Policy*, 106, 102164.
- Collard, M., Ruttle, A., Buchanan, B., & O'Brien, M. J. (2013). Population size and cultural evolution in nonindustrial food-producing societies. *PloS one*, 8(9), e72628.
- Collings, P., Marten, M. G., Pearce, T., & Young, A. G. (2016). Country food sharing networks, household structure, and implications for understanding food insecurity in Arctic Canada. *Ecology of food and nutrition*, 55(1), 30-49.
- Cone, M. (2005). *Silent Snow: The Slow Poisoning of the Arctic*. New York, (NY): Grove Press.
- Council of Canadian Academies, (2014). *Indigenous food security in northern Canada: an assessment of the state of knowledge*, Ottawa, ON. The expert panel on the state of knowledge of food security in northern Canada, Council of Canadian Academies.
- Crosby, A., & Monaghan, J. (2012). Settler governmentality in Canada and the Algonquins of Barriere Lake. *Security Dialogue*, 43(5), 421-438.
- Cunsolo Willox, A., Harper, S. L., Ford, J. D., Landman, K., Houle, K., & Edge, V. L. (2012). “From this place and of this place:” climate change, sense of place, and health in Nunatsiavut, Canada. *Social science & medicine*, 75(3), 538-547.

- Deaton, B. J., Scholz, A., & Lipka, B. (2020). An empirical assessment of food security on First Nations in Canada. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 68(1), 5-19.
- DeBoer, Z., Heal, B., & Chen, D. (2022). Assessing perceived food security among British Columbian rural and urban residents. *BCIT Environmental Public Health Journal*.
<https://doi.org/10.47339/ephj.2022.206>.
- Dixon, J. (2014). The Public health contribution to the discursive struggles surrounding food security and food sovereignty. *Dialogues in Human Geography*, 4, 200 - 205.
<https://doi.org/10.1177/2043820614537157>.
- Dodd, W., Scott, P., Howard, C., Scott, C., Rose, C., Cunsolo, A., & Orbinski, J. (2018). Lived experience of a record wildfire season in the Northwest Territories, Canada. *Canadian Journal of Public Health*, 109, 327-337.
- Domingo, A., Charles, K. A., Jacobs, M., Brooker, D., & Hanning, R. M. (2021). Aboriginal community perspectives of food security, sustainable food systems, and strategies to enhance access to local and traditional healthy food for partnering Williams treaties first nations (Ontario, Canada). *International journal of environmental research and public health*, 18(9), 4404.
- Egeland, G. M., Williamson-Bathory, L., Johnson-Down, L., & Sobol, I. (2011). Traditional food and monetary access to market-food: correlates of food insecurity among Inuit preschoolers. *International Journal of Circumpolar Health*, 70(4), 373-383.
- Findlay, L. C., Langlois, K. A., & Kohen, D. E. (2013). Hunger among Inuit children in Canada. *International Journal of Circumpolar Health*, 72(1), 20324.
- Food and Agricultural Organisation (2006). Policy brief: food security. Available at: https://www.fao.org/fileadmin/templates/faoitally/documents/pdf/pdf_Food_Security_Concept_Note.pdf. Accessed on 25/11/2023.
- Food and Agricultural Organisation (2008). An introduction to the basic concepts of food security. Available at: <https://www.fao.org/3/al936e/al936e00.pdf>. Accessed on: 24/10/2023.

- Food and Agricultural Organization and the World Health Organization (2019). Sustainable healthy diets – Guiding principles. Rome
- Ford, J. & Berrang-Ford, L. (2009). Food security in Igloolik, Nunavut: An exploratory study. *Polar Record*, 45(234), 225-236.
- Ford, J. D., & Beaumier, M. (2011). Feeding the family during times of stress: experience and determinants of food insecurity in an Inuit community. *The Geographical Journal*, 177(1), 44-61.
- Ford, J., Couture, N., Bell, T., & Clark, D. (2018). Climate change and Canada's north coast: Research trends, progress, and future directions. *Environmental Reviews*, 26, 82-92. <https://doi.org/10.1139/ER-2017-0027>.
- Foster, J. S., Schwartz, M. B., Grenier, R. S., Burke, M. P., Taylor, E. A., & Mobley, A. R. (2019). A qualitative investigation into the US Department of Agriculture 18-item Household Food Security Survey Module: Variations in interpretation, understanding and report by gender. *Journal of Public Affairs*, 19(3), e1861.
- Geyer, S., Spreckelsen, O., & Knesebeck, O. (2014). Wealth, income, and health before and after retirement. *Journal of Epidemiology & Community Health*, 68, 1080 - 1087. <https://doi.org/10.1136/jech-2014-203952>
- Google Map (2024). Grocery stores in northwest territories. Available at: <https://www.google.com/maps/search/The+number+of+grocery+shops+in+a+community+and+region+of+Northwest+Territories/@63.8156089,-159.9207501,3z?entry=ttu>. Accessed on 07/09/2023.
- Google Maps (2023). Northwest territories. Available at: <https://www.google.com/maps/d/u/0/viewer?mid=1Q9IUywsWk6fmgH6CY6LOW-BuYNzI&hl=en&ll=67.29749716386888%2C-117.114258&z=4>. Accessed on: 21/01/2023.
- Government of Canada, (2022). Northern Residents Deductions for 2021. Available at: <https://www.canada.ca/en/revenue-agency/services/forms-publications/publications/rc4650/northern-residents-deductions.html>. Accessed on: 18/06/2024

