

## Food in the cold: exploring food security and sovereignty in Whitehorse, Yukon

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### ABSTRACT

Harsh weather patterns that are unpredictable owing to climate change, remoteness, dependence on food imports and limited local food production place Arctic and Subarctic food systems under serious pressure. The model of food sovereignty provides a surprisingly interesting contribution to address the food insecurity in these regions; it promotes long-term stable provision of healthy foods (sustainable) that are accessible to all (equity) and fosters local food production–consumption patterns (localisation). This study aims to deepen the understanding of food insecurity in the Subarctic regions and explores the possibilities for a food sovereignty approach at both individual and regional level. The study focuses on Whitehorse, capital of Yukon, Canada, and uses a cross-sectional online survey among residents of Whitehorse and semi-structured in-depth interviews with food-systems experts in Yukon. The findings indicated a need for affordable year-round local food production. Application of food sovereignty has provided the opportunities for local food procurement, innovation hubs, and several types of greenhouses including hydroponics and vertical farming, to work towards a more localised food system, thereby improving food security and sovereignty in Yukon. The findings constitute the scientific knowledge base for the formulation of prospective scenarios in the spirit of the food sovereignty theory.

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## Introduction

Yukon, a remote territory in Northern Canada, is located within and adjacent to the Arctic Circle. Due to its characteristic landscape and long winter periods, Yukoners have to cope with restricted potential for crop production, leading to a high dependency on food imports from the South [1]. Moreover, the hazards created by climate change are causing glacier and permafrost thaw, forest fires and other extreme weather events, such as floods, which affect communities, aquatic health and ecosystems [2]. Climate-change-induced alterations in ecosystems have limited the access and availability of traditional food sources, which are critical to Yukon's food system and culture [3]. The changes in land conditions and wildlife health in combination with high fuel and equipment costs render access to traditional food more difficult. In this study, traditional foods are defined as foods native to Yukon, which are harvested using traditional or non-traditional hunting or gathering methods by both Indigenous as well as non-Indigenous Yukoners. The environmental pressure, in combination with social and economic pressures, has led to a significant reliance on purchased foods that are less accessible in rural areas and more expensive due to

the high import costs [4]. Hence, a combination of remoteness, dependence on food imports and the impacts of climate change have created an environment of food insecurity for the 40,000 residents of Yukon. Indeed, the unpredictability of Yukon food systems has resulted in a food insecurity prevalence of 17%, in comparison to 8.3% in Canada [6].

Food insecurity is a serious problem that affects the health and well-being of people in Northern Canada [7]. It is a key contributor to malnutrition and weight-related conditions including obesity, and micronutrient inadequacies [8,9]. Therefore, it is critical to address food security from early childhood. The need for more sustainable food systems has created a demand for more locally focused food policies that emphasise the importance of autonomy and equity, taking the interdependence of food systems and socio-ecological context into account [10,11]. Hence, the framework of food security may well identify problems in food systems, but fails to address the need for establishing resilient and equitable food systems that takes the local context into account [12]. In this context, the concept of food sovereignty seems to provide better answers to address the challenges of Yukon's food systems. Food

sovereignty is extensively used as a framework to introduce principles that promote resilient and secure food systems that complement the local context in a sustainable manner [12]. Accordingly, the concept is dynamic, in constant evolution and highly context dependent [13]. The food sovereignty framework can be used to introduce justice, security, and sustainability into already existing food systems [14]. As a result, localisation of food systems is promoted, assisting with the introduction of more nutritious diets that include local, fresh, less processed foods respectively [15][16].

Food sovereignty fosters long-term stable provision of healthy foods (sustainable) that are accessible for all (equity) and is based on local food production–consumption patterns [localisation]. Hence, complementing the food security framework with food sovereignty leads to a holistic approach that expands our understanding of the unique context of Yukon’s food systems. Moreover, applying a food sovereignty lens resolves the limitations of the concept of food security and aims to lead to more meaningful and tailored recommendations on food policy.

The FAO [17] defines food security as “a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”.

Food sovereignty is initially defined by de Nyéléni & Sélingué [1819] as “people’s right to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems”. Yet, the conceptualisation is fluid to different contexts.

Various policies and strategies aimed at improving elements of food security, food sovereignty and to mitigate some of the negative impacts of climate change have been developed and implemented at the territorial level. The Yukon Nutrition Framework released in 2010 by the Health and Social Services department addresses nutrition-related issues that Yukoners face, and offers steps to improve food security [5]. The ‘Local Food Strategy for Yukon’, released by the Yukon Government in 2016, shows the importance of self-sustaining food systems and aims to reduce food insecurity and increase food sovereignty. The report provides a clear overview of plans and initiatives aimed at strengthening the local economy, improving food access and safety, building community infrastructure for cold-climate production, processing and storage, reducing food waste and promoting Yukon-grown food consumption [1]. Awareness and action towards ensuring more food security for Yukoners

notwithstanding food insecurity remains evident as the food system remains vulnerable to external changes and still lacks a resilient answer to meet the key elements of food sovereignty. The need for a more localised food system thus remains prominent.

