



# Summary Report

## Mapping Food System Impacts, Hazards, and Vulnerabilities in the Fraser Valley Region Workshop

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## 1. Project Background

In 2021, the Food and Agriculture Institute (FAI) at the University of the Fraser Valley (UFV), in collaboration with the Fraser Valley Regional District (FVRD) and Royal Roads University (RRU), initiated a community-based participatory research effort<sup>1,2</sup> to explore food systems vulnerabilities, resiliency, and approaches to integrated planning in the Fraser Valley. The FVRD identified a need for long-term planning to develop resilient and sustainable food systems. Accordingly, the project aims to identify and map food system vulnerabilities and impacts, alongside local and regional efforts. The research draws from participants' experiences during multiple hazard events (COVID-19 pandemic, extreme heat events, extreme flooding events) over the past two years and during a real-time natural disaster disrupting participation and resulting in major food security and national supply-chain implications, the extent of which is still unclear. The work employs integrated planning and systems perspectives to (1) reflect upon the challenges and vulnerabilities that the COVID-19 pandemic has revealed about local and regional food and farming systems, and (2) explore ways of increasing local/regional resilience to future shocks (e.g. climate change impacts, economic recessions, mass migration).

This summary report presents the outcomes of a second workshop in a three-workshop series. The first workshop, in the summer of 2021, reflected on what COVID-19 has taught us about food systems vulnerabilities, and it explored food system impacts arising from the pandemic. The second workshop, on November 24<sup>th</sup>, 2021, built off the first by exploring a variety of environmental and socioeconomic/sociopolitical hazards that are likely to impact the region's food system and which food system components were most vulnerable and why.

### 1.1 Environmental and Socioeconomic/political Hazards

The Fraser Valley region is susceptible to a variety of environmental hazards (EH) and socioeconomic/political hazards (SEPH) which have the potential to disrupt local and regional food systems by impacting social and physical infrastructure and critical ecosystem services. The first workshop explored food system impacts related to the COVID-19 pandemic. A major outcome of this work included observations around compounding and interacting impacts from other issues, such as the ongoing fentanyl crisis, climate change, residential school findings, and the pandemic. Building on these observations, the second workshop took a broader perspective on examining regional food systems issues and exploring a variety of hazards.

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<sup>1</sup>Newell, R., Picketts, I.M., & Dale, A. (2020). Community systems models and development scenarios for integrated planning: Lessons learned from a participatory approach. *Community Development*. doi: 10.1080/15575330.2020.1772334

<sup>2</sup>Hacker, K., Tendulkar, S. A., Rideout, C., Bhuiya, N., Trinh-Shevrin, C., Savage, C. P., Grullon, M., Strelnick, H., Leung, C., and DiGirolamo, A. (2012). Community capacity building and sustainability: outcomes of community-based participatory research. *Progress in Community Health Partnerships*, 6(3), 349-360.

The workshop explored hazards that were identified from numerous sources, including local climate change reports,<sup>3</sup> food system vulnerability reports,<sup>4,5,6</sup> major global environmental assessments,<sup>7,8,9</sup> and the first workshop in the series.<sup>10</sup> Food system vulnerability reports identified key EHs including wildfires, floods, drought and extreme heat, pandemics, soil degradation, air pollution, water pollution, and loss of habitat and biodiversity. SEPHs included rapid population growth, rapid population decline, economic recession, and war/conflict. A key strength, and challenge, of this workshop is that participants directly reference actual hazard events over the past year (e.g. heat dome, wildfires) and atmospheric river events leading to the on-going real-time flooding event.

## 1.2 Defining Food System Vulnerability

Food systems can be described as complex networks of people, processes, and infrastructure required to produce, process, distribute, access, and consume food. These are complex systems that are layered with ecological, social, and political dimensions and factors, and are never completely knowable, extremely dynamic, with both linear and non-linear causal linkages.<sup>11</sup> Therefore, these systems vary depending on their local/regional contexts, and there is no ‘one size fits all solution’ for improving local and regional food system resilience.<sup>12</sup> Accordingly, identifying and addressing food systems vulnerabilities for informing integrated long-term planning requires place-based approaches.

<sup>3</sup> BC Agriculture & Food Climate Action Initiative (2015). Fraser Valley: BC agriculture & climate change regional adaptation series. Agriculture & Agri-Food Canada, BC Ministry of Agriculture. Retrieved from <https://www.climateagriculturebc.ca/app/uploads/RegionalStrategies-FraserValley.pdf>

<sup>4</sup> <https://clf.jhsph.edu/sites/default/files/2019-01/baltimore-food-system-resilience-advisory-report.pdf>

<sup>5</sup> <https://www.thomsonreuters.com/content/dam/ewp-m/documents/thomsonreuters/en/pdf/reports/global-food-system-stability-and-risk-0718.pdf>

<sup>6</sup> Balfour, R. & Keenan, E.M. (2007). *Strategic Sustainable Planning: A Civil Defense Manual for Cultural Survival*. Old City Foundation Press.

<sup>7</sup> IPCC (2021). Climate Change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou (eds.). Cambridge: Cambridge University Press.

<sup>8</sup> IPBES (2019). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, J. Settele, E. S. Brondizio E.S., H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y. J. Shin, I. J. Visseren-Hamakers, K. J. Willis, & C. N. Zayas (eds.). Bonn, Germany: IPBES Secretariat.

<sup>9</sup> Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., ... & Murray, C. J. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, 393(10170), 447-492. [https://doi.org/10.1016/S0140-6736\(18\)31788-4](https://doi.org/10.1016/S0140-6736(18)31788-4)

<sup>10</sup> Dring, C., & Newell, R. (2021). Fraser Valley food system vulnerability workshop. University of the Fraser Valley. <https://doi.org/10.13140/RG.2.2.34634.08648>

<sup>11</sup> Niles, Meredith, Jimena Esquivel, Richie Ahuja, and Nelson Mango. 2017. “Climate Change and Food Systems: Assessing Impacts and Opportunities.” Washington, D.C.: Meridian Institute. [http://www.merid.org/Content/Projects/Climate\\_Change\\_and\\_Food\\_Systems\\_Assessing\\_Impacts\\_and\\_Opportunities.aspx](http://www.merid.org/Content/Projects/Climate_Change_and_Food_Systems_Assessing_Impacts_and_Opportunities.aspx)

<sup>12</sup> Knezevic, I., Blay-Palmer, A., Levkoe, C. Z., Mount, P., & Nelson, E. (2017). *Nourishing communities: From fractured food systems to transformative pathways*. Cham, Switzerland: Springer International Publishing.

Food system vulnerability can be described as the susceptibility of the food system and different elements and aspects of the system (e.g., people, infrastructure, processes, and resources) to the impacts of hazard events. Assessing the vulnerability of the FVRD food system is a key outcome of this project as it ties directly to long-term resiliency planning efforts, with cascading effects extending beyond the region. Understanding food systems vulnerability requires examining the state of different system components, such as food access and affordability, food supply chains (production to distribution), food quality and acceptability (nutrition, safety, cultural appropriateness), and the governance and supportive networks in the region. Examining these various components, states, and systems relationships reveal how different shocks or disturbances can adversely impact food system functioning. Populations that are currently food insecure are particularly vulnerable and can be further affected by these shocks/disturbances.

It is important to note that this workshop did not exhaustively cover all hazards and related vulnerabilities. For example, seismic risk is a key concern; critical infrastructure across the region will be susceptible to damage, with climate change exacerbating the impacts. Seismic risk was not included in the workshop as it did not appear in the food system vulnerability or climate change reports, but it should be incorporated in future vulnerability assessments and resiliency planning efforts.