- Government of Canada (2023). Nutrition North Canada. Available at: <https://www.nutrition-northcanada.gc.ca/eng/1415385762263/1415385790537>. Retrieved on 05/10/2023.
- Government of Northwest Territories (2021). Economic review 2-22-2023 Northwest territories. Available at: https://www.fin.gov.nt.ca/sites/fin/files/resources/2022-23_budget_address_and_papers_final_-_economic_review.pdf. Retrieved on: 12/07/2023.
- Grey, S., & Patel, R. (2015). Food sovereignty as decolonization: some contributions from Aboriginal movements to food system and development politics. *Agriculture and Human Values*, 32, 431-444. <https://doi.org/10.1007/S10460-014-9548-9>.
- Grimaccia, E., & Naccarato, A. (2018). Food insecurity individual experience: a comparison of economic and social characteristics of the most vulnerable groups in the world. *Social Indicators Research*, 143, 391-410. <https://doi.org/10.1007/S11205-018-1975-3>
- Halim, H., Astuty, P., & Hubeis, M. (2022). Effect of inflation, consumption credit on purchase power of the community. *International Research Journal of Management, IT and Social Sciences*, 9(2), 226-234.
- Hall, R. (2021). Aboriginal/state relations and the “Making” of surplus populations in the mixed economy of Northern Canada. *Geoforum*, 126, 461-470.
- Huet, C., Ford, J. D., Edge, V. L., Shirley, J., King, N., IHACC Research Team Lea Berrang-Ford Shuaib Lwasa Didacus Namanya Cesar Carcamo Alejandro Llanos James D. Ford Victoria L. Edge Sherilee L. Harper, & Harper, S. L. (2017). Food insecurity and food consumption by season in households with children in an Arctic city: a cross-sectional study. *BMC Public Health*, 17, 1-14.
- Hunter, S., Skouteris, H., & Morris, H. (2021). A conceptual model of protective factors within Aboriginal and Torres Strait Islander Culture that build strength. *Journal of Cross-Cultural Psychology*, 52, 726 - 751. <https://doi.org/10.1177/00220221211046310>.
- Hwalla, N., El Labban, S., & Bahn, R. A. (2016). Nutrition security is an integral component of food security. *Frontiers in life science*, 9(3), 167-172.
- Ike, C., Jacobs, P., & Kelly, C. (2015). Towards Comprehensive Food Security Measures: Comparing Key Indicators. *Africa insight*, 45, 91-110. <https://doi.org/10.4314/AI.V45I3>.