To address the difficulties Yukon is currently facing in relation to prospective food policies, there will be a need for greater insight and a deeper understanding in order to appraise the complexity of the Yukon food system from both an individual and a systemic perspective. We therefore opted for a mixed-method approach that used a cross-sectional online survey to measure individual opinions of Whitehorse residents and semi-structured in-depth interviews with food-systems experts in Yukon, which informed us about the opportunities and constraints of prevailing food policies.

We believe that our approach to investigating food security and food sovereignty in Yukon addresses a critical knowledge gap that can support the formulation of targeted and evidence-based food policies. The study therefore aims to make recommendations for prospective food policies by gaining insight into food security and sovereignty in the Whitehorse area. The overall research question was “*How can a deeper understanding of the constraints of food insecurity and opportunities presented by the food sovereignty concept support the formulation of adequate food policies for Yukon?*”

## Methodology

### Design and procedure

A convergent mixed-methods design combining both qualitative and quantitative methods was used and found to be best suited to answer the research question. By using a concurrent triangulation study design, it was aimed to collect diverse types of data that are complementary and give a holistic understanding of the research topic [20].

A quantitative, cross-sectional online survey among residents of the Whitehorse area was conducted. A random sampling method including different areas of Whitehorse was intended, yet due to restrictions of the COVID-19 pandemic was prohibited, and the survey was administered in an online form. In addition, qualitative in-depth, semi-structured interviews with experts in the Whitehorse food systems were conducted. The quantitative and qualitative components were independent and consecutive. The online survey was distributed with the assistance and collaboration of the Arctic Institute of Community Based Research, which contacted actors and organisations connected to the local

**Table 1.** Participant profiles (n = 45).

Sample characteristics	Sample composition
Age	33.3% (n = 15) age group 25–39 57.8% (n = 26) age group 39–64 8.9% (n = 4) age group 65+
Sex	71.1% (n = 32) Female 28.9% (n = 13) Male
Household size	17.8% (n = 8) 1 adult 44.4% (n = 20) 2 adults 15.5% (n = 7) ≥ 3 adults 2.2% (n = 1) 1 adult and 1 child 2.2% (n = 1) 1 adult and 2 children 6.7% (n = 3) 2 adults and 1 child 6.9% (n = 4) 2 adults and ≥ children 2.2% (n = 1) 3 adults and 1 child
Identity	84.4% (n = 38) Canadian 4.4% (n = 2) European 2.2% (n = 1) First Nation 2.2% (n = 1) Métis 6.7% (n = 3) Other
Education	11.1% (n = 5) Secondary school 4.4% (n = 2) Vocational education 44.4% (n = 20) Bachelor 40.0% (n = 18) Graduate school
Occupational sector	24.4% (n = 11) Public service 15.6% (n = 7) Education 8.9% (n = 4) Healthcare 6.7% (n = 3) Arts/Culture 4.4% (n = 2) Agriculture 4.4% (n = 2) Leisure 2.2% (n = 1) Automotive/Heavy diesel 2.2% (n = 1) Recreation 2.2% (n = 1) First Nation governance 8.9% (n = 4) Retired, 20.0% (n = 9) Other
Annual household income	20.0% (n = 9) \$15,000 – \$40,000 40.0% (n = 18) \$40,000 – \$100,000 31.1% (n = 14) \$100,000 – \$150,000 2.2% (n = 1) more than \$200,000
Distance to Whitehorse	57.8% (n = 26) Living in Whitehorse 33.3% (n = 15) 0–50 km from Whitehorse 2.2% (n = 1) 50–100 km from Whitehorse 6.7% (n = 3) > 200 km from Whitehorse

community, alongside an advertising campaign to reach a larger audience. Advertisements of the survey were posted in the local Yukon papers ‘What’s up Yukon’, ‘Whitehorse Daily Star’ and ‘Yukon News’, in the period 4–24 May. Furthermore, social media and email were used to distribute the survey. Interviewees were selected through purpose expert sampling and approached via email. To ensure the internal validity of the interviews, a member check was performed. The member check was constructed from initial findings and field notes. The research ethics review committee of the VU University Amsterdam has waived the requirement of obtaining ethical approval to conduct the current research.

### Study population

The intended research population were residents living in the area of Whitehorse, Yukon. Although participants in remote areas of Yukon were reached, the survey sample can be characterised as an urban

population. Exclusion criteria for the online survey were being under the age of 18 years and living outside Yukon. No survey respondents had to be excluded. The conditions of the COVID-19 regime obliged us to use a non-probability convenience sampling method. For the semi-structured interviews, a purposive expert sampling method was used. This non-random technique does not need a set number of participants [21]. A total of 45 Yukoners took part in the survey, of whom 58% were living in Whitehorse and 33% within 50 km of Whitehorse. Additional details about participants are shown in Table 1.

Food-system experts (n = 4) included in the interviews were as follows: a board member of the Yukon Agricultural organisation, an agricultural entrepreneur, a researcher for a non-profit research institution and an independent consultant and public health expert.