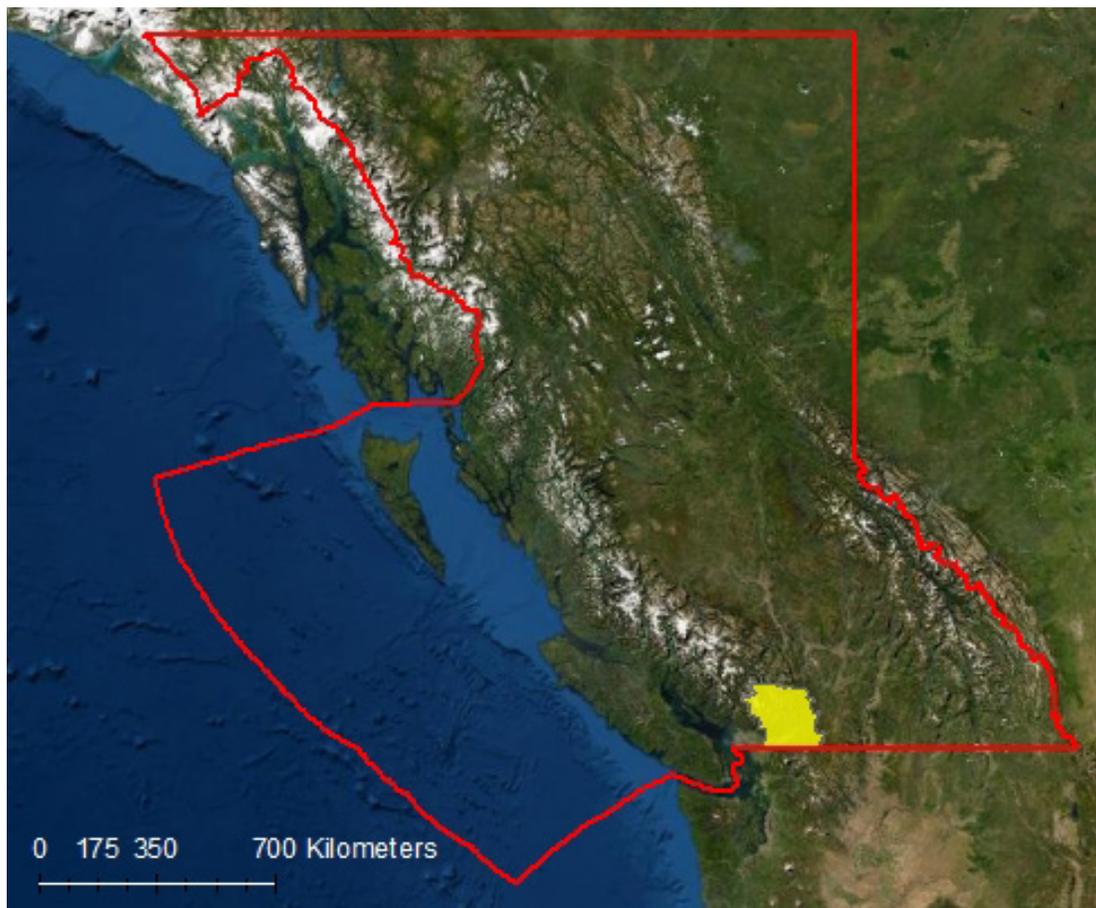
## 2. Regional Context

The project is based in the Fraser Valley region in the southwest of British Columbia, directly east of the province's most populous metropolitan region of Metro Vancouver (Figure 1). The region is one of the most agriculturally productive areas in Canada, and the agriculture sector provides the basis for strong economic and cultural relationships, and identities within and among urban and agricultural communities. The project builds upon existing efforts based out of government, industry, and civil society organizations aimed at improving food resilience in the region, such as the [Climate & Agriculture Initiative, BC - Fraser Valley Adaptation Strategies Plan](#), [FVRD and FoodMesh](#), and [FVRD Clean Economy in the Fraser Valley Resource Guide](#). The region has multiple food assets - ranging from food banks, community meals, food retailers, food processors and distributors, and farmers. Additionally, the area is home to strategic infrastructure with implications for food security within the region and abroad including BC Hydro infrastructure (e.g., substations and transmission grids), transportation infrastructure (e.g. airports, ports, ferry terminals, railways, highways and rapid transit), emergency services (e.g. police, fire and ambulance first responders and hospitals) and other critical infrastructure (e.g. sewage treatment plants, water supplies, schools and universities, and key communications – telephone lines, cell towers).<sup>13</sup>

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<sup>13</sup> Fraser Basin Council (2016). Lower Mainland flood management strategy project 2: Regional assessment of flood vulnerability. Vancouver, BC: Fraser Basin Council. [https://www.fraserbasin.bc.ca/\\_Library/Water\\_Flood\\_Strategy/Regional\\_Assessment\\_of\\_Flood\\_Vulnerability\\_April\\_25\\_2016\\_web.pdf](https://www.fraserbasin.bc.ca/_Library/Water_Flood_Strategy/Regional_Assessment_of_Flood_Vulnerability_April_25_2016_web.pdf)

Figure 1. Location of Fraser Valley Regional District (yellow) within British Columbia (red)  
*Data sources:* BC Data Catalog, Esri, DigitalGlobe, GeoEye, Earthstar Geographies, CNES/Airbus DS, USDA, USGS, AeroGRID, and ISN



The FVRD comprises eight electoral areas (A through H), six municipalities, and 30 First Nations communities.<sup>14,15</sup> Multiple agricultural organizations and resources are located within the region, including the Pacific Agri-Food Research Centre (AAFC), the Abbotsford Agriculture Centre (BC Ministry of Agriculture), the UBC Dairy Education and Research Centre, and the University of the Fraser Valley's Agriculture Centre of Excellence. Additionally, the BC Agriculture Council is based in the Fraser Valley, which is a network organization representing multiple agricultural industries, and several commodity-specific industry associations and organizations.<sup>16</sup>

Economically, the Fraser Valley capitalizes on the proximity of nearby large markets, highways and other transportation (rail and air), resulting in the highest gross farm receipts across the province (39% of provincial gross farm receipts), with over \$1.5 billion in 2015.<sup>17</sup>

<sup>14</sup> FVRD (2019). What is the FVRD? Retrieved from <https://www.fvrd.ca/EN/main/about-the-fvrd/what-is-the-fvrd.html>

<sup>15</sup> FVRD (2020). First Nations. Retrieved from <https://www.fvrd.ca/EN/main/about-the-fvrd/first-nations.html>

<sup>16</sup> British Columbia Agriculture Council <https://www.bcac.bc.ca/>

<sup>17</sup> Fraser Valley Regional District. (2017). Regional Snapshot Series: Agriculture. Agricultural Economy in the Fraser Valley Regional District. <https://www.fvrd.ca/assets/About~the~FVRD/Documents/RGS/AgricultureSnapshot.pdf>

occurs across 5.1% of the region's land base (71,780 hectares in the ALR in 2012)<sup>18</sup>. This includes roughly 2,700 farms producing a variety of crops: berries, dairy, poultry, forage, mushrooms, and greenhouse vegetables.<sup>19,20</sup>

### 3. Data Collection and Analysis Approach

The project consists of three workshops held over the course of 2021 to 2022. The first workshop explored food system vulnerabilities and impacts in the FVRD from the COVID-19 pandemic. The second mapped and assessed food system vulnerabilities from multiple hazards (EH and SEPH). The third workshop will identify ways of leveraging existing (and needs for developing new) food system initiatives, programs, and assets to initiate long-term integrated resiliency planning. The research employs an emergent approach, allowing for flexibility between community concerns and needs as they arise over the course of the project.

This second workshop on food system vulnerabilities and impacts in the Fraser Valley was run on November 24th, 2021, from 1 to 4 pm, using the virtual Zoom platform, with a total of 22 participants from non-profit organizations, food businesses, local government staff and elected officials, and health authority staff (Appendix A for list of participating organizations). As the real-time flooding event was occurring during the planned event, this limited attendance from some organizations as they were called to emergency response functions. As discussed above, a series of ten hazards were explored in terms of their impacts to food systems (Table 1).

Table 1. List of ten environmental, socioeconomic, and political hazards employed in the workshop

Hazard Type	Information Source
Flooding	CAI, 2015; PICS, 2013
Wildfires	CAI, 2015; Biehl et al. 2017; PICS, 2013
Drought/Extreme Heat	CAI, 2015; PICS, 2013
Air pollution	Biehl et al. 2017
Water pollution	CAI, 2015; Biehl et al. 2017
Loss of wildlife habitat & ecosystems	CAI, 2015; IPBES, 2019
Rapid population growth	Balfour & Keenan, 2007; Biehl et al. 2017; Jahn et al. 2018
Rapid population decline	Balfour & Keenan, 2007; Biehl et al. 2017; Jahn et al. 2018
Threat of war, conflict, or invasion	Balfour & Keenan, 2007; Biehl et al. 2017; Jahn et al. 2018
Economic recession & market failure	Balfour & Keenan, 2007; Biehl et al. 2017; Jahn et al. 2018

<sup>18</sup> Fraser Valley Regional District. (2011). Regional Snapshot Series: Agriculture. Agricultural Economy in the Fraser Valley Regional District. <http://www.fvrd.bc.ca/AboutUs/Documents/AgricultureSnapshot.pdf>

<sup>19</sup> Statistics Canada, Census of Agriculture and BC Ministry of Agriculture Fast Stats, Agriculture, Aquaculture & Food, 2014

<sup>20</sup> Statistics Canada. (2012). 2011 Census of Agriculture, Farm and Farm Operator Data, catalog no. 95-640-XWE.

The workshop began with the facilitators introducing the agenda (Table 2) and the purpose of the workshop, which was (1) to identify hazards and their impacts on food system components, (2) to determine the location of vulnerable food system components, and (3) to determine gaps in current efforts across the region.

Table 2. Fraser Valley Food System Vulnerability workshop agenda

Order	Activity type	Description
1	Researcher presentation	Introductions to the project and workshop objectives
2	Researcher presentation	Hazard Events and Food System Vulnerability in the Fraser Valley
3	Participant input	Hazard Events and Food System Impacts Mapping
4	Participant input	Locating Vulnerable Food System Components Across the Fraser Valley Region
5	Researcher presentation	Closing and next steps

### 3.1 Approach to Hazard Events and Food System Impacts Mapping

Workshop activities were facilitated using the CoLabS platform<sup>21</sup> and employed Padlet-based, digital ‘working tables’ for providing thoughts and comments on the various hazards (Figures 2 and 3) to create concept maps that capture hazard-impact relationships. Workshop participants were randomly assigned into breakout rooms to map different hazard events and their impacts on food systems. The activity involved first identifying direct impacts from the hazards and then identifying indirect effects/impacts that emerge from the direct impacts. Two 20-minute rounds of mapping were held for the EHs, allowing participants to contribute to two different hazards, and one round of mapping was done for the SEPH events (there were fewer SEPHs explored in the workshop).