- Islam, D., & Berkes, F. (2016). Aboriginal peoples' fisheries and food security: a case from northern Canada. *Food Security*, 8, 815-826. <https://doi.org/10.1007/s12571-016-0594-6>.
- Islam, D., Zurba, M., Rogalski, A., & Berkes, F. (2017). engaging Aboriginal youth to revitalize cree culture through participatory education. *Diaspora, Aboriginal, and Minority Education*, 11, 124 - 138. <https://doi.org/10.1080/15595692.2016.1216833>.
- Jacques, J., & Sauchyn, D. (2009). Increasing winter baseflow and mean annual streamflow from possible permafrost thawing in the Northwest Territories, Canada. *Geophysical Research Letters*, 36. <https://doi.org/10.1029/2008GL035822>.
- James-Abra, E. (2022). First Nations in the Northwest territories. Available at: <https://www.the-canadianencyclopedia.ca/en/article/first-nations-in-the-northwest-territories>. Accessed on 15/03/2024
- Javadi, M., Pakbin, B., Ziaeeha, M., Barikani, A., & Brück, W. (2023). Household food security and demographic factors in children and their parents. *Journal of Nutrition and Food Security*. <https://doi.org/10.18502/jnfs.v8i1.11765>.
- Jessiman-Perreault, G., & McIntyre, L. (2017). The household food insecurity gradient and potential reductions in adverse population mental health outcomes in Canadian adults. *SSM-population health*, 3, 464-472.
- Jog, R., Nareshkumar, G., & Rajkumar, S. (2016). Enhancing soil health and plant growth promotion by actinomycetes., 33-45. https://doi.org/10.1007/978-981-10-0707-1_3.
- Jula, N. (2014). Multilevel model analysis using R. *The Romanian Statistical Review*, 62, 55-66.
- Kenny, T. A., Fillion, M., MacLean, J., Wesche, S. D., & Chan, H. M. (2018a). Calories are cheap, nutrients are expensive—the challenge of healthy living in Arctic communities. *Food Policy*, 80, 39-54.
- Kenny, T. A., Fillion, M., Simpkin, S., Wesche, S. D., & Chan, H. M. (2018b). Caribou (*Rangifer tarandus*) and Inuit nutrition security in Canada. *EcoHealth*, 15, 590-607.

- Kortright, R., & Wakefield, S. (2011). Edible backyards: a qualitative study of household food growing and its contributions to food security. *Agriculture and Human Values*, 28, 39-53. <https://doi.org/10.1007/S10460-009-9254-1>.
- Kuhnlein, H. V., & Receveur, O. (2007). Local cultural animal food contributes high levels of nutrients for Arctic Canadian Indigenous adults and children. *The Journal of nutrition*, 137(4), 1110-1114.
- Kuhnlein, H. V., Goodman, L., Receveur, O., Spigelski, D., Duran, N., Harrison, G. G., & Erasmus, B. (2013). Gwich'in traditional food and health in Tetlit Zheh, Northwest Territories, Canada: phase II. Indigenous peoples' food systems and well-being: interventions and policies for healthy communities, 101-120.
- Lambden, J., Receveur, O., Marshall, J., & Kuhnlein, H. (2006). Traditional and market food access in Arctic Canada is affected by economic factors. *International Journal of Circumpolar Health*, 65(4), 331-340. <https://doi.org/10.3402/ijch.v65i4.18117>.
- Laurin, W., & Jamieson, J. (2015). Aligning energy development with the interests of Indigenous peoples in Canada. *Alberta law review*, 53, 453-453. <https://doi.org/10.29173/ALR409>.
- Lemay, M., Radcliffe, J., Bysouth, D., & Spring, A. (2021). Northern food systems in transition: the role of the emerging agri-food industry in the northwest territories (Canada) food system. 5. <https://doi.org/10.3389/fsufs.2021.661538>.
- Matheson, J., & McIntyre, L. (2013). Women respondents report higher household food insecurity than do men in similar Canadian households. *Public Health Nutrition*, 17, 40 - 48. <https://doi.org/10.1017/S136898001300116X>.
- McIntyre, L., Pow, J., & Emery, J. (2015). A path analysis of recurrently food-insecure Canadians discerns employment, income, and negative health effects. *Journal of Poverty*, 19, 71 - 87. <https://doi.org/10.1080/10875549.2014.979462>.
- Mirzaei O. Natcher D., (2022). Indigenous food sovereignty requires better and more accurate data collection. Available at: <https://theconversation.com/indigenous-food-sovereignty-requires-better-and-more-accurate-data-collection-189296>. Accessed on 15/11/2023.

- Missens, R. M., Anderson, R. B., & Dana, L. P. (2014). A study of natural resource use by the Nehiyaw (Cree) First Nation. *International Journal of Entrepreneurship and Small Business*, 21(4), 495-512. <https://doi.org/10.1504/IJESB.2014.062017>.
- Moraine, M., Duru, M., Nicholas, P., Leterme, P., & Thérond, O. (2014). Farming system design for innovative crop-livestock integration in Europe.. *Animal : an international journal of animal bioscience*, 8 8, 1204-17 . <https://doi.org/10.1017/S1751731114001189>.
- Morton, L., Bitto, E., Oakland, M., & Sand, M. (2005). Solving the problems of Iowa food deserts: food insecurity and civic structure. *Rural Sociology*, 70, 94-112. <https://doi.org/10.1526/0036011053294628>.
- Morton, V., Manore, A., Ciampa, N., Glass-Kaastra, S., Hurst, M., Mullen, A., & Cutler, J. (2021). Country food consumption in Yukon, Northwest Territories and Nunavut, Foodbook study 2014-2015. *Canada communicable disease report. Releve des maladies transmissibles au Canada*, 47(1), 30–36. <https://doi.org/10.14745/ccdr.v47i01a06>
- Natcher, D. C. (2009). Subsistence and the social economy of Canada's Aboriginal North. *North-ern Review*, (30), 83-98.
- Norris, M. J., & Clatworthy, S. (2011). Urbanization and migration patterns of Aboriginal populations in Canada: A half century in review (1951 to 2006). *Aboriginal policy studies*, 1(1). <https://doi.org/10.5663/APS.V1I1.8970>.
- Northwest Territories Bureau of Statistics (2017). Education and labour market activity – 2016 census. Available at: https://www.statsnwt.ca/census/2016/Labour%20and%20Education%202016_Final.pdf. Accessed on 05/10/2023.
- Northwest Territories Bureau of Statistics (2020): Government of Northwest Territories labour market transfer agreements. Available at https://www.ece.gov.nt.ca/sites/ece/files/resources/20192020_lmta_annual_plan_jun_7_2019.pdf. Accessed on: 05/10/2023.
- Northwest Territories Bureau of Statistics (2021). Family income by community and geographic aggregation. Available at: <https://www.statsnwt.ca/labour-income/income/index.html>. Accessed on 07/09/2023.

Northwest Territories Bureau of Statistics (2021). Personal income. Available at: <https://www.statsnwt.ca/labour-income/income/index.html>. Accessed on 07/09/2023.

Northwest Territories Bureau of Statistics, (2022b). Families, Households, Military Experience & Income 2021 Census. Available at: https://www.statsnwt.ca/census/2021/Census_Families_Households_Military_Income.pdf. Accessed on: 18/06/2024

Northwest Territories Bureau of Statistics (2022). Population estimates by community. Available at: <https://www.statsnwt.ca/population/population-estimates/bycommunity.php>. Accessed on 07/09/2023.

Northwest Territories Bureau of Statistics (2023). Labour force activity. Available at: https://www.statsnwt.ca/labour-income/labour-force-activity/Monthly/June2023_NewStats%20LFS.pdf. Accessed on 05/10/2023.

Nutrition North Canada (2024). Eligible communities. Available at: <https://www.nutrition-northcanada.gc.ca/eng/1415540731169/1415540791407>. Accessed on: 01/03/2024.

NWT & Nunavut Chamber of Mines, (2016). Our industry. Available at: <https://www.miningnorth.com/ourindustry#:~:text=In%20the%20NWT%2C%20we%20have,the%20Mary%20River%20iron%20mine>. Accessed on 19/05/2024

NWT Bureau of Statistics (2021). Aboriginal peoples 2021 Census. Available at: https://www.statsnwt.ca/census/2021/Census_Aboriginal_Peoples.pdf. Accessed on: 21/10/2023.

NWT Bureau of Statistics (2023). Available at: https://www.google.com/maps/d/u/0/viewer?mid=1GD0OYsPYLyLnGdBB_-IU-QyoA_N0&hl=en_US&ll=62.45045300000002%2C-114.371796&z=17. Accessed on: 12/05/2023.

NWT Bureau of Statistics, (2018). Food insecurity by characteristics and community. Available at: <https://www.statsnwt.ca/food-security/index.html>. Accessed 21/05/2023.

- NWT Bureau of Statistics, (2021). Population estimates by community. Available at: <https://www.statsnwt.ca/population/population-estimates/bycommunity.php>. Accessed on: 21/01/2024.
- NWT HIRA (2014). Overview of the Northwest Territories. Available at: <https://www.maca.gov.nt.ca/sites/maca/files/resources/hira-02-overview-of-the-north-west-territories.pdf>. Retrieved on: 21/10/2023.
- Ogot, N. (2021). Metrics for identifying food security status. In Food Security and Nutrition (pp. 147-179). Academic Press
- Otto, P., & Steinert, R. (2023). Estimation of the spatial weighting matrix for spatiotemporal data under the presence of structural breaks. *Journal of Computational and Graphical Statistics*, 32(2), 696-711.
- Olabiyi, O. M., & McIntyre, L. (2014). Determinants of food insecurity in higher-income households in Canada. *Journal of Hunger & Environmental Nutrition*, 9(4), 433-448.
- Pagaduan, J. E., Lazarescu, C., Vallieres, E., Skinner, K., Zuckermann, A. M., & Idzerda, L. (2024). The impacts of the Nutrition North Canada program on the accessibility and affordability of perishable, nutritious foods among eligible communities: a scoping review. *International Journal of Circumpolar Health*, 83(1), 2313255.
- Panikkar, B., & Lemmond, B. (2020). Being on land and sea in troubled times: climate change and food sovereignty in Nunavut. *Land*, 9(12), 508.
- Pérez-Escamilla, R. (2017). Food Security and the 2015–2030 Sustainable Development Goals: from human to planetary health. *Current Developments in Nutrition*, 1. <https://doi.org/10.3945/cdn.117.000513>.
- Pierre M, McComb M. Mhlanga S. (2022). Small-scale diversified farming is prominent in Yukon and the Northwest Territories. Available at: <https://www150.statcan.gc.ca/n1/pub/96-325-x/2021001/article/00011-eng.htm>. Accessed on: 21/10/2023.
- Pinstrup-Anderson, P. (2009). Food security: definition and measurement. *Food Sec.* 1: 5–7. Springer Science + Business Media B.V. & *International Society for Plant Pathology*.

- Available at: <http://argus.iica.ac.cr/Esp/organizacion/LTGC/Documentacion/BibliotecaVenezuela/Bolletines/2009/n4/foodsecurity-Springer-art%C3%ADculo2.pdf>. Accessed on 21/10/2023
- Power, E. M. (2008). Conceptualizing food security for Aboriginal people in Canada. *Canadian Journal of Public Health*, 99, 95-97.
- Proof (2018). Household Food Insecurity in Canada: A Guide to Measurement and Interpretation. Available at: <https://proof.utoronto.ca/wp-content/uploads/2018/11/Household-Food-Insecurity-in-Canada-A-Guide-to-Measurement-and-Interpretation.pdf>. Accessed on: 20/01/2024.
- Proverbs, T., Lantz, T., Lord, S., Amos, A., Ban, N., & Heritage, G. (2020). Social-ecological determinants of access to fish and well-being in four Gwich'in communities in Canada's Northwest Territories. *Human Ecology*, 48, 155-171. <https://doi.org/10.1007/s10745-020-00131-x>.
- Ramirez Prieto, M., Ratelle, M., Laird, B. D., & Skinner, K. (2022). Dietary intakes of traditional foods for Dene/Métis in the Dehcho and Sahtú Regions of the Northwest Territories. *Nutrients*, 14(2), 378. <https://doi.org/10.3390/nu14020378>
- Ready, E. (2018a). Sharing-based social capital associated with harvest production and wealth in the Canadian Arctic. *PLoS One*, 13(3), e0193759.
- Ready, E. (2018b). Who, being loved, is poor?: Poverty, marriage, and changing family structures in the Canadian Arctic. *Human Organization*, 77(2), 122-134.
- Ready, E. (2021). Impacts of carbon pricing on the hunting, fishing, and trapping economy in the Inuvialuit settlement region.
- Ross, P., & Mason, C. (2020). "We hardly have any moose around here anymore": climate change and the barriers to food security in the Dehcho Region, Northwest Territories. *Arctic*, 73, 368-385. <https://doi.org/10.14430/ARCTIC71082>.
- Qatalyst, (2023). Regional economic development plan-South Slave. Available at: https://www.iti.gov.nt.ca/sites/iti/files/REDP_South_Slave_Final_Report_2023.pdf Accessed on: 6/19/2024.

- Ruiz-Castell, M., Muckle, G., Dewailly, É., Jacobson, J. L., Jacobson, S. W., Ayotte, P., & Riva, M. (2015). Household crowding and food insecurity among Inuit families with school-aged children in the Canadian Arctic. *American Journal of Public Health, 105*(3), e122-e132.
- Shafiee, M., Keshavarz, P., Lane, G., Pahwa, P., Szafron, M., Jennings, D., & Vatanparast, H. (2022). Food security status of Indigenous peoples in Canada according to the 4 pillars of food security: A scoping review. *Advances in Nutrition, 13*(6), 2537-2558.
- Sheikh, N., Egeland, G. M., Johnson-Down, L., & Kuhnlein, H. V. (2011). Changing dietary patterns and body mass index over time in Canadian Inuit communities. *International journal of circumpolar health, 70*(5), 511-519.
- Spring, A., Carter, B., & Blay-Palmer, A. (2018). Climate change, community capitals, and food security: Building a more sustainable food system in a northern Canadian boreal community. *Canadian Food Studies/La Revue canadienne des études sur l'alimentation, 5*(2), 111-141. <https://doi.org/10.4018/978-1-7998-7415-7.ch006>.
- Spring, A., Skinner, K., Wesche, S., Fresque-Baxter, J., Brockington, M., Bayha, G., ... & Zoe, J. B. (2020). Building community-university research partnerships to enhance capacity for climate change and food security action in the NWT. *North. Public Affairs, 6*, 63-67.
- Statistics Canada (2017). Focus on Geography Series, 2016 Census: Northwest Territories. Available at: <https://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-PR-Eng.cfm?TOPIC=4&LANG=Eng&GK=PR&GC=61>. Retrieved on: 12/07/2023.
- Tarasuk, V., St-Germain, A., & Mitchell, A. (2019). Geographic and socio-demographic predictors of household food insecurity in Canada, 2011–12. *BMC Public Health, 19*. <https://doi.org/10.1186/s12889-018-6344-2>.
- The North Group (2004). Diamond tourism in northwest territories. Available at: <http://library.assembly.gov.nt.ca/2004/ITI/02-0023804.pdf>. Accessed on: 21/01/202.
- Thornton, P., Ericksen, P., Herrero, M., & Challinor, A. (2014). Climate variability and vulnerability to climate change: a review. *Global Change Biology, 20*, 3313 - 3328. <https://doi.org/10.1111/gcb.12581>.

- Tod-Tims, C. (2020). " Hungry all the time": Contemporary experiences of and perspectives on traditional food access in Inuvik, NWT. Thesis, Simon Fraser University. Available at: <https://summit.sfu.ca/item/34769>. Accessed on 15/03/2024.
- Upton, J. B., Cissé, J. D., & Barrett, C. B. (2016). Food security as resilience: reconciling definition and measurement. *Agricultural economics*, 47(S1), 135-147.
- USDA. 2003. Food stamp participants' access to food retailers summary of findings. Accessed February 18, 2003 (http://www.fns.usda.gov/oane/menu/published/Nutrition_Education/Files/sumnfsp2.htm).
- Usher, P. J., Duhaime, G., & Searles, E. (2003). The household as an economic unit in Arctic Aboriginal communities, and its measurement by means of a comprehensive survey. *Social Indicators Research*, 61, 175-202.
- Vermeulen, S. J., Park, T., Khoury, C. K., Mockshell, J., Béné, C., Thi, H. T., ... & Wilson, B. (2019). Changing diets and transforming food systems. CCAFS Working Paper.
- Wenzel, G. W. (2017). Canadian Inuit subsistence: Antinomies of the mixed economy. *Hunter Gatherer Research*, 3(4), 567-581.
- Wichelns, D. (2011). Assessing water footprints will not be helpful in improving water management or ensuring food security. *International Journal of Water Resources Development*, 27, 607 - 619. <https://doi.org/10.1080/07900627.2011.597833>.
- Wikipedia (2023). List of mines in northwest territories. Available at: https://en.wikipedia.org/wiki/List_of_mines_in_the_Northwest_Territories. Accessed on: 07/09/2023.
- Willows, N., Veugelers, P., Raine, K., & Kuhle, S. (2011). Associations between household food insecurity and health outcomes in the Aboriginal population (excluding reserves). *Health reports*, 22 2, 15-20
- Wilson, K. (2003). Therapeutic landscapes and First Nations peoples: An exploration of culture, health and place. *Health and Place*, 9, 83-93.
- World Bank (2023). Food security update world bank response to rising food insecurity. Available at: <https://www.worldbank.org/en/topic/agriculture/brief/food-security->

Appendix

Table A1. Food insecurity at the regional level.

	Regions						
	Pooled sample	Beaufort Delta	Sahtu	Thcho	Dehcho	South Slave	Yellowknife
Yes (% of HHs)	30.75	31.00	31.20	55.10	31.50	18.70	17.00
Often (% of HHs)	7.60	10.40	6.90	11.00	7.80	5.70	3.80
Sometimes (% of HHs)	23.10	20.60	24.40	44.20	23.40	12.90	13.10
Number of communities	33	8	5	4	8	6	2

Note: Food insecurity measures the percentage of households in region who responded “YES”, “OFTEN”, and “SOMETIMES” to worried about not having enough money to buy food. Two communities in the South slave region do not have data for HHs who often enough money does not have to buy food.

Source: NWT website (2018), own calculations

Table A2. Likelihood ratio test for RIM

	npar	Loglik	Chisq	DF	Pr(>Chisq)
No random intercept	17	-96.192			
Random Intercept	16	-96.651	0.919	1	0.338

Null Hypothesis (H0): Adding the random intercept to the model does not significantly improve the fit compared to the model without random effects. In other words, the random effects do not statistically improve the model fit. Alternative Hypothesis (H1): Adding the random intercept to the model significantly improves the fit compared to the model without random effects. In other words, the random effects significantly improve the model.

Table A3. Sensitivity test for OLS estimation excluding Yellowknife.

	Yes	Often	Sometimes
Grocers (weighted sum of small & large grocery stores)	-23.822** (10.980)	-7.409 (5.751)	-15.737 (10.302)
Population density [ln(people/km ²)]	5.511** (2.190)	1.039 (1.147)	4.308* (2.055)
Country food consumption (% of HHs)	13.208 (9.440)	6.598 (4.944)	5.252 (8.857)
Airport facilities (binary)	-16.912** (7.121)	-10.478** (3.729)	-5.159 (6.681)
All-weather roads (binary)	-20.704* (10.480)	-7.595 (5.489)	-18.168* (9.833)
Family income (CAD)	4.090 (13.214)	1.076 (6.921)	-2.671 (12.398)
Food price index	0.237 (0.147)	0.124 (0.077)	0.100 (0.138)
% of HHs with 6 or more people (% of HHs)	-0.160 (0.523)	-0.571* (0.274)	0.686 (0.491)
Married HHs (% of HHs)	0.437 (0.267)	0.430 (0.140)	0.018 (0.251)
Education (% pop. 15+ with at least high school diploma)	-0.445* (0.220)	-0.230* (0.115)	-0.025 (0.206)
Owned house (% of HHs)	0.247 (0.263)	0.212 (0.138)	0.022 (0.247)
No. of active mines	-7.017 (9.432)	-7.929 (4.940)	1.330 (8.849)
Participate in traditional activities (% of pop.)	0.548** (0.218)	0.271** (0.114)	0.293 (0.205)
NNC Subsidy (binary)	-24.084** (10.278)	-9.389 (5.383)	-19.887* (9.643)
Constant	-84.695 (143.462)	-51.064 (75.137)	26.718 (134.604)
Observations	31	31	31
Adjusted R²	0.573	0.383	0.404

Note: (a) The dependent variable is food insecurity, measures the percentage of households in region who responded “YES”, “OFTEN” and “SOMETIMES” to worried about not having enough money to buy food. (b) The Yellowknife region was excluded from the analysis. The number of regions reduced from 6 to 5 and the number of communities from 33 to 31 (c) Airport facilities, all weather roads are binary variables, if a variable = 1, it indicates that a community has access to corresponding facility, otherwise, it is zero. NNC’s subsidy is binary variable, if a variable = 1, it indicates that a community is eligible and receives a subsidy from the nutrition north Canada, otherwise, it is zero. (d) ***, **, and * indicate 1, 5, and 10 percent significant levels respectively. (e) Standard errors clustered at the community level in parentheses. (e) “no”, “pop.”, “HHs” are abbreviations for the word “number”, “population”, “households”, respectively. Source: NWT website and google maps, own computations.

Table A4. Model assumption and fit test.

Assumption & model test	Name of test	Yes			Often			Sometimes		
		Test statistic	P-value	Results	Test statistic	P-value	Results	Test statistic	P-value	Results
Linearity	Rainbow test ⁸	0.197	0.9621	0.962 > 0.05	0.658	0.7655	0.765 > 0.05	0.252	0.937	0.937 > 0.05
Homoscedasticity	Breusch - Pagan test ⁹	9.76	0.78	0.78 > 0.05	19.911	1.33	1.33 > 0.05	7.146	0.929	0.929 > 0.05
Normality	Shapiro-wilk normality test ¹⁰	0.956	0.205	0.205 > 0.05	0.980	0.791	0.791 > 0.05	0.965	0.351	0.351 > 0.05
Independence & Autocorrelation	Durbin-Watson test ¹¹	2.117	0.482	0.482 > 0.05	1.944	0.292	0.292 > 0.05	1.785	0.156	0.156 > 0.05
Overall significance of the OLS model in Table 5.1	F-test ¹²	F statistic = 3.510	0.007	0.007 < 0.05	F statistic = 2.459	0.037	0.037 < 0.05	F statistic = 2.459	0.037	0.037 < 0.05
Overall significance of the OLS model in Table A3	F-test	F statistic = 3.870	0.006	0.006 < 0.05	F statistic = 2.33	0.054	0.054 < 0.05	F statistic = 2.452	0.044	0.044 < 0.05

Note: The results indicate that the P-value of linearity, homoscedasticity, normality, independence, and autocorrelation tests are greater than the significance level, this means that we are failing to reject the null hypothesis. This implies that at 0.05 level of significance, there is enough evidence to conclude that the model exhibits OLS assumptions.

⁸ Ho: The relationship between food insecurity and the community characteristics is linear while H1: The relationship between food insecurity and the community characteristics is non-linear.

⁹ Ho: The residuals of the mode exhibit constant variance while H1: The residuals of the mode do not exhibit constant variance

¹⁰ Ho: The Shapiro–Wilk normality test says that residuals are normally distributed while H1: says the residuals are not normally distributed.

¹¹ Ho: There is no autocorrelation in the residuals while H1: says there is autocorrelation in the residuals

¹² Ho: F statistics says that the overall model is not statistically significant while the H1: says that the overall model is statistically significant

Table A4. Continued

Multicollinearity test	VIF
Grocers (weighted sum of small & large grocery stores)	2.2606
Population density [ln (people/km ²)]	3.9176
Country food consumption (% of HHs)	6.3100
Airport facilities (binary)	3.5085
All-weather roads (binary)	2.1148
Family income (CAD)	2.5570
Food price index	4.6894
% of HHs with 6 or more people (% of HHs)	3.8845
Married HHs (% of HHs)	2.5507
Education (% pop. 15+ with at least high school diploma)	2.9755
Owned house (% of HHs)	5.3754
No. of active mines	7.5670
Participate in traditional activities (% of pop.)	4.5496
Subsidy(binary)	1.1948

Note: Variance Inflation Factor (VIF) represents the degree of multicollinearity in a regression model. A VIF value greater than 10 indicates the presence of significant multicollinearity.

Table A5. Random intercept and OLS estimation of association between food insecurity and characteristics associated with food accessibility and availability

	RIM	OLS
Grocers (weighted sum of small & large grocery stores)	-2.075 (2.536)	-2.082 (2.478)
Population density [ln (people/km ²)]	3.745** (1.800)	3.984** (1.849)
Country food consumption (% of HHs)	7.950 (7.073)	7.650 (7.320)
Airport facilities (binary)	-17.424** (7.162)	-16.530** (7.559)
All-weather roads (binary)	-23.905** (10.606)	-25.292** (10.840)
Family income (CAD)	-2.569 (9.700)	-1.772 (9.887)
Food price index	0.147 (0.145)	0.167 (0.143)
% of HHs with 6 or more people (% of HHs)	0.430 (0.457)	0.402 (0.476)
Married HHs (% of HHs)	0.430 (0.264)	0.478 (0.264)
Education (% pop. 15+ with at least high school diploma)	-0.311* (0.171)	-0.350* (0.176)
Owned house (% of HHs)	0.012 (0.211)	0.063 (0.213)
No. of active mines	-2.326 (9.083)	-2.888 (8.567)
Participate in traditional activities (% of pop.)	0.479** (0.226)	0.477** (0.229)
NNC subsidy (binary)	-23.359** (11.610)	-25.579** (10.886)
Constant	13.040 (123.504)	-1.475 (128.264)
Observations	33	33

Note: (a) The dependent variable is food insecurity, measures the percentage of households in region who responded “YES” to worried about not having enough money to buy food. (b) Airport facilities, all weather roads are binary variables, if a variable = 1, it indicates that a community has access to corresponding facility, otherwise, it is zero. Subsidy is binary variable, if a variable = 1, it indicates that a community receives a subsidy from the government, otherwise, it is zero. (c) ***, **, and * indicate 1, 5, and 10 percent significant levels respectively. (d) Standard errors clustered at the community level in parentheses. (e) “no”, “pop.”, “HHs” are abbreviations for the word “number”, and “population”, “households”, respectively.

Source: NWT website, NWT community survey and Statistics Canada, and google maps, own calculations.