### Research instruments

Quantitative data of this study were collected using an online survey. The survey considered demographic questions, food security and food sovereignty. The questions were based on multiple sources, addressing the transdisciplinary approach of the research. Demographic questions enabled an accurate description of the sample so inferences of different groups within the population could be made. Questions on food security (n = 11) were based on indicators adopted from research conducted in Québec describing the needs of food-insecure households [22]. Questions on food sovereignty (n = 12) were based on indicators of food sovereignty as described by 23. The survey made use of a thorough description of fresh local food and food from the land: ‘*Fresh local food includes anything that is produced by Yukon agricultural or community initiatives, or individuals and has not undergone any major processing such as packed meals, cookies etc.*]. Please be aware that foods that are hunted, gathered or fished fall under the “food from the land” category. Valuations of food-related initiatives were included in order to assess the population’s appreciation of these initiatives. The survey was piloted among 16 individuals to test clarity and manageability.

Qualitative data were compiled from semi-structured interviews that were conducted online and recorded. All interviews were fully transcribed. Participants gave consent to the inclusion of personal information as long as they could not be

identified via the paper, and were fully anonymised in the processing of the gathered information.

### **Statistical methods**

Quantitative data from the survey were analysed using IBM SPSS statistics V26. Both descriptive and inferential statistics were carried out, in order to study relationships. An ex-post stratification divided people living within and outside Whitehorse, as well as various income groups, in order to determine the significance of disparities between the strata. A 2-tailed Fisher exact test was conducted.

All qualitative data were analysed using MAXQDA Analytics Pro 2020. All transcripts were coded, in conformity with a code book which was predetermined but allowed the emergence of new codes. Data were analysed comparing codes between respondents to identify patterns. Thematic analysis and axial coding were used to relate codes and themes with one another. A convergent design was adopted, in order to complement quantitative and qualitative data, which allowed for a comprehensive and coherent understanding of food security and sovereignty in Yukon.

### **Results**

The results of this study are twofold. First, we identified issues and constraints regarding the current situation of food security by the findings of the survey supplemented with salient and informative opinions of the food-system experts. Second, we present opportunities and solutions for the aforementioned challenges by applying the concept of food sovereignty in our argumentation, which we hope provides a constructive, sustainable and holistic approach to address current challenges of Yukon's food systems.

### **Constraints/barriers**

#### **Localised food system**

The survey asked respondents where various kinds of foods were obtained and found that 56% of all food groups combined were obtained from the grocery store. Experts indicated that the majority of these products are imported from outside Yukon or Canada. Nevertheless, at household level it was indicated that the food groups of traditional food (40%), fish (29%) and bread (22%) were often self-provisioned (see Table 2). Another part of the survey showed that 69% of the participating households grow edible plants at home.

On a larger scale, the need for a more localised food system is expressed by experts in the following quote:

*'How do we create a food system that as an example or something worse than Covid happened and we lost all of those links to the South or we weren't able to get food for months on end, how do we secure and make sovereign the food that we create within this territory.'*

The provision of locally produced food to consumers is bound to meet various blockades.

Although 42% of the sample indicated that they did not experience any barriers to obtaining fresh, local food, an equal number of respondents (42%) reported that fresh, local food was too expensive. Moreover, lacking knowledge on where it is sold (9%) and the physical inaccessibility to local fresh food (7%) are constraints as indicated by the survey results (3).

Explicitly, a lack of production of vegetables and fruits in Yukon was mentioned by experts as a constraint for local food consumption. The result is an increased and persistent dependence on southern distribution routes for fresh foods. Regarding the role of the government, it was argued that there is currently too little support for increasing local food production. As a result, fresh local foods remain costly. Furthermore, the current food policy subsidises imported goods, which disadvantage local producers and offer consumers with little choice than to purchase imported food. Indeed, the majority of the survey respondents (71%) indicated that local fresh food formed not part or only some part of their diet (Table 4). This underlines the lack of local fresh food consumption that was repeatedly expressed by experts.

#### **Economic constraints**

Financial constraints to buy the necessary foods were reported by 31% of the survey respondents (Table 5). Financial barriers were not significantly correlated to household income in the survey results, contradicting experts' opinions who indicated a relation between financial accessibility of fresh foods and household income. These contrasting findings could be attributed to the urban character and underrepresentation of low-income households in the survey sample. Experts confirmed that financial barriers seriously constrain access to fresh food.