<sup>21</sup>Jost, F., Newell, R., & Dale, A. (2021). CoLabS: A collaborative space for transdisciplinary work in sustainable community development. *Heliyon*, 7(2), e05997. <https://doi.org/10.1016/j.heliyon.2021.e05997>

Figure 2. Sample mapping of increased water pollution and food system impacts

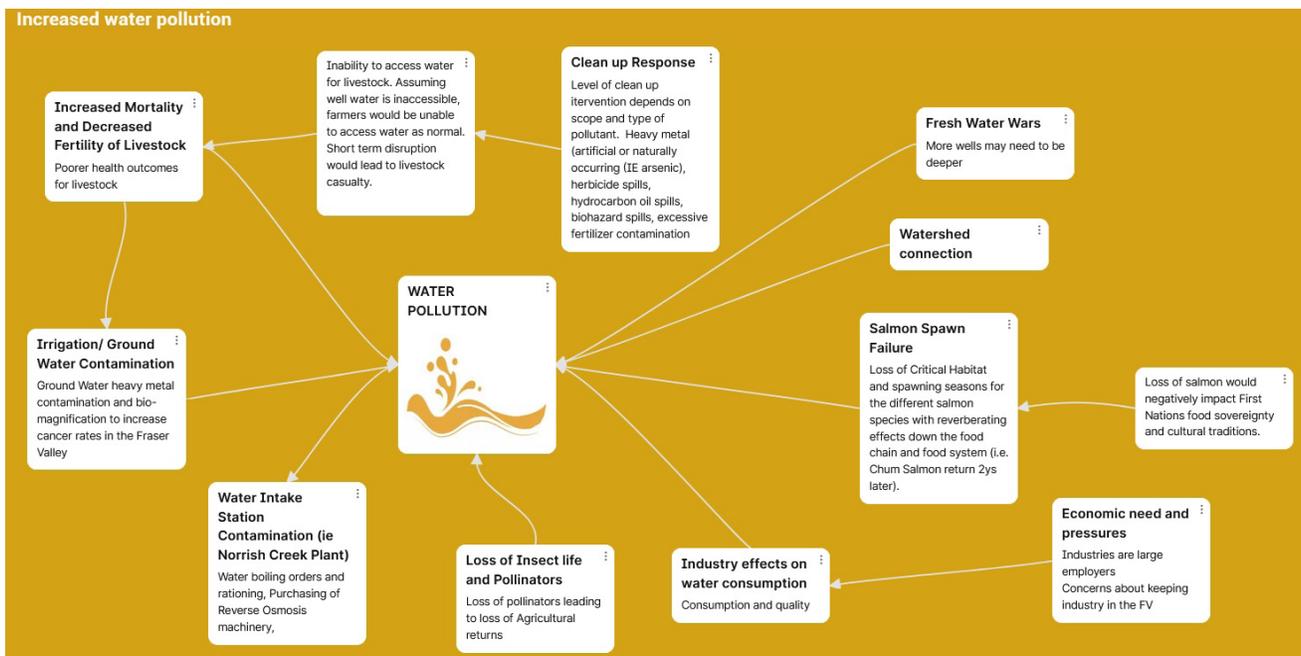


Figure 3. Sample mapping of rapid population growth and food system impacts



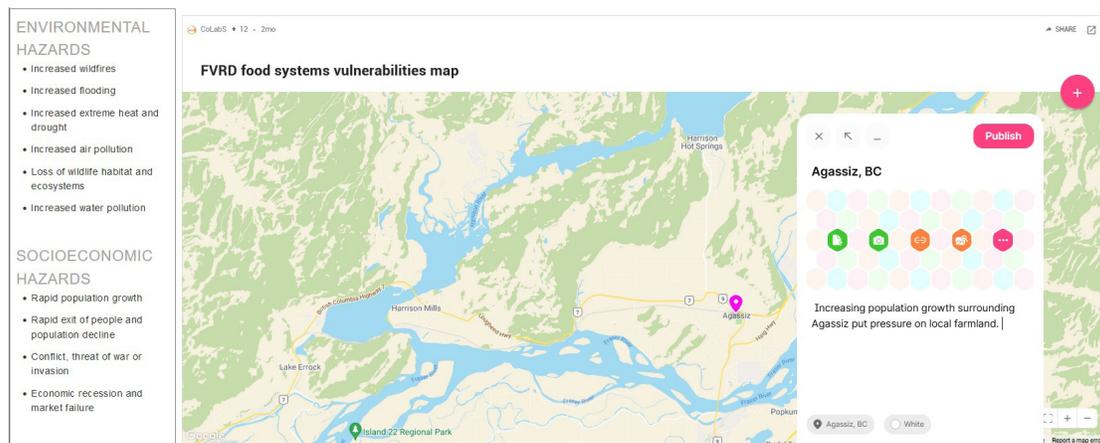
### 3.2 Approach to Spatial Mapping of Hazards and Food System Components

In the latter part of the workshop, participants were asked to locate vulnerable food system components across the Fraser Valley region. In CoLabS, participants identified these locations by placing various pins on a digital map (Figure 4). The mapping application used for this activity involved embedding Padlet mapping widgets (which use Google base maps) in the CoLabS platform. The activity was not restricted to the FVRD jurisdictional boundaries, and participants were free to place pins within

what they understood as the Fraser Valley region and/or areas linked the region's food systems. Different hazards were provided for ease of reference on the left side of the screen. For each vulnerable food system component identified, participants were asked to provide information on:

1. The name of the food system component (e.g. Archways Food Bank)
2. The hazard threatening or impacting the component (e.g. wildfires, drought, flooding)
3. Reasons why the food system component is vulnerable to the hazard

Figure 4. Spatial mapping activity sample input screenshot



The workshop concluded with a plenary discussion of approximately 20-30 minutes, which involved a deeper dive into the various hazards and food system impacts identified in both mapping activities. Participants were asked about how the mapping activities show connections between hazards and food system impacts, where repetition of food system impacts was arising, and how multiple food system shocks might render particular aspects of the food system vulnerable (Appendix C). The workshop closed with a synthesis of participants' responses, identification of next steps, including future workshops and topics, and additional proposed research activities.

It is important to recognize that at the time of the workshop, several hazard events had recently occurred, or were occurring, across the Fraser Valley region. This included: major flooding across vast parts of the floodplain, the ongoing COVID-19 pandemic, and recent summer extreme heat events and wildfires. For example, the Fraser Valley Regional District were unable to participate due to the flooding emergency, Electoral Areas across the region were heavily impacted with effects extending beyond the Sumas Prairie flooding. While other hazard assessments rely on conjecture, this workshop drew on lived experiences of community members who have and were experiencing multiple shock events.

### **3.3 Hazard and Food System Impact Mapping Analysis**

Analysis of the conceptual maps was done by first organizing participant responses by hazards and then the various food system impacts that were linked to these hazards. Responses were tabulated by hazard with each column representing primary, secondary, and third-level impacts as identified by participants (Appendix B). The research team then coded impacts for consistency and to reduce redundancy, for example, participant responses of decreased food access and loss of access to food were coded to reduce food access. Initially, 193 impacts were present in the data, and the coding process reduced this number to 140 impacts (see Appendices B & C).

After coding, linkages among the hazards and food system impacts were mapped using Gephi network graphing software. This resulted in a systems map that features the complex inter-relations between and among hazards and food system impacts (Figure 7). The map was examined to find impacts that were highly connected in terms of forming relationships with multiple hazards and impacts, as well as occurring on numerous paths between hazards, direct impacts, and/or indirect impacts.

### **3.4 Spatial mapping of food system assets and components across the Fraser Valley region**

The spatial mapping activity resulted in 57 location pins, representing different food systems assets or components vulnerable to hazards and direct/indirect impacts from these hazards. Redundant locations were removed and amalgamated into singular pins. In addition, locations without descriptions of the food system component, what made it vulnerable, and/or the hazard were examined on a case-by-case basis to determine whether they featured enough information to include in the analysis. The resulting dataset consisted of 53 location pins.

The map pins were examined for hotspots or areas where major concentrations of vulnerable food system assets were located. Pins were also examined to determine which referred to larger geographic areas, rather than specific sites, with respect to both the scales of impact and hazard activity. This latter area of analysis revealed a weakness of the online mapping tool, which only allowed for point data to be displayed rather than line (i.e., paths) or polygon (i.e., area) data as well. Point data or pins do not effectively highlight large areas of hazards/impacts and/or the paths of these hazards (e.g. smoke from a wildfire, rising/falling water levels, conflict origins).

## 4. Results and Discussion

### 4.1 Hazards and Connections to Food System Impacts

Participants identified 140 impacts across the ten exogenous shock/hazard events that were explored during the workshop (Appendix C). As seen in Figures 4 and 5, participants connected impacts to hazards through the mapping activity. We also wanted to determine the connections between different hazards and their impacts on other hazards and impacts. Determining what impacts would be common across multiple hazards allows for both resiliency and emergency response planning.

Figure 5 displays a systems map of the relationships among the ten hazards (blue) and the 140 food system impacts (yellow) identified through the workshop (Appendix C). The map was analyzed to determine 'density' and 'centrality' of the network nodes (i.e., impacts and hazards), which respectively refer to the number of connections/relationships observed for a given node and the frequency a node occurs on the path between two other nodes<sup>22</sup>. The analysis focused specifically on the food systems impacts, rather than the hazards.

Below are findings from the analysis of the hazard-impacts systems map, which show particularly salient impacts in terms of their numerous relationships within the system. Next to the impacts listed below are their respective identification numbers (in parenthesis), as seen in Figure 5. A full list of the impact identification numbers can be found in Appendix C. The impacts the displayed the highest number of connections/relationships in the systems map are (from most to least):

1. Decreased food supply (41)
2. Supply chain disruptions (4)
3. Diminished agricultural production (28)
4. Impacts to livelihood (67)
5. Loss of productive farmland (2)
6. Animal damages/losses (3)
7. Reduced labour (6)
8. Impacts to mental health (77)
9. Diminished crop quality/health (9)
10. Costs of rebuilding infrastructure (14)

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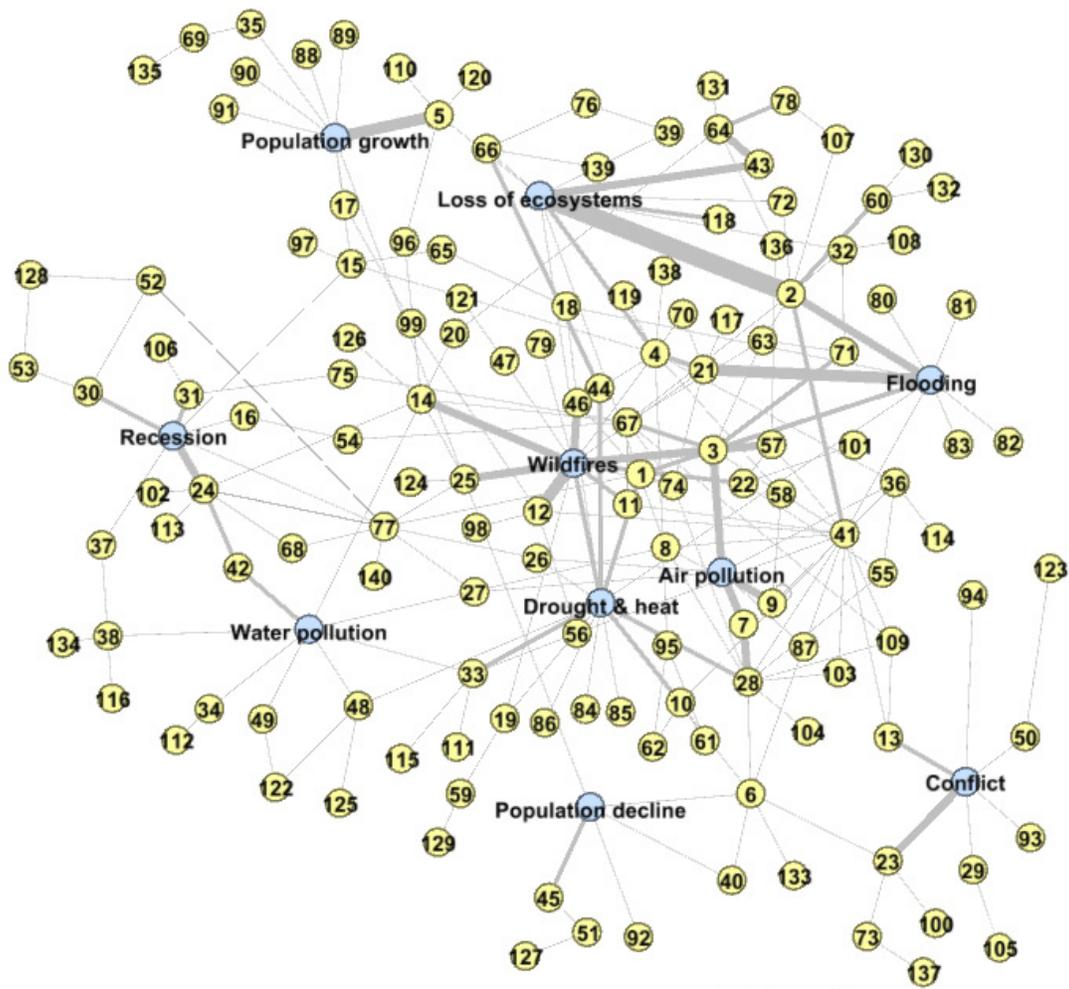
<sup>22</sup>Cordeiro, M., Sarmiento, R. P., Brazdil, P., & Gama, J. (2018). Evolving networks and social network analysis methods and techniques. In Višňovský, J., & Radošinská, J. (eds.) *Social Media and Journalism: Trends, Connections, Implications* (101-125). London, UK: IntechOpen

The analysis also examined impacts that displayed the highest number of connections specifically to the different hazards. This was done to identify key impacts that arise multiple times across the different environmental, socioeconomic, and sociopolitical hazards. According to the impacts-hazards systems map analysis, the impacts with the highest number of connections to hazards are (from most to least):

1. Decreased food supply (41)
2. Loss of productive farmland (2)
3. Supply chain disruptions (4)
4. Diminished agricultural production (28)
5. Impacts to livelihood (67)
6. Limited transportation routes (21)

Finally, the analysis examined impacts with the highest centrality values, that is, those that occur most frequently on paths between multiple impacts and hazards. An example of such a path includes droughts being connected to diminished agricultural production (28), which is connected to decreased food supply (41), and decreased food supply is subsequently connected to increased cost of food (109). Analyzing impacts with high centrality values provides insight on which of these are found within numerous hazard-to-impact and impact-to-impact systems paths, and thus are connected in the system through multiple direct and indirect relationships. Impacts with the highest centrality values are (from most to least):

1. Decreased food supply (41)
2. Reduced labour (6)
3. Supply chain disruptions (4)
4. Increased stress on healthcare services
5. Loss of productive farmland (2)
6. Increased food waste (15)
7. Impacts to mental health (77)
8. Loss of pollinators (8)
9. Increased food prices (23)
10. Impacts to livelihoods (67)

Figure 5. Network analysis of hazards and connection to food system impacts<sup>23</sup>

## 4.2 Environmental Hazards (EH) and Food System Impacts

This section provides a summary of the various impact and hazard maps generated for each of the ten hazard events. The descriptions are drawn from the original data and focus on the key cascading linkages within the mapping activity.

### 4.2.1 Increased Fire Events in the Fraser Valley

Primary food system impacts arising from fires centered on two major themes. One theme pertains to the damages and losses incurred directly from destruction from fires to crops, animals, infrastructure (e.g., dikes, roads), soils, and food/seed reserves. Wind-driven fires represent a risk to both remote and urban communities, particularly in dense areas where man-made structures can act as fuel sources. The second theme relates to the increased costs associated with living with diminished local food supply, an increased reliance on imported foods, and expenses from continually repairing/rebuilding damaged infrastructure. Participants also noted the potential for transportation route closures, community panic, impacts on global food

<sup>23</sup> Impact identification numbers can be found in Appendix C. Thicker connecting lines refer to relationships that appear multiple times in the digital working table data (i.e., the thicker the line, the more appearances).

supply chains, and a disproportionate share of negative impacts facing low/fixed income populations.

Indirect impacts, arising from the primary impacts identified in the workshop, reveal causal chains where impacts can cascade and result in additional downstream effects, particularly with respect to loss of income for farmers, food system laborers, and other food system businesses. In addition, participants noted the increasing challenge of providing services in the face of diminished housing supply, increased insurance and infrastructure rebuilding costs, and community health issues. The identified impacts were described as leading to strains on neighbouring municipalities and in extreme cases abandonment of houses and neighbourhoods. As well, displaced populations having to be relocated, which places additional pressure on municipalities. It was noted that infrastructure damage/destruction, power outages, and diminished water access may ultimately result in increased food waste, and participants also identified that wildfire hazards would diminish access to food retail and food supply. Finally, community panic from supply chain disruptions was described as linked to hoarding behaviors of food and gasoline.

#### *4.2.2 Increased Flooding in the Fraser Valley Region*

Participants identified 10 different primary food system impacts from floods that exert effects on food production, food distribution, and food retail/consumption. Food production impacts included losses and damages to agricultural inputs - land, labour, and equipment. These were linked to secondary impacts of water and soil contamination, diminished economic viability for producers, and an increasing reliance on imported goods. Impacts to food distribution related to damages transportation routes and remote and Indigenous communities becoming inaccessible. Indirect impacts linked to transportation disruptions included supply chain disruptions resulting in lowered food access, in particular for charitable food organizations. Participants also discussed flooding impacts on livestock, involving evacuation and their removal from flood areas. Food retail and consumption impacts included those related to losses of water, food, and power. Losses in water and food supply had downstream impacts on animal health and mortality, and consequences for safe disposal of animal remains. With respect to power supply, participants identified the potential increase in food safety concerns and food waste due to diminished cold storage of food.

#### *4.2.3 Increased Droughts & Extreme Heat Events in the Fraser Valley*

Increased droughts and extreme heat hazards were noted to produce 15 different impacts, and these are primarily related to food production and retail/consumption. Participants noted the lower yields for food and feedstock production impacting both food retail and community-food organizations provision of food. Adapting to these hazards may require changing to more heat resistant crop varieties. The impact of

diminished feedstock was seen to decrease capacity for agricultural product exports and increase the need for product imports, resulting in a net negative effect in GDP contribution from the agricultural sector. Additional impacts from drought and extreme heat were found in worker and livestock health. The former involved a decreased capacity to work in extreme heat, subsequently decreasing agricultural production. The latter also involved increased costs related to insurance and veterinary bills, due to water shortages and exposure to heat.

Water shortages were linked to human health impacts with higher rates of hospitalization, illness, and mental health issues. Additionally, the increased energy requirements for refrigeration and cooling may lead to a higher risk of power failures. Participants noted the impact of drought and heat on habitat and ecosystems resulting in multiple impacts around soil loss, loss of biodiversity, and diminished water and nutrient retention. This hazard was also seen as tightly coupled with an increased risk for wildfires and flooding.

#### *4.2.4 Increased Air Pollution in Fraser Valley*

Impacts identified for this environmental hazard centered mostly on health impacts to humans and livestock. Participants noted that air pollution would impact agricultural worker health, leading to decreased production and ultimately to increased food costs, food hoarding, and shortages. It was also noted that there would be a higher human health impact on vulnerable populations, such as the elderly, immune-compromised, and those with respiratory conditions. These populations would then be at greater risk for hospitalization, illness, and mental health impacts. Air pollution was also seen to reduce food access due to stay-at-home advisories, resulting in an increased need for government support for facilitating food access.

With respect to animal health impacts, participants noted decreases in animal production can lead to decreased food supply and (thusly) panic buying/hoarding. In addition to these production impacts, crop health was seen to be impacted which may cause declines in pollinators, crop quality, and increased pest and disease outbreaks. These drops in crop health were linked to decreased food supply.

#### *4.2.5 Increased Water Pollution in Fraser Valley*

Participants noted the primary impacts of water pollution to be loss of safe water consumption for both humans and livestock, as well as adverse effects on wildlife species (e.g. insects, pollinators, and fish). These impacts would place additional demands on groundwater resources, and the increased water rationing and energy needs for boil water advisories could result in the purchase of expensive water treatment and storage infrastructure. Water pollution may result in greater mortality and illness for local communities, due to contamination of freshwater sources with

carcinogenic materials and heavy metals and also biomagnification issues through food chains. Participants also noted that the increased mortality and illness of livestock may result in increased demand for clean up responses.

Food production was seen as being heavily impacted by water pollution, as both the agriculture and food industries rely on access to safe, good-quality water. The loss of safe water was seen as impacting both the employment and viability of businesses. Further decreases in agricultural production were seen to arise from the loss of beneficial insects and pollinator services. Participants also noted that the loss of critical fish habitat would ultimately impact communities reliant on fish species (e.g., salmon) as part of Indigenous Food Sovereignty and cultural traditions.

#### *4.2.6 Loss of Wildlife Habitat & Ecosystems in Fraser Valley*

Impacts from habitat and ecosystem loss were primarily linked to food production and riparian habitat. Similar to the theme of water pollution, the degradation of riparian habitat was seen to impact fish species (e.g., salmon), thereby affecting Indigenous communities that harvest these culturally-important species, as well as creating issues for fisheries (e.g., unemployment and business viability).

The other major area of impact related to losses of productive farmland due to damages to supportive ecosystem services. Diminished farmland was seen to decrease food supply and subsequently food access and community-food organization food services. This was also seen as resulting in land conflicts, particularly between farmers and wildlife (e.g. land in conservation). It was also suggested that this impact would result in remaining agricultural land becoming more expensive, thereby displacing farmers and diminishing food variety. Participants predicted that such issues would result in increased dependence on industrial agriculture and (thus) the further introduction of invasive species and loss of native plants and wild stocks. It was suggested that increased industrial agriculture would lead to further environmental contamination and degradation, subsequently spurring greater conflict between farmers and environmental agencies.

### **4.3 Socioeconomic and Political Hazards (SEPH) and Food System Impacts**

This section summarizes the various impact and hazard maps generated for each of the ten hazard events. These descriptions are drawn from the original data and focus on the key cascading linkages within the mapping activity.

#### *4.3.1 Rapid Population Growth in the Fraser Valley*

Participants noted that the rapid population increase in the Fraser Valley region carries risks of land-use conflicts and increasing demand for agricultural space due to urban, commercial, and industrial encroachment, along with further impacts to

habitat and ecosystem services. Additionally, participants identified issues from increasing demands for expansion of infrastructure and services (e.g. water, sewage, transportation), affordable housing, health services, schools and childcare, and ultimately food. The increased demand for food was linked to an increased need for accessible food retail and a demand for agricultural and food system workers. Some participants noted a potential positive effect from population growth, that is, an increased workforce may address the labour shortages and needs, and increased demand for agricultural goods.

#### *4.3.2 Rapid Population Decline in the Fraser Valley*

Participants noted the primary impacts of rapid population decline to be reductions in the labour force across the food system, particularly in agricultural workers, farmers, and new entrants into farming. These impacts were seen to result in a diminished food supply. Paradoxically, participants also noted that with declining numbers of farmers, this would allow for existing farmers to potentially expand, further constraining new entrants' access to markets, quota, and land. On the positive side, participants noted two effects that would benefit the region, these being less strain on the health system and less pressure on agricultural lands (i.e. Agricultural Land Reserve (ALR)) for non-farm development.

#### *4.3.3 Threat of War, Conflict, or Invasion in the Fraser Valley*

Participants identified impacts related to conflict/war/invasion to be in the areas of transportation, supply chain, price of commodities, migration, and foreign ownership of land. Transportation and supply chain disruptions were tightly linked, with the movement of food stuffs in and out of the region being impacted, ultimately decreasing the amount of food available and increasing the cost of foods. The increasing price of commodities was seen to increase risks of food hoarding and rationing, a loss of workforce, and disruptions to immigration. Potential conflicts arising in the United States were identified as direct pathways for increasing migration and thus a rapid increase in local/regional population. Conflicts with the United States were also discussed, particularly in terms of shared water resources and downstream users of transboundary water systems.

#### *4.3.4 Economic Recession and/or Market Failure in the Fraser Valley*

Participants discussed the primary impact of economic recession and market failure to be increased unemployment and poverty. These were seen to result in a series of indirect impacts, such as increased homelessness, higher rates of crime, and increased demand for social services. In addition, increased unemployment was described as a driver of greater consumption of less nutritious foods, ultimately resulting in health impacts among children growing up in poverty. Others state that the diversity of the agricultural sector would provide a stabilizing effect as food is a basic need and farmers may switch to different commodities.

Impacts to primary production from economic recession were discussed as resulting from farmers and food businesses re-evaluating the timing of activities (e.g. decision to plant) and the sale of farm properties. These were presumed to result in indirect impacts to the sale of crops and livestock ultimately impacting farm viability and further downstream market failures. Participants also noted increased food waste and less coordination of food (i.e. supply and demand) indirectly occurring from economic recession. Finally, participants identified an increased reliance on foreign aid and capital with lasting consequences for interest rates, taxation, inflation, and loss of livelihood.

## 5. Spatial Mapping of Hazards and Food System Components

Exploring the spatial components of the mapping activity (Figure 6) revealed several key vulnerabilities for food system components, and these observations have been organized into the following thematic areas: Food Retail & Food Access Organizations; Transportation; and Regional/Large Area Effects. The mapping activity covered the entirety of the region, but had a clear skewing towards the municipalities of Abbotsford and Mission, given the greater presence of participants familiar with those areas (Table 3). Interestingly, participants noted five First Nations communities whose traditional and unceded territories intersect with the jurisdictional boundary of the Fraser Valley region. In addition, participants noted five transportation routes and three landscape features.

Figure 6. Spatial mapping of hazards and food system impacts across the Fraser Valley Region

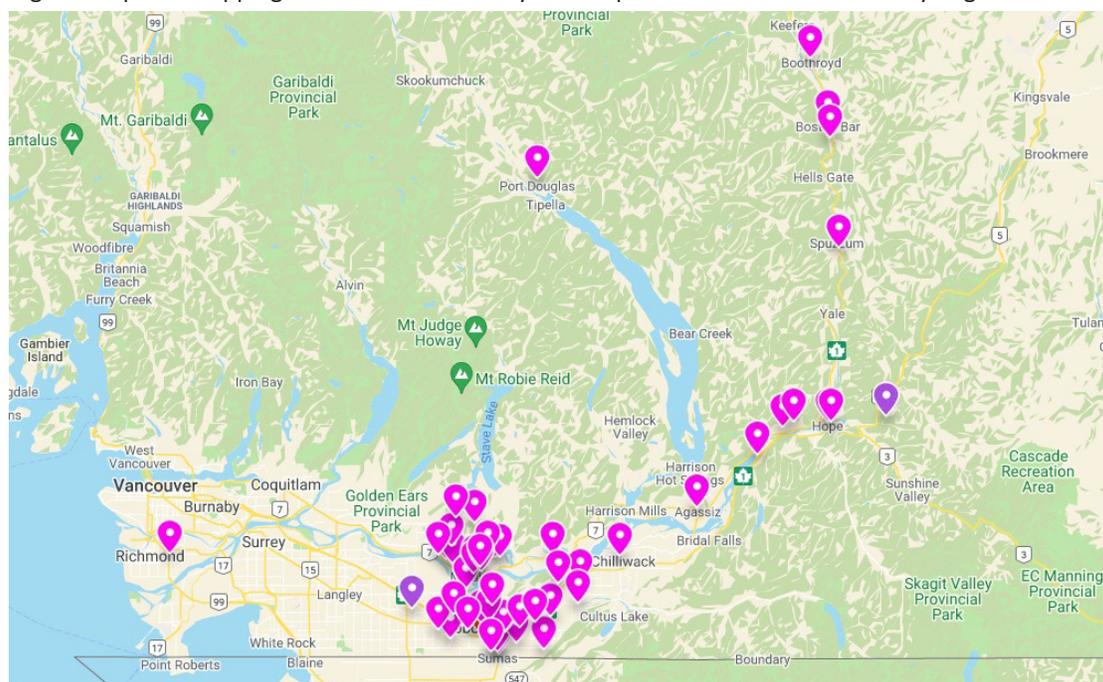


Table 3. Fraser Valley municipalities and number of map locations identified

Abbotsford	19
Agassiz	1
Boston Bar	1
Chilliwack	3
First Nations	5
Hope	4
Laidlaw	1
Mission	13

Participants were tasked with linking food system components spatially across the map to various hazards. The 53 locations were linked to 136 different hazards, with one participant adding pandemics to the map. As shown in Table 4, there is a higher emphasis on the EHs (111 of 136 or 81%) with the majority of locations deemed vulnerable to flooding, extreme heat and drought, and wildfire hazards (66 of 136 or 49%). The SEPHs (25 of 136 or 18%) were primarily associated with the hazard of rapid population change (15 of 136 or 11%).

Table 4. Number of food system locations identified as vulnerable per hazard

Environmental hazards	Flooding	Extreme heat & drought	Wildfires	Water pollution	Air pollution	Loss of Wildlife & Habitat
	31	19	16	16	15	14
Socio-economic & political hazards	Population Increase	Population Decrease	Conflict	Economic recession	Pandemic	
	11	4	5	4	1	

## 5.1 Food Retail & Food Access Organizations

Of the locations identified, a common theme was around the impact of hazards to food retail (e.g., supermarkets, farmers' markets) and food access organizations (e.g., food banks, faith institutions, food centers, meal programs). Flooding and extreme heat were most often identified as creating challenges to food distribution. This was particularly true for charitable and faith-based organizations, as they have capacity limitations that create challenges for addressing increased demand for food, services, and associated logistics of coordinating donations, purchases, and access. Additionally, demands on limited parking and physical access to locations were identified as concerns, particularly for locations within the floodplain. Many of these organizations serve additional social and basic needs functions such as food storage, food distribution, shelter space, and cooling centers. Urban centers with a higher density of population and residential areas lacking other infrastructure or mixed uses were seen as particularly vulnerable to hazards given the spatial uniformity of uses, the concentration of people, and impacts to food access.

## 5.2 Transportation

Five major transportation routes were identified by participants, three as road/highway infrastructure, including the Trans Canada Highway, Lougheed Highway, and Dewdney Trunk Road; one associated with rail infrastructure, and one associated with the Abbotsford Airport. For road/highway and rail infrastructure, hazards from flooding and wildfire were stated to result in closures to these highways preventing road access for the movement of goods in and out of the Fraser Valley region.

Participants note that these are major thoroughfares, and during the recent flooding, sections of the Trans Canada Highway were under water and damaged. Participants also noted the potential for hazards to prevent the flow of goods and people via the Abbotsford Airport. Importantly, there is a reliance on food imports for culturally-significant foods, which increases vulnerability for community members of different ethnic and cultural backgrounds, and hazards impacting import routes were thus identified as being particularly relevant to these communities.

*“South Asian, Arabic, and other diverse community members rely on diverse import foods for cooking -- natural disasters pose risk to import routes and leave community members vulnerable to food insecurity due to lack of culturally appropriate food” - Spatial Mapping Activity Comment*

## 5.3 Critical Infrastructure

Participants identified three critical categories of infrastructure that are located in vulnerable areas. The first is hospitals across the region in Hope, Chilliwack, Mission and Abbotsford. Participants emphasized the Abbotsford Regional Hospital and Cancer Centre, the current building is suggested to be poorly equipped to address rapid population growth (driven by a housing crisis and rural migration from climate change), and the ability of the hospital to deliver services is compromised due to compounding effects of the ongoing pandemic and other (and future) hazards. The second piece of critical infrastructure is the Barrowtown Pump Station, located in Abbotsford, which drains the floodplain and is vulnerable to extreme flooding that pushes its capacity limits. The third is the Transmountain Pipeline which provides fuel to the region and was shut down during the floods resulting in fuel rationing.

## 5.4 Development Pressures

Sites under this theme primarily relate to the hazard of rapid population growth, with many participants highlighting farming regions and communities (e.g. Greendale, Silverdale, Westminster Abbey) or municipalities (e.g. Agassiz) that are particularly vulnerable to development pressures. Population growth was linked to an increased demand for housing and industrial sites, which would increase pressures on farmland removals from the ALR. Impacts to agricultural lands and watersheds were linked to affordability (or lack thereof) in areas adjacent to Fraser Valley communities, as such issues push population growth to more affordable places. As one participant noted:

*“Growth and affordability is pushing people out to the East. And so here in Mission, we are going to grow faster than any other community in the metro Fraser Valley area over the next 20 years. And that will often put pressure on agricultural lands or on the watershed feeding into that. And I think that the same is true for Chilliwack, where they’re really having to make a decision to build on hillsides or to try and take land out of the ALR.”*

A second concern arose around land tenure and precarity of two food growing initiatives in Mission. The first is a community farm called Emma’s Acres, located on City-owned land with concerns around loss of tenure if the City needs to expand its cemetery. The second is the Mission Institution farm, a food growing initiative operated by a non-profit organization (Beef with Hunger) susceptible to tenure loss with political shifts at the federal government. While precarious land tenure is a challenge, the linkage between income and increasing housing prices means that farmers will find it more challenging to pay a living wage to their workers.

For example:

*“...more difficult for farmers to get workers at a wage that they are able to support. They aren’t able to support the worker because their income isn’t high enough on the farm to support the worker in order for the worker to live in the area because the price of rent is going up. So with expensive rent, you have to pay workers more, but they can’t afford to, so they don’t get the workers.”*

## 5.5 Regional/Large Area Effects

Two geographical features were identified that showed larger area effects beyond the boundaries of the Fraser Valley region. Participants noted the importance of the Fraser River and the negative impact of multiple EHs (e.g., flooding, wildfires, water and air pollution, extreme heat), climate change, and foreign United States policies (e.g., lack of flood protection on the Nooksack River). Additionally, salmon farming pens may cause downstream impacts on wild salmon populations. In the northern parts of Mission and in the Electoral Areas, it was noted that there are multiple communities that would be susceptible to both floods and wildfires.

## 5.6 Indigenous and Remote Communities

Five First Nations communities were identified in the mapping exercise, with key vulnerabilities facing these communities being water and air pollution, wildfires, extreme heat and drought, and loss of wildlife habitat and ecosystems. These vulnerabilities were linked to participants’ understanding of Indigenous food systems and the importance of local wildlife as a staple of diet (e.g., salmon, birds).

A key food distribution challenge for remote communities is the issue of road access. Participants noted food supply issues result from highway closures and gravel road washouts associated with rock and mudslides due to flooding and extreme precipitation. Participants highlighted a lack of understanding of the severity of environmental impacts to Indigenous and remote communities and that the research would benefit from connecting with elders and knowledge keepers across these communities. Participants also noted the tendency to forget that there are often consequences of impacts and development occurring from upstream and neighbouring communities on Indigenous communities.

*“I just wanted to point out that I don’t think we really capture the Indigenous perspective here because many of our First Nations communities still rely on traditional ways and means of accessing food, and we haven’t really addressed what all of these environmental impacts will have on that. And I think at some point in time it will be nice to connect with elders and knowledge keepers from the various communities and see if they can add to this.”*

*“We often forget that for people living in remote and indigenous communities, access to wildlife is a staple of their diet. And we often don’t think about how something we may be doing in another part of a watershed may affect, for example, the salmon population or the bird population. And so it’s not just those who are directly neighbouring indigenous communities, but who have upstream kind of impacts on that.”*

## 5.7 Connections and Relationships Between Multiple Hazards and Impacts

While the workshop focused on individual hazards and the food system impacts, participants pointed to the difficulty in treating hazards as discrete events. Rightly so, as one participant notes:

*“[Hazards] can happen at the same time, in fact, you could argue we’re doing that right now with the flood in the middle of the pandemic, for example, Freshet season, which is a high risk flooding season, overlaps with the beginning of fire season.”*

Participants highlighted the importance of considering the connectivity between the region and other parts of the province and for large urban centers (e.g. Metro Vancouver). In particular, the importance of coordination between regions and the mutual aid and codependency that exists beyond state-determined jurisdictional boundaries were discussed. Participants identified the importance of planning for these broader resiliency objectives.

*“The population of the Fraser Valley is 300000. The population of Metro is literally 10 times that. And we are the breadbasket for that. And so we shouldn’t just think about how much we have to provide in a crisis for the Fraser Valley, but for ten times that population? And how do we move those goods there and so forth?”*

Similarly, participants identified temporal concerns of hazards and their impacts crossing multiple generations and having long-lasting effects. As one participant states, the impact of poverty and job loss on children can impact their physical health, educational attainment, and mental health.

*“...the impact can be generational...with an economic downturn, some people lose their jobs and some kids would be living in poverty. But then I started thinking about the statistics I had heard about the impact it has on a child to grow up in poverty and to not have proper nutritional food. The impact on their education. Their ability as an adult to function their mental health.”*

In another example, the paradox of dependency of imported food supply was seen as both a vulnerability and a strategy. Having little control over foreign supply chains was noted as a key vulnerability and a hazard in its own right.

*“...in many of the ones we talked about, dependency on foreign food supply was kind of both a response to some of the hazards and in its own way was a hazard because we have...so little influence over what can happen if we rely on foreign food supply.”*

## 6. Conclusions, Implications, & Next Steps

In this workshop we have explored how different hazard events (both real and hypothetical) can cause multiple impacts to different components of the Fraser Valley region’s food system. With the recent flooding, wildfires, extreme heat, and on-going COVID-19 pandemic, food system impacts were identified primarily in the areas of production and access, impacting both local and regional food security and economic viability of businesses, farm operations, and residents. In exploring SEPH, population growth was the most explored, with impacts associated with housing and urbanization impacts and resulting conflicts with agricultural lands.

We note the importance of examining and understanding connections between hazard events and impacts. Knowing the direction and nature of impacts and hazards is vital to contributing to future food system planning processes and emergency management. While there is a strong emphasis on localization of the food system, participants also noted that the Fraser Valley region contributes greatly to food

security beyond its administrative borders. The food system should not be in the jurisdiction of one or two sectors in isolation. The workshop draws attention to the lack of coordination as both an impact and a vulnerability/challenge. Associated with this challenge is the lack of control over aspects of the supply chain and emergency responses, resulting in greater dependence and security on external decision-makers. Partly, this is based on the assumption by participants that there was already in place integration or some level of coordination in food system governance. A key challenge is to coordinate actions across these jurisdictional boundaries (between municipalities, regional districts, and with higher levels of government; domestically to internationally). There is an appeal around local control, however, hazards demonstrate that the current configuration of food system infrastructure and flows of goods, inputs, energy, and interactions requires a more flexible and emergent approach. That is, a key aspect of vulnerability is inflexible and rigid systems, and maintaining this perspective.

Future activities of the project will focus on two areas to complement the previous work exploring the food system impacts of COVID-19 in Workshop 1 and multiple EH and SEPH events in Workshop 2. A survey questionnaire will be designed off of the content and ideas explored in the first two workshops. This survey will be delivered to Fraser Valley community members in February 2022 to both broaden understanding of food system vulnerability in different areas of the region and explore options for long-term resiliency planning efforts. A third, and final workshop will be delivered in February/March 2022 to build the foundation of future efforts by key food system stakeholders in the region. This includes:

1. Exploring existing food system assets, not limited to infrastructure, programs, but also to people and networks
2. Building from existing assets to increase adaptive capacity, explore reconfigurations of the landscape, increase coordination among food system actors, and scale up key initiatives and efforts
3. Continuing to build and strengthen relationships between stakeholders, food system organizations, and governance to develop long-term stamina and capacity to transition the food system.

## Appendices

### Appendix A: List of Participating Organizations

University of the Fraser Valley
Fraser Valley Regional District <sup>a</sup>
Archway Abbotsford Food Bank
City of Abbotsford
City of Mission
Community Futures/FRESH Network
Fraser Health Authority
Hope Community Services
Mission Community Foundation
Mission Community Skills Center Society
Mission Food Coalition/FRESH Network

<sup>a</sup> The FVRD was unable to attend this workshop due to the flood emergency. Additional comments and responses were included upon revision of the draft summary report.

### Appendix B: Hazards and Food Systems Impacts - Padlet Data

#### *Environmental Hazards & Food System Impacts*

Table A: Increase in Wildfires in the Fraser Valley & Food System Impacts

Primary Impacts	Secondary Impacts	Third-Level Impacts
Loss of grain reserves/seed stock		
Crop damages/losses	Farmer loss of income	
Crop damages/losses	Decreased food supply	
Animal damages/losses	Farmer loss of income	
Animal damages/losses	Decreased food supply	
Animal damages/losses	Animal waste contamination of environment	
Soil contamination / destruction		
Infrastructure damage	Power outages	
Infrastructure damage	Water access	
Infrastructure damage	Supply chain disruptions	Increased food waste
Transportation route closures	Increase in global food imports	
Community Panic	Food hoarding	Decreased food access
Community Panic	Gas hoarding	
Impacts on low income population	Providing services becomes challenging	
Increased cost of living	Diminished household supplies	

Primary Impacts	Secondary Impacts	Third-Level Impacts
Increased cost of living	Diminished housing availability	
Increased cost of living	Decreased food supply	Decreased food access
Increased cost of living	Increased insurance costs	Decreased food access
Increased demand on healthcare services	Increased cost of rebuilding	Abandonment of house/ neighbourhood
Increased demand on healthcare services	Recovery from repetitive fires challenging	
Increased demand on healthcare services	Higher rates of illness, hospitalization, and mental health impacts	Strain on neighbouring municipalities
Increased cost of rebuilding	Decreased rebuild of infrastructure	
Increased cost of rebuilding	Decreased livelihood	
Increased cost of rebuilding	Loss of jobs & businesses	
Increase in global imports		
Impacts on global supply chains	Decrease in GDP	

Table B: Increase in Flooding in the Fraser Valley &amp; Food System Impacts

Primary Impacts	Secondary Impacts	Third-Level Impacts	Fourth Level Impacts
Just in time' food safety training			
Loss of water supply	Animal damages/ losses	Economic viability/ farmer losses	
Loss of water supply	Dependence on foreign suppliers	Loss of human food crops	
Loss of power supply	Diminished refrigeration and storage	Food waste	
Loss of food	Loss of feedstock		
Lack of transportation routes	Feeding emergency response workers	Interruptions in supply chain	
Lack of transportation routes	Logistics of livestock evacuation		
Lack of transportation routes	Interruptions in supply chain	Loss of donations	
Lack of transportation routes	Interruptions in supply chain	Loss of access to food	
Loss of agricultural land	Water contamination	Economic viability/ farmer losses	Increased cost of food
Loss of agricultural land	Land contamination		
Loss of agricultural land	Economic viability/ farmer losses	Increase in global food imports	

Primary Impacts	Secondary Impacts	Third-Level Impacts	Fourth Level Impacts
Animal losses	Safe animal disposal	Water contamination	
Animal losses	Safe animal disposal	Land contamination	
Loss of temporary foreign workers			
Loss/damages to agricultural equipment			
Challenges to reach remote and indigenous communities			

Table C: Increase in Droughts/Extreme Heat in the Fraser Valley &amp; Food System Impacts

Primary Impacts	Secondary Impacts	Third-Level Impacts
Biosphere changes	Native species loss	Loss of lumber revenue
Biosphere changes	Native species loss	Habitat loss
Increased susceptibility to other environmental hazards (E.g. wildfires, floods)		
Water shortages	Animal damages/losses	
Water shortages	Higher rates of illness, hospitalization, and mental health impacts	
Increased energy usage for air conditioning, refrigeration	Risk of power failure from extra demand	
Shortages of fans/air conditioners stores selling out		
Labour impacts inability to work in heat	Decreased agricultural production	
Livestock health and safety impacts	Increased insurance costs	
Livestock health and safety impacts	Increased veterinary costs	
Diminished food production - crop damage/loss	Impacts to local supply chain	
Diminished food production - crop damage/loss	Impacts to charitable food system	
Diminished food production - crop damage/loss	Decreased feedstock exports	Drop in GDP contribution from agriculture
Diminished food production - crop damage/loss	Increased feedstock imports	Drop in GDP contribution from agriculture

Primary Impacts	Secondary Impacts	Third-Level Impacts
High impact of vulnerable populations - isolated, limited cooling options, pre-existing medical conditions		
Long-term damage to soils	Diminished soil water storage capacity	Diminished nutrient retention capacity
Negative impacts to habitat		
Reduced capacity to achieve UN SDGs	Loss of animals/fish/birds	
Need to change to heat resistant crops		
Increased risk for wildfires		

Table D: Increase in Air Pollution in the Fraser Valley &amp; Food System Impacts

Primary Impacts	Secondary Impacts	Third-Level Impacts
Decreased agricultural worker health	Decreased agricultural production	Increasing food costs
Decreased agricultural worker health	Decreased agricultural production	Food hoarding
Decreased agricultural worker health	Decreased agricultural production	Food shortages
Negative human health impacts (elderly, immune compromised, asthma)	Higher rates of illness, hospitalization, and mental health impacts	
Negative livestock health impacts	Decreased animal production	Decreased food supply
Negative livestock health impacts	Decreased animal production	Panic buying
Negative livestock health impacts	Decreased animal production	Increased food insecurity
Diminished crop health	Pollinator decline	Decreased food supply
Diminished crop health	Decreased crop quality	Decreased food supply
Diminished crop health	Increased disease and pest occurrence	Decreased food supply
Reduced food access	Increased need for government financial support	
Adjacent areas impacted from wind - e.g. forest/artificial fires?	Higher rates of illness, hospitalization, and mental health impacts	
Environmental advisories to stay indoors		

Table E: Increase in Water Pollution in the Fraser Valley &amp; Food System Impacts

Primary Impacts	Secondary Impacts	Third-Level Impacts
Freshwater conflicts	Increased demand on groundwater resources	
Loss of critical fish habitat	Drop in salmon populations	Negative impact Indigenous Food Sovereignty and cultural traditions
Agriculture and food industry diminished water access	Loss of jobs & businesses	
Agriculture and food industry diminished water access	Loss of jobs & businesses	
Increased mortality and illness of livestock	Increased demand of clean up responses	
Increased mortality and illness for people	Increasing cancer rates (heavy metals/ biomagnification)	
Increased energy needs for boil water advisories	Purchase of expensive infrastructure	
Increased water rationing	Purchase of expensive infrastructure	
Loss of insects/pollinators	Decreased agricultural production	

Table F: Loss of Wildlife Habitat &amp; Ecosystems in the Fraser Valley &amp; Food System Impacts

Primary Impacts	Secondary Impacts	Third-Level Impacts	Fourth Level Impacts
Loss of pollinators			
Loss of riparian habitat	Loss of salmon	Increased food insecurity	
Loss of riparian habitat	Loss of salmon	Fisheries and fisher impacts (viability)	
Loss of riparian habitat	Loss of salmon	Negative impact Indigenous Food Sovereignty and cultural traditions	Increased conflict between farmers and wildlife
Loss of productive farmland	Decreased food supply	Impacts to charitable food system	
Loss of productive farmland	Decreased food supply	Loss of affordable foods	
Loss of productive farmland	Increased conflict between farmers and wildlife		
Loss of productive farmland	Available farmland more expensive	Displaced farmers	
Loss of productive farmland	Available farmland more expensive	Food variety diminishes	

Primary Impacts	Secondary Impacts	Third-Level Impacts	Fourth Level Impacts
Loss of productive farmland	Increase in greenhouses	Less land for wildlife	
Supply chain disruptions	Loss of predators		
Supply chain disruptions	Increased pest populations		
Increased dependence on industrial agriculture/ monocultures	Introduction of invasive species	Loss of native/ indigenous plants and wild stocks	
Increased environmental toxins and contaminants	Increased conflicts between farmers and environmental agencies		

### *Socioeconomic and Political Hazards and Food Systems Impacts*

Table G: Rapid Population Growth in the Fraser Valley & Food System Impacts

Primary Impacts	Secondary Impacts	Third-Level Impacts
Rapid increase in poverty		
Increase in food waste		
Increased demand for affordable housing	Diminished housing availability	
Increased workforce		
Increase demand/need for transportation infrastructure		
Increased demand in health services		
Increased demand for schools & childcare		
Increased demand for food	Increased need for accessible food retail	Increased demand for agricultural and food workers
Increase in conflicts around land uses	Increased demand for agricultural spaces	
Increase in conflicts around land uses	Need to build out infrastructure encroaching on private lands	
Increase in conflicts around land uses	Decrease in wildlife habitat	Decrease in biodiversity
Increase in conflicts around land uses	Increased demand for building infrastructure	

Table H: Rapid Population Decline in the Fraser Valley &amp; Food System Impacts

Primary Impacts	Secondary Impacts	Third-Level Impacts
Loss of agricultural workers	Diminished food supply	
Less strain on health system		
Farmer population decline	New entrant limitations	Access to market spaces
Fewer new farmers		
Less pressure on ALR for non-farming development		
Increased urbanization	Loss of agricultural workers	

Table I: Threat of War, Conflict or Invasion in the Fraser Valley &amp; Food System Impacts

Primary Impacts	Secondary Impacts	Third-Level Impacts
Increased conflict around transboundary watershed	Impacts to water resources downstream	
Northward migration from USA	Rapid population increase	
Increasing price of commodities (foods)	Food rationing	
Increasing price of commodities (foods)	Usual shipping lanes interrupted for military movement	Loss of ability to move food goods
Increasing price of commodities (foods)	Loss of workers	Immigration interruption
Increased foreign speculation and ownership of agricultural lands		
Food supply interruptions	Decreased food supply	
Food supply interruptions	Increased cost of food	
Movement of foods disrupted from planes/ships/rail/freight		

Table J: Economic Recession and/or Market Failure in the Fraser Valley &amp; Food System Impacts

Primary Impacts	Secondary Impacts	Third-Level Impacts
Increased food waste	Diminished coordination of supply and demand of food	
Shifts timing of ag industry	Inability to sell crops/livestock	Cascading effects with market collapses
Shifts timing of ag industry	Increased reliance on safety net	Cascading effects with market collapses
Increase in reliance on foreign aid/borrowing	Increased in interest rates	Loss of livelihoods
Increase in reliance on foreign aid/borrowing	Increase in taxes/inflation	
Forced to sell farm properties	Diminished economic activity	Decreased farmer revenues

Primary Impacts	Secondary Impacts	Third-Level Impacts
Increased unemployment	Increased homelessness	
Increased unemployment	Higher rates of crime	
Increased unemployment	Social support needs increase	Increase in personal stress and distress
Increased consumption of cheap/less nutritious foods	Increased risk of illness/malnutrition	Impacts on learning and relationships
Increased trauma and negative mental health of children growing up in poverty		

### Appendix C: Network Analysis Legend of Food System Impacts for Hazards

Figure ID	Description	Figure ID	Description
1	Reduced water availability	71	Safe animal disposal needs
2	Loss of productive farmland	72	Increase in greenhouses
3	Animal damages/losses	73	Usual shipping lanes interrupted for military movement
4	Supply chain disruptions	74	Increased reliance on imports
5	Land use conflicts	75	Increased in interest rates
6	Reduced labor	76	Introduction of invasive species
7	Laborer health impacts	77	Impacts to mental health
8	Loss of pollinators	78	Impacts on Indigenous food sovereignty
9	Diminished crop quality/health	79	Loss of grain and seed stock
10	Reduced feedstock supply	80	Just in time food safety training
11	Crop damages/losses	81	Reduced labor
12	Reduced affordability	82	Loss/damages to agricultural equipment
13	Food supply interruptions	83	Challenges reaching remote and Indigenous communities
14	Cost of rebuilding infrastructure	84	Shortages of fans and air conditioners
15	Increased food waste	85	Reduced capacity to achieve UN SDGs
16	Forced to sell farm properties	86	Need to change to heat resistant crops
17	Increased demand for affordable housing	87	Environmental advisories to stay indoors
18	Loss of power supply	88	Rapid increase in poverty
19	Loss of soil quality	89	Increased workforce
20	Loss of critical fish habitat	90	Increase need for transportation infrastructure

Figure ID	Description	Figure ID	Description
21	Limited transportation routes	91	Increased demand for schools & childcare
22	Community panic	92	Less pressure on ALR for non-farming development
23	Increased food price	93	Increased foreign ownership of agricultural lands
24	Increased unemployment	94	Movement of foods disrupted from planes/ships/rail/freight
25	Increased stress on healthcare services	95	Decline in GDP
26	Health impacts to vulnerable populations	96	Increase need for building infrastructure
27	Wind erosion	97	Diminished coordination of supply and demand of food
28	Diminished agricultural production	98	Decreased household supplies
29	Transboundary water conflicts	99	Decreased housing availability
30	Timing changes for agriculture	100	Food rationing
31	Increase in reliance on foreign aid/borrowing	101	Gas hoarding
32	Increased contaminants	102	Higher rates of crime
33	Impacts to livestock health	103	Increased stress on charitable food services
34	Freshwater conflicts	104	Impacts to local supply chain
35	Increased food demand	105	Impacts to water resources downstream
36	Reduced food access	106	Increase in taxes/inflation
37	Increased consumption of low-nutrition food	107	Increased conflict between farmers and wildlife
38	Impacts to public health	108	Increased conflicts between farmers and environmental agencies
39	Increased dependence on monocultures	109	Increased cost of food
40	Increased urbanization	110	Increased demand for agricultural spaces
41	Decreased food supply	111	Increased demand of clean up responses
42	Agriculture and food industry diminished water access	112	Increased demand on groundwater resources
43	Loss of riparian habitat	113	Increased homelessness

Figure ID	Description	Figure ID	Description
44	Biosphere changes	114	Increased need for government financial support
45	Farmer population decline	115	Increased veterinary costs
46	Infrastructure damage	116	Increasing cancer rates
47	Impacts on low income population	117	Logistics of livestock evacuation
48	Increased energy consumption	118	Loss of biodiversity
49	Increased water rationing	119	Loss of predators
50	Northward migration from USA	120	Infrastructure encroaching on private land
51	New entrant limitations	121	Providing services becomes challenging
52	Inability to sell crops/ livestock	122	Purchase of expensive infrastructure
53	Increased reliance on safety net	123	Rapid population increase
54	Diminished economic activity	124	Recovery from repetitive fires challenging
55	Food hoarding	125	Stress on power grid
56	Increased insurance costs	126	Abandonment of house/ neighbourhood
57	Decreased animal production	127	Access to market spaces
58	Increased crop disease and pests	128	Cascading effects with market collapses
59	Diminished soil water storage capacity	129	Diminished nutrient retention capacity
60	Increased farmland prices	130	Displaced farmers
61	Decreased feedstock exports	131	Impacts to fisheries
62	Increased feedstock imports	132	Decreased food variety
63	Water contamination	133	Impacts to immigration
64	Loss of salmon	134	Impacts on learning and relationships
65	Diminished refrigeration and storage capacity	135	Increased labour demand
66	Native species loss	136	Increased food insecurity
67	Impacts to livelihoods	137	Impacts to food distribution
68	Increased need for social services	138	Loss of donations
69	Increased need for food retail access	139	Loss of lumber revenue
70	Emergency response food demand	140	Strain on neighbouring municipalities