

Understanding the vulnerabilities and resilience of food systems: A case-study of three food service operations in the City of Vancouver

by
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Approval

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Abstract

Local governments are increasingly undertaking research to identify vulnerabilities of their food system with the goal of understanding how food security will be impacted during and after a disturbance. This research uses a case study of three food service operations (FSOs) within the City of Vancouver to understand how a short term and a long-term disturbance may impact the FSOs' ability to provide low-cost meals to the public in need of this service. Food service operations set the menu, purchase, prepare and serve food at a facility or institution such as a community centre cafeteria. The aims of this research are to: (1) characterize vulnerabilities of the FSOs, and (2) identify characteristics of the FSOs that can or do increase resilience to the disturbances. This research develops a framework, the Food Service Operations Vulnerability Assessment Framework, to assess the overall impact a disturbance may have on the FSOs' ability to provide food. The Framework was developed through a literature scan of food system vulnerability, through resilience research, and by incorporating and building upon similar frameworks used by other local governments. Interviews with the three FSOs staff were conducted and applied to the Framework, using the disturbances of an extreme weather event and an earthquake as hypothetical examples. Results found that the structural stability of buildings, power and water supply are the most vulnerable characteristics, as damage to them is likely to reduce the ability of the FSO to provide food to the public. Possible cumulative impacts, such as simultaneous road network damage and power loss, increase the vulnerability of the FSOs. The flexibility and resourcefulness of the FSOs staff, the multiple food distributors to the FSOs and on-site food storage may increase the resilience of the FSO to disturbances. Overall, this research provides other FSOs with a framework to understand their vulnerabilities and identifies resilience characteristics that could maintain food security during and after a disturbance.

Keywords: Food System Vulnerabilities; Food Service Operation Resilience; Post-Disturbance Food Security

Dedication

To the Food Service Operations (Low-Cost Meal Program) staff and the City of Vancouver; may this research aid in the continual provision of meals to the Vancouver community.

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List of Acronyms

| | |
|------|-------------------------|
| LCMP | Low Cost Meal Program |
| FSO | Food Service Operations |

Glossary

| | |
|------------------------|---|
| Disturbance | The term disturbance and hazard are used interchangeably in this research to mean an event or condition that impacts the normal functioning of the food system. |
| Food distributors | Food distributors are the companies that transport food directly to the low-cost meal programs from food warehouses in the region. |
| Food service operation | A food service operation sets the menu, purchases, prepares and serves food at a facility or institution. |
| Framework | Framework refers to the “Food Service Operations Vulnerability Assessment Framework”. It is a framework intended for use by food service operations or other organizations purchasing, preparing and serving food. |
| Hazard | The term disturbance and hazard are used interchangeably in this research to mean an event or condition that impacts the normal functioning of the food system. |
| Low-cost meal programs | The “low-cost meal programs” is the name used to describe the three food service operations studied in this research. The low-cost meal programs set the menu, purchase, prepare and serve food to the public in Vancouver. |

Chapter 1. Introduction and Background

Increasingly, cities are studying their food systems to understand the food security of their citizens after a disturbance. Food systems are deeply intertwined with global-scale systems such as climatic, economic and political systems. Cities must respond to how these global-scale systems impact food security of individuals within their jurisdictions. Cities are the first level of government that feels the impacts and responds to disruptive events such as earthquakes, storms and social unrest, which have the potential to negatively impact their food systems. Studying the vulnerabilities and resilience of a city's food system is an approach currently used to gain knowledge about post-disturbance food security. These food system analyses are being used to identify weaknesses in, and threats to, a city's food system with the goal of making recommendations for actions to mitigate vulnerabilities and increase resilience, ensuring food supply returns to pre-disruption levels quickly and equitably following a disturbance (Zeuli & Nijhuis, 2017). The City of Vancouver is seeking to join these cities to understand the resilience of their food system and how disruptions may impact the food security of its citizens.

Toronto, Baltimore, Boston and New York City are among the cities that have undertaken some form of food system resilience analysis. The Rockefeller Foundation has supported food system resilience research and has created a framework to assess cities' food system resilience, applying this framework to several North American cities including Toronto and Boston (Zeuli & Nijhuis, 2017). Recently, the City of Baltimore has partnered with John Hopkin Centre for a Livable Future and created a framework to analyse the vulnerabilities and resilience of Baltimore's food system (Biehl et al., 2017). In New York City, staff have completed a detailed study of the food distribution system (transportation routes, food warehouses, quantities of food, etc.) that bring food into the city to inform policies and practises to make the food system more resilient (New York, 2016). Dozens of cities in North America have created food system strategies that gather baseline data about their food system and are taking actions to address food security issues, ranging from household to community to post-disturbance food insecurity.

The City of Vancouver has had dedicated staff working on food system and food security topics for over 15 years. In 2007, a Food Charter was created in consultation with citizens of the city, which set a vision for a food system in Vancouver that “promotes education, celebration, a healthy economy, a healthy ecology and a healthy society which benefits the city and the environment” (City of Vancouver, 2007). The dialogue started through the creation of the Food Charter set Vancouver on a path to develop a coordinated municipal food policy. In 2013, a food strategy for the city was produced that set targets to “improve the food system for everyone by addressing issues around the food production, processing, distribution, access, consumption and waste management of food” in a just and sustainable way (City of Vancouver, 2013). Since 2013 there has been positive progress on many of the issues identified within the Food Strategy.

In 2016, the City of Vancouver was chosen to participate in the 100 Resilient Cities program, an initiative of the Rockefeller Foundation, and since then has been drafting a Resilience Strategy for the city. In 2017, a process to renew the Food Strategy took place to ensure the Food Strategy remains relevant to current food system issues. The process produced a report, the *Food Strategy Action Plan for 2017-2020*, that identified three new focus areas to include in Vancouver’s Food Strategy. Food System Resilience was identified as a new focus area with the aim “to inform the City about the flow of food into and out of the region, the short and long-term impacts on residents should food distribution fail, and how to mitigate impacts” (O’Neill & Carten, 2017). The efforts to address food system resilience align with the City of Vancouver’s mandate to develop a broader Resilience Strategy.

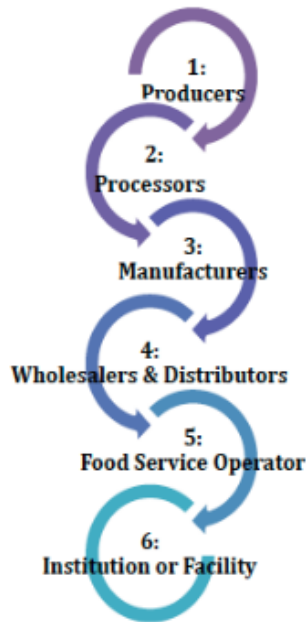
The research in this report builds upon the momentum and goals to understand the resilience of the City of Vancouver’s food system. Studying the resilience of Vancouver’s food system is crucial to ensure food is available to citizens during and after a hazard that has interrupted the food system. Currently, there are no studies that show the flow of food into and out of the Metro Vancouver region or the impacts on residents should food distribution infrastructure fail due to a hazard (O’Neill & Carten, 2017). The research presented here is using a small component of Vancouver’s food system as a case-study to gain knowledge about the broader food system resiliency of the city.

Chapter 2. Literature Review

In this chapter I will situate my research within the context of food systems and the concept of food security. First, I will describe the food system process relevant to my research and define food security. I will then introduce the concepts of vulnerability and resiliency within a food system as factors that influence food security. Finally, I will discuss the role of local governments in identifying vulnerabilities and highlighting resilience opportunities within food systems to address 'place-based' food security. Situating my research within these concepts will set the context for analyzing the case-study of this research and for the subsequent chapters of this document.

2.1. The Food System and Food Security

Food systems are complex and dynamic. The food system includes all the activities, materials and actors involved in the production, processing, transport, preparation, consumption and disposal of food. Food systems occur at many scales; from small communities producing and consuming their own food locally to large organizations purchasing and consuming food from across the world. There are various steps involved in the food system process and the steps will differ depending on the scale of the system. The food system process and its steps relevant to this research is the institutional supply chain as described by Lapalme and Lambla (2013) (Figure1). Some food products (e.g. soup bases) may go through all the steps described in **Error! Reference source not found.** (while others may skip some steps (e.g., cucumbers may skip step 3). Often food waste is also described as part of the food system. Other methods of food access (Step 6) include food retail stores and markets. However, these methods are beyond the scope of this study.



Step 1. Producer: The individuals and business that grow or raise food.

Step 2. Processor: Food products are sent to processors to prepare the raw product for the next step, manufacturing. For example, vegetable products would be washed graded, cut and bagged at this step while meat products would go to an abattoir to be processed.

Step 3. Manufacturers: The minimally processed product from Step 2 goes through a further-value added process, for example the vegetables and meat products are prepared into a canned stew.

Step 4. Wholesalers & Distributors: The products from previous steps are aggregated from hundreds or thousands of producers, processors and manufacturers by wholesaler and distribution companies. Some wholesalers/distributors specialize in specific foods (e.g. meats or vegetables) while others provide a full scope of foods.

Step 5. Food Service Operator: The food service operator (FSO) is a contractor that sets the menu, purchases, prepares and serves food at a facility or institution.

Step 6. Institution or Facility: The institution or facility is the end-user who procures food, through a distributor or a FSO, and prepares and serves food to customers.

Figure 1 Steps in an institutional supply chain (Lapalm & Lambla, 2013).

Food security is an outcome of a food system (Toth et al., 2016). A food system has achieved food security when “all people, at all times have physical, social and economic access to sufficient, safe and nutritious foods that meet their dietary needs” (World, 1996). The food system intersects with other systems such as economic, political, social, transportation, energy, water, and climate. The feedbacks and interactions between the food system and these other systems must be addressed when analyzing a food system’s ability to provide food security. Food security can be assessed at many spatial scales from an individual to a national scale as each have unique factors that influence availability, access and acceptability of food. Food security can also be temporal, as some individuals or communities may experience chronic food insecurity through time (e.g. due to poverty) or short periods of acute, transitory food insecurity due to a shock or disturbance that negatively impacts the food system (Food and Agriculture, 2008). A well-functioning food system that results in food security ensures food is accessible, available and acceptable to all people at all times (Biehl et al., 2017). This research looks at one aspect of food security; which is an organization’s capacity to ensure food is available to consumers (who may be chronically food insecure) during a hazard that is disruptive to other systems on which the food system is dependent.

2.2. Food System Vulnerability and Resilience

Vulnerability is the degree to which a system is susceptible to, or unable to cope with a disturbance (City of Vancouver, 2012). Vulnerability is a function of *exposure*, *sensitivity* and *resilience* to a disturbance, and when these three factors are combined, they influence the overall response of a system (Lengnick, 2015; Prospero, 2016). The characteristics and magnitude of the hazard experienced by a system will influence the system's *exposure* to the hazard. *Sensitivity* is the degree to which the system is affected by a hazard (City of Vancouver, 2012). *Resilience* is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012). *Exposure*, *sensitivity* and *resilience* are three functions of vulnerability used to understand the response to a change (e.g. caused by a hazard) in the dynamic interactions between environmental, political and social systems (Gallopín, 2006).

The level of vulnerability of a food system will influence its ability to achieve food security post-disturbance. Being unable to cope with a disturbance often results in a decrease in food security for the affected populations within that food system (i.e., less food is available because of the disturbance). The conditions determined by the physical, social, economic and environmental characteristics of the food system and interacting systems influence the susceptibility of the system to the impacts of the disturbance or hazard¹ (United Nations, 2017). A Framework (the Food Service Operations Vulnerability Assessment Framework) to assess the vulnerability of food systems to hazards is developed in this research and described in Chapter 4.

As mentioned, the vulnerability of a food system cannot be fully understood without knowing the resilience of that system. The concept of resilience has been used in many disciplines, including foundationally in ecology and natural resource management, and more recently in international development, health, disaster management and food security (Quinlan et al., 2016). C.S Holling first described resilience in the context of ecological systems as a management approach based on

¹ The term disturbance and hazard are used interchangeably in this research to mean an event or condition that impacts the normal functioning of the food system.

viewing events in a regional rather than local context, emphasizing heterogeneity of systems and assuming unexpected events will occur that need to be managed (Holling, 1973). He described resilience as “the ability to experience change and disturbance without catastrophic qualitative change in the basic functional organization” (Holling, 1973). A system is no longer resilient when it cannot absorb stresses and shocks without undergoing a fundamental change involving loss of function (Levin, et al., 1998). These basic concepts of resilience are the foundational theory that informs food system resilience research.

Resilience is a property of a system that is not static; it is a property that is always changing over time as internal conditions change or conditions of the larger systems in which it is embedded change (Cabel & Oelofse, 2012). Despite these changing properties, it is useful to identify and operationalize characteristics of resiliency of a system to ensure continuation of that system’s function during a hazard. To put resilience into a food system context, Tendall et al. (2015) describe food system resilience as “the capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances (pg. 19)”. This definition situates food system resilience as a concept within food security - more resilient food systems will be more likely to result in food security (Figure 2).

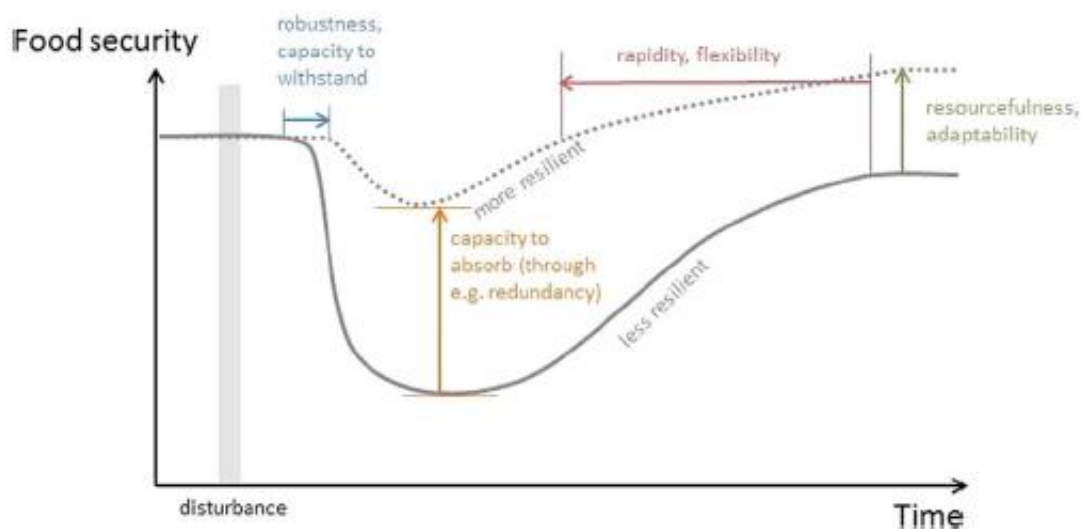


Figure 2 Food system resilience as the capacity to provide food security over time and despite disturbances (Tendall et al., 2015).

Social, ecological, economic, technical and organizational resilience are all interrelated aspects that affect the resilience of food systems. Economic resilience is the capacity to avoid or reduce potential financial losses due to a disturbance (Bruneau et al., 2003; Tagtow & Roberts, 2011). Social resilience is the web of relationships that enables the communities' to cope with disturbances while positively adjusting to change (Tagtow & Roberts, 2011). Ecological resilience is the capacity of ecosystems to withstand disturbances without changing basic processes and structures (Holling, 1973). Technical resilience is the ability of the physical systems (buildings, roads, utilities, etc.) to perform at acceptable/desirable levels when subjected to a disturbance (Bruneau et al., 2003). Last, organizational resilience is the capacity of organizations to maintain decision making and management abilities and exhibit adaptive, flexible governance during and after a disturbance (Bruneau et al., 2003; Smith & Lawrence, 2018). These dimensions of resilience need to be considered when attempting to recognize resilience of a food system.

2.3. Local Governments and Food Security

Local governments are increasingly taking a role in food systems policy and planning to help ensure household, community, and post-disturbance food security for their citizens. One way local governments and cities across North America are doing this is by analyzing vulnerabilities of their food systems to understand their resiliency in the face of potential hazards. Food system vulnerability and resilience analyses are being used to identify weaknesses in a city's food system with the goal of making recommendations for actions to mitigate vulnerabilities and increase resilience and food security following a hazard (Zeuli & Nijhuis, 2017). As vulnerabilities to hazards vary greatly based on location, local governments are well situated to address hazards and impacts specific to their location. "Place-based" analysis has been used to describe research that encompasses spatially continuous communities coupled with environmental systems, such as a city's food system (Turner et al., 2003). While many hazards are influenced by global-scale processes (such as climate change), understanding the potential responses of a place to these hazards can be accomplished by local analyses. The uniqueness of food systems in different places makes undertaking 'place-based' analyses involving stakeholders at the local level even more relevant. Cities conducting place-based analyses of their food systems can help to

address the unique areas of vulnerability and areas of resilience to be fostered within their food system to enhance food security.

Chapter 3. Research questions

A case-study emerged as a research project for my Master's degree to support the City of Vancouver's food system resilience research. Due to the limitations of time and resources for my Master's project, in addition to the complexities of analyzing the entire vulnerability and resiliency of the City's food system, a small aspect of the City's food system was identified as the research focus. Often, understanding