In addition to the constraints on buying the necessary foods, 42% of survey respondents indicated that there is an economic barrier to buy local fresh foods (Table 3); the situation is exacerbated for Northern communities as an expert indicated:

***"The further North you go, the food prices start becoming astronomical"***

*Connection to the land* Of all survey respondents, 67% harvested some food from the land (Table 6). Yet,

**Table 2.** Obtaining household food per item (n and row percentages).

	Local Public Market (%)	Small Family Store (%)	Local Food Box Program (%)	Grocery Store (%)	Food Bank (%)	Online (%)	Self-Provisioning (%)	I do not eat this type of food (%)	Total (%)
Fruit and Vegetables (%)	4.4 (n = 2)	2.2 (n = 1)	0.0 (n = 0)	82.2 (n = 37)	2.2 (n = 1)	0.0 (n = 0)	8.9 (n = 4)	0.0 (n = 0)	100.0 (n = 45)
Legumes (%)	0.0 (n = 0)	0.0 (n = 0)	4.4 (n = 2)	71.1 (n = 32)	0.0 (n = 0)	4.4 (n = 2)	11.1 (n = 5)	8.9 (n = 4)	100.0 (n = 45)
Traditional Foods (%)	8.9 (n = 4)	4.4 (n = 2)	0.0 (n = 0)	13.3 (n = 6)	0.0 (n = 0)	0.0 (n = 0)	40 (n = 18)	33.3 (n = 15)	100.0 (n = 45)
Bread (%)	0 (n = 0)	15.6 (n = 7)	0.0 (n = 0)	60 (n = 27)	0.0 (n = 0)	0.0 (n = 0)	22.2 (n = 10)	2.2 (n = 1)	100.0 (n = 45)
Dairy Products (%)	4.4 (n = 2)	4.4 (n = 2)	0.0 (n = 0)	84.4 (n = 38)	0.0 (n = 0)	0.0 (n = 0)	0.0 (n = 0)	6.7 (n = 3)	100.0 (n = 45)
Meat (%)	13.3 (n = 6)	26.7 (n = 12)	0.0 (n = 0)	37.8 (n = 17)	2.2 (n = 1)	0.0 (n = 0)	13.3 (n = 6)	6.7 (n = 3)	100.0 (n = 45)
Fish (%)	4.4 (n = 2)	24.4 (n = 11)	0.0 (n = 0)	40 (n = 18)	0.0 (n = 0)	0.0 (n = 0)	28.9 (n = 13)	2.2 (n = 1)	100.0 (n = 45)
All food types combined (%)	5.1 (n = 16)	11.1 (n = 35)	0.6 (n = 2)	55.6 (n = 175)	0.6 (n = 2)	0.6 (n = 2)	17.8 (n = 56)	8.6 (n = 27)	100.0 (n = 315)



**Table 3.** Barriers to obtaining fresh local food.

	%
I do not experience any barriers	42.2 (n = 19)
I do not know where fresh local food is sold	8.9 (n = 4)
Fresh local food is too expensive	42.2 (n = 19)
I physically do not have access to places where fresh local food is sold	6.7 (n = 3)

against this high share we also found that 50% of the experts recognised a loss of knowledge on harvesting and cultivating food from the land in the communities they work in.

### Initiatives

In this sub-section we report on current initiatives that directly or indirectly linked the respondents to food security and sovereignty in Whitehorse. Survey respondents engaged in various local food production initiatives. Participation in community gardens was reported by 24% of the survey respondents, 9% participated in a programme that connects gardeners in order for them to share gardening resources, 29% in seed library activities, 56% in a composting programme, 9% in community food-processing kitchens, 7% in food banks, 11% in food hubs and 24% in online markets. Food hubs are businesses or organisations that manage the aggregation, distribution and marketing of food primarily from local producers [24]. Overall, experts felt positive about current food-related initiatives. However, they also expressed that more could be done, especially

for initiatives aiming at an increasing awareness for food in relation to security and sovereignty issues.

### Climate change

Experts consistently expressed their concern regarding the effects of a fast-changing climate on local food systems. An expert involved in agricultural initiatives pointed towards several trends related to climate change such as unpredictable weather patterns that complicated planning of agricultural operations. Moreover, effects of climate change on the migration patterns of local fauna and the alterations in ice-bridge existence was indicated by experts as a worrying development illustrated by the following quote:

*'Outside of Whitehorse you have problems with climate change, we're losing our ice bridges right, in the winter. A lot of communities depend on those winter months when they have the ice highway and the ice bridges so that the food can get there ...'*

### Opportunities

#### Localisation of food systems

Experts indicated that localising food systems contributes to food security and sovereignty in Yukon, and indicated that the government should take on more responsibility for developing the agricultural sector in Yukon. That initiatives of localising food systems can count on much support was confirmed by 69% of survey respondents (Table 7), who valued availability of local fresh food as extremely important.

**Table 4.** Local fresh food consumption.

Part of Diet Consisting of Local Fresh Food	None of my diet (%)	Some of my diet (%)	About half of my diet (%)	Most of my diet (%)	All of my diet (%)
	8.9 (n = 4)	62.2 (n = 28)	15.6 (n = 7)	13.3 (n = 6)	0 (n = 0)

**Table 5.** Financial accessibility.

Financial accessibility	Never (%)	Rarely (%)	Sometimes (%)	Often (%)	Always (%)
	0.0(n = 0)	2.2(n = 1)	6.7(n = 3)	22.2(n = 10)	68.9(n = 31)

\*financial accessibility = I have enough money to buy the food I need

**Table 6.** Harvesting food from the land.

Variable 10: Harvesting food from the land	(%)
Yes, less than 25% of total food consumption:	55.6 (n = 25)
Yes, 25% – 50% of total food consumption:	11.1 (n = 5)
No, not economically accessible	4.4 (n = 2)
No, not physical accessible	11.1 (n = 5)
No, other reason	17.8 (n = 8)

In order to make local fresh foods more accessible an expert suggested subsidising local products in order to make local producers more competitive in relation to imported goods.

**Table 7.** Evaluations of initiatives.

	Extremely important (%)	Very important (%)	Moderately important (%)	Slightly important (%)	Not important at all (%)
Increasing the availability of local fresh food	68.9(n = 31)	24.4(n = 11)	6.7(n = 3)	0.0(n = 0)	0.0(n = 0)
Making fresh products more affordable	57.8(n = 26)	31.3(n = 14)	8.9(n = 4)	2.2(n = 1)	0.0 (n = 0)

*“It would be if anything more beneficial if they were subsidizing local products”.*

Furthermore, experts suggested that Yukon should adopt innovative approaches that change the agricultural system towards a self-provisioning food system throughout the whole year in a sustainable manner. One of the experts suggested an ‘out-of-the box’ approach by developing agricultural changes that would lead to an increased food security.

*“So, there’s ways of doing things, we just need to be very creative about it”.*

An example mentioned by an expert was the use of greenhouses that are supplied by renewable energy sources as a viable alternative that aligns with food sovereignty and adapts to the harsh climatic conditions in Yukon.

### **Economic interventions**

Financial initiatives to make fresh produce more affordable were highly valued by 91% of survey respondents (Table 1A, Annexe 1). Experts mentioned the importance of reducing the financial barrier to fresh and local food in order to enable people to enjoy a healthier and more affordable diet. Indeed, this could lead to both more food security as well as health equity. The importance of making fresh local foods more affordable is demonstrated in the following quote:

*‘We put emphasis on the wrong things because fresh foods are much more expensive like fresh foods and vegetables’. ‘It would be if anything more beneficial if they were subsidising local products.’*

### **Connection to the land**

According to one of the experts, Yukoners have a unique connection to the land:

*‘I do think it is unique here because I think we’re a little closer to our land, and to the species that are here than maybe when you’re in the South and so we feel the loss of a species or we feel the loss of a plant ...’*

Experts believed that there should be more public awareness of traditional foods and focus on initiatives reconnecting people to the land, in order to bring society and the land closer together:

***“Things that connect the land again to culture and to communities are really important”***

**Initiatives** Experts highly valued food-related grassroots initiatives, and increasing the diversity of food-related initiatives was mentioned as an important contribution to the awareness of food localisation. Furthermore, interconnection between programmes was proposed by experts as a unique opportunity to deepen the understanding and increase the shared interest in local food systems:

*‘I think there needs to be more interconnection between programs, I think that there’s a lot of siloing sometimes between programs ... so I think there could be a lot more interlinking, to close that net so you don’t have those little holes in the net. And I think people are maybe falling through.’*

### **Climate change**

The topic of climate change was rather controversial and led to contradictory statements by the experts. On the positive side, a food-system expert indicated that the effects of climate change could lead to longer growing seasons, which in turn would extend opportunities for agricultural initiatives as illustrated by the following quote:

*‘I think over the long-term agricultural initiatives will get easier’ ... ‘Less cold weather, longer growing season. Ehm, later frost, cause it’s yeah, I mean it’s not, it’s not something to be incredible excited about and it’s happening slowly, well relatively slowly, but you know the longer your frost-free days are, then there might be a change of getting a second cut on the hay or you know then you’re doubling your feed.’*

At the same time, the effects of climate change on agriculture were also a concern:

*‘So, it is not an advantage. We’re not all of a sudden like ohh we can grow pineapples here. That’s not the way it is going to be. If anything, it’s just more risk ... More diverse and extreme weather patterns.’*

### **Discussion and conclusion**

The aim of this research was to deepen the understanding of food insecurity and explore the possibilities for a food sovereignty approach at personal and regional level in

Yukon, Canada. The overall research question that was posed in the introduction could be answered as follows.

By integrating qualitative and quantitative data we revealed five main themes that can be considered as barriers to and opportunities for enhancing food security and sovereignty in Yukon:

- localisation of the food system
- economic consequences
- connection to the land
- local and regional initiatives
- climate change.

These themes allow for a deeper understanding on how the combination of the concepts of food security and sovereignty can present opportunities to create resilience and sustainability in Yukon's food systems. Analysing the results of this study show that localisation of food systems is a fundamental pillar for Yukon's food security and sovereignty that interconnects all other identified themes as illustrated in the following schematic reciprocity framework (Figure 1).

### Localisation of food systems

Buying local food promotes self-determination and protects cultural and personal identities that are tied to food [25]; both are necessary conditions for food sovereignty. Predefined supply systems from outside Yukon, subsidy programmes and the government's failure to obtain local food procurement thwarts development of local food production. This makes it hard for local producers to expand their enterprises and increase their production in order gain efficiencies of scale. As a result, food systems remain dependent on imported goods, negatively affecting food security and sovereignty. However, the reciprocal relationship between the economic aspect, connection to the land, food security and sovereignty initiatives and climate

change ignite opportunities to improve localisation of food systems, and so contribute to improved food security and sovereignty in Yukon. We will illustrate this for each of these themes in the following paragraphs.

### Economic

This study demonstrated the financial barriers to local and affordable fresh food in Yukon, which underlines other studies conducted in Subarctic regions [4]. Improving the affordability of fresh and local food is not only necessary in order to realise food security, but also to increase the market share of local products. 25, argue that buying local products initiates a multiplier effect on the local economy that makes fresh products more affordable. Moreover, improving affordability of fresh and local food creates health equity, an important aspect of food sovereignty [26] [27].

### Connection to the land

Connection to the land is predominantly used to describe the unique cultural and traditional meaning of land to the Indigenous population of Yukon especially in the light of food sovereignty. Yet, this study found that an understanding of where food comes from and a connection to the land are important aspects for food security and sovereignty among all Yukoners. 28, and 29, confirmed the importance of programs that reconnect indigenous and non-Indigenous Yukon inhabitants to the land and improve land-based competencies. The current study has pointed out a concern regarding the loss of and desire to reconnect society to land. The 'Connecting Canadians with Nature' report by the 30, described this separation from nature as an unintended consequence of the modern world. More localised food systems would stimulate a reconnection to the land,

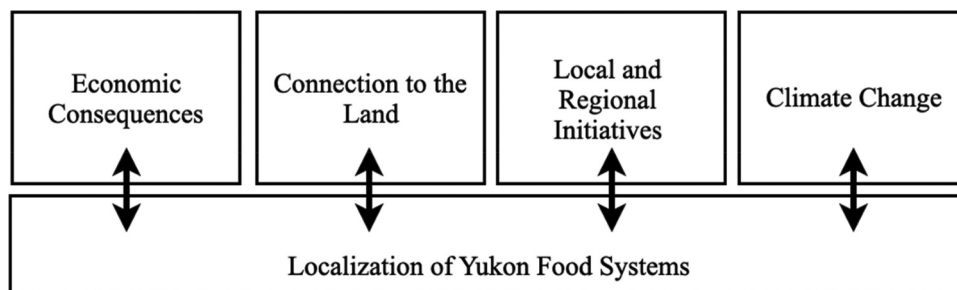


Figure 1. Overview of themes and their reciprocity.



as there will be a closer link between society and the food consumed. Thus, the reciprocity in connection to the land and localisation of food systems lies in the capacity of both elements to strengthen one another.

### **Initiatives**

Existing food security initiatives in Yukon are effective but fail to reach their full potential because of their limited reach. The “holes in the net” prevent these initiatives from contributing to food security and sovereignty for Yukon’s more vulnerable population groups. Interlinking initiatives create the capacity for a social safety net as well as increasing stability of food security. Furthermore, grassroots initiatives can create local empowerment, initiating opportunities for improved food sovereignty and inclusiveness (Ghai & Vivian, 214). Moreover, there is increasing evidence that in general, the transition to sustainable development depends on full support at the community level and active participation of its members [31]. Taking into consideration that social interaction is an important element of food sovereignty, creating and consolidating a strong social fabric through grassroots initiatives are key aspects for both food security and sovereignty [32]. Moreover, grassroots initiatives have the capacity to create a culturally rich and socially cohesive community which is an important element of food security and sovereignty [33].

### **Climate change**

The effects of climate change in Yukon seem to provide opportunities for agricultural initiatives as growing seasons are prolonged, but simultaneously raises concerns that are hard to mitigate. Increasing temperatures globally have caused growing seasons in the North to expand. In Whitehorse and Dawson, the two major agricultural areas in Yukon, the average length of the frost-free season of 62 and 55 days, respectively, is projected to increase to 116 and 100 days by 2081 according to ‘the Representative Concentration Pathway 8.5 scenario’ [34]. However, farming conditions overall will not be improved due to an increase of unpredictable weather patterns [34]. The existing inability to grow food during the dark winter months and the precarious farming conditions during the summer as a result of changing weather patterns make local food production challenging throughout the year. Creating a resilient food system that is capable of year-round food production is therefore a necessity for food security and sovereignty in Yukon [35]. Although resources for sustainable food production are limited in Yukon,

innovative options, such as aquaponics, vertical farming or geothermally heated greenhouses may be solutions to the difficulties of increasing local food production in Yukon [36,37]. However, these options can only solve the problem when they are widely implemented and taken to scale. The opportunities of hydroponics, vertical farming and geothermally heated greenhouses will be further elaborated in the recommendations.

In sum, applying the lens of food sovereignty to the challenges facing Yukon’s food systems has been shown to be useful in determining underlying issues that make the realisation of food security in Yukon so challenging. This study has identified localisation of food systems as a critical overarching aspect that should be improved in order to create a more food-secure and sovereign Yukon. By addressing economic barriers, connection to the land, food security and sovereignty initiatives and the mitigation of climate-change effects, Yukon can get a step closer to more localised and sustainable food systems. In the next section, we make several concrete recommendations on how to address these issues.

### **A roadmap towards food security and sovereignty in Yukon**

The insights offered reasons to look for solution generations and assisted in facilitating the development of policy recommendations. The issues raised by experts regarding food security and sovereignty in the Whitehorse area were leading in formulating the recommendations and the provided recommendations are mainly addressing the issues faced by Yukoners located in urban regions. However, they do not exclude the more remote communities as beneficiaries.

#### ***Incorporate local food procurement into Yukon policies to act locally, creating contracts and helping local farmers to expand their enterprises into efficient farms***

This study showed that Yukon’s food systems and the situation of food security and sovereignty in particular would benefit from more localisation. Currently, the competitive disadvantage of local producers with respect to farmers in the South hinders prospective development options for the marketing of local products. The Yukon government can implement a policy to procure local food as a way to support local producers and thus create more demand for their produce. 38, established a toolbox to promote locally sourced, sustainably grown and healthy foods in order to create food systems which promote local entrepreneurship. These aims align well

with the concept of food sovereignty. Similar policies have already been implemented in Alaska, where municipalities receive state money if they purchase in-state products that are priced no more than 7% above the out-state product [39]. In order to implement such policies, there is a need for collaboration between different stakeholders [40]. Nevertheless, the proposed food procurement would be effective only if local growers are able to accommodate the needs of the state institutions and customers. Local production will need to increase and be more consistent throughout the year. In order to achieve this Yukon should look into ways to innovate current agricultural production.

### ***Designing infrastructure to facilitate innovation through initiatives such as innovation-hubs***

The ability to grow food throughout the entire year will contribute tremendously to Yukon's food security and sovereignty. Lack of food production in the colder months is currently an important barrier as the short days and permafrost inhibit agriculture in the winter. This calls for an innovative approach as current agricultural systems do not allow for year-round production. Social cohesion among farmers is important as the decision-making process is often based on each other's experience [41]. Increasing the sense of connectedness and social cohesion through knowledge sharing could therefore facilitate innovation among Yukon's farmers. In order to incorporate sustainable innovation to improve food production throughout the year it is proposed to engage in (Arctic) Innovation hubs (AIH). AIHs have been established in Scandinavia in order to generate growth and cooperation [42]. The Yukon government could facilitate such innovation hubs to initiate knowledge sharing, generate new businesses from ideas and innovation and improve the sense of community among local farmers. Furthermore, they often operate in global networks, creating more opportunities for capital and talent [42]. At the policy level, these hubs can generate knowledge on what actions to take in order to create a favourable environment for innovation [42].

### ***Increase year-round fresh, local food production through greenhouses and vertical farming on large scale***

Innovative solutions are critical in order to work towards year-round local food production. Proposed opportunities are geothermally heated greenhouses, hydroponics, aquaponics and vertical farming. Greenhouses have been built in several indigenous communities, among others the Tr'ondëk Hwëch'in

First Nation community. The cold climate innovation research centre (CCI) is also experimenting with different greenhouse designs [43]. Conventional greenhouses need to be located in areas where they can capture the appropriate amount of winter sunlight in order to be effective. Geothermally heated greenhouses, however, pre-empt this as they rely on natural heating sources. Hydroponics make it possible to grow plants without soil by using mineral nutrient solutions. Aquaponics are closed-loop water systems combining conventional aquaculture (fish production) and hydroponics in a symbiotic fashion. Due to their soilless culture and efficient water systems hydro – and aquaponics have the capacity to address problems of food security without compromising vulnerable soil characteristics, while energy from renewable resources also contribute to mitigating the deleterious effects of climate change [44]. There is already a Yukon initiative experimenting with hydroponic vegetable greenhouses that run on automated biomass boilers [45]. The principles of hydroponics are also practiced in so-called vertical farms where food is grown in layers in an indoor facility where light and humidity can be controlled. Furthermore, vertical farms are capable of growing more food per unit area than traditional farming, as well as using less water, land and chemicals. Vertical farming creates the possibility of year-round produce as well as providing healthy, local food with instant access, hereby hugely improving food security. However, these greenhouse variations require a stable energy supply, imposing yet another challenge in terms of sustainability. Currently, corporations have invested in vertical farming technologies to construct large scale, automated facilities [46]. Clearly, these vertical farms and other hydro – or aquaponics cultivation techniques are not meant to replace staple foods, but primarily focus on leafy vegetables and fruits that enrich and diversify the diet. The promising recent developments acknowledge the need for innovative approaches to address food security and to work towards a more food sovereign Yukon. Yet, realising accessibility of locally produced food throughout the year for all Yukoners requires more resources to take innovative solutions to scale.

The proposed recommendations flow from the understanding of the constraints of food security and build on opportunities presented by the concept of food sovereignty. We argue that the localisation of food systems will lead to a more food-secure and sovereign Yukon. Local food procurement, innovation hubs and advanced solutions are proposed as means to reach this aim. The hubs have the ability to initiate the innovations needed to work towards year-round

local production. Local food procurement leads to more protection of local innovations once established. Therefore, if these recommendations are implemented together, they have the potential to complement and strengthen one another, leading to more resilience and stability of the Yukon food system. Especially in the light of the persistent and continuing threats of climate change, creating more stable, secure and sovereign food systems is a priority. Furthermore, this will also lead to improved coping abilities to shocks to food systems caused by events such as COVID-19. Even though the contextual and cultural complexities of Yukon make the realisation of food security and sovereignty challenging, the proposed initiatives, based on expert insights and a dialogue on the current food system, propose a starting point to contribute to both.

### Strengths and limitations

This study has been strengthened by several beneficial factors. First, the collaboration with the Arctic Institute of Community Based Research helped to contextualise this research and tailor the research question to the location-specific needs with practical links to local communities in Yukon. Second, choosing a mixed-method design proved to be very useful for an integrated presentation of quantitative data at the community level with qualitative expert insights that created a solid and comprehensive overview of the food security and sovereignty constraints and opportunities in Yukon.

A limitation lies in the non-representative character of the survey respondents. In order to check the survey sample's validity and accuracy, the realised sample was compared to the actual characteristics of Yukon's population. In terms of age, the 18–24 age group was missing. With regard to gender, men represented only 28.9% of participants but 50.79% of Yukon's population [47]. With regard to identity, 4.4% of respondents identified as Indigenous, which makes up 23.3% in Yukon's population [48]. The survey sample did not include anyone with a household income under \$15,000 CAD, but represents 4.4% of Yukon's population [48]. The survey sample missed people who completed primary school as the highest education level. A university degree or higher education was completed by 84.4% respondents. For Yukon's population, the highest scores for post-secondary qualification is 68.3%, while 10.7% completed less than high school education [49]. Based on previous comparisons it can be assumed that the sample is biased towards women, middle – and higher income groups and highly educated people. This non-representative character of survey respondents is a direct cause of the restrictions that were imposed by

the COVID-19 crisis, which prohibited inclusive, on-site data collection through a well-designed and stratified sampling scheme, hence collected data were fully dependent on the available distribution channels.

A probability sampling was aimed for, yet due to non-representativity of the study population, the sample qualifies as a non-probability convenience sampling method. This means the probability that every respondent included in the sample could not be identified and all individuals could choose whether to participate in the study [50]. This method was, however, suitable for the current research as the target population met practical criteria such as accessibility and proximity [21]. Moreover, the results of the survey were in line with the expert opinions that jointly resulted in an interesting account with concrete recommendations for possible scenarios for food policy.

### Implications for further research

Especially in light of the COVID-19 pandemic, there is growing recognition of the fragility of food systems and the importance of fast and adequate responses and supporting networks. The current research indicated challenges and improvements with regard to food security and sovereignty, but did not investigate the impacts of specific events and threatening factors on food security. Therefore, follow-up research should focus on the impacts of specific threats to food stability on local food security. Moreover, future research should include a more representative sample of the Yukon population including remote and Indigenous communities. Including the people who are most affected by food insecurity enables a more comprehensive investigation of food security and sovereignty constraints and disparities.

### Geolocation information

Whitehorse, Yukon, Canada. Coordinates: 60°43'27"N 135°03'22"W

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## Appendices

Table(s) with caption(s) (on individual pages)

**Table A1.** Valuation of focuses of food security initiatives.

Initiatives.	Extremely important (%)	Very important (%)	Moderately important (%)	Slightly important (%)	Not at all important (%)
Increasing the amount of food available	22.2 (n = 10)	33.3 (n = 15)	33.3 (n = 15)	11.1 (n = 5)	0.0 (n = 0)
Improving the quality of food available	37.8 (n = 17)	37.8 (n = 17)	13.3 (n = 6)	8.9 (n = 4)	2.2 (n = 1)
Increasing the diversity of food available	17.8 (n = 8)	33.3 (n = 15)	31.1 (n = 14)	17.8 (n = 8)	0.0 (n = 0)
Increasing the availability of local fresh produced food	68.9 (n = 31)	24.4 (n = 11)	6.7 (n = 3)	0.0 (n = 0)	0.0 (n = 0)
Making fresh products more affordable	57.8 (n = 26)	31.3 (n = 14)	8.9 (n = 4)	2.2 (n = 1)	0.0 (n = 0)
Aimed at overcoming geographical barriers	28.9 (n = 13)	28.9 (n = 13)	28.9 (n = 13)	11.1 (n = 5)	2.2 (n = 1)
Increasing the social aspects of food	13.3 (n = 6)	26.7 (n = 12)	35.6 (n = 16)	22.2 (n = 10)	2.2 (n = 1)
Improving knowledge and skills to budget, shop and prepare nutritious food	33.3 (n = 15)	35.6 (n = 16)	22.2 (n = 10)	8.9 (n = 4)	0.0 (n = 0)
Improving the awareness of food safety and agriculture	37.8 (n = 17)	35.6 (n = 16)	22.2 (n = 10)	4.4 (n = 2)	0.0 (n = 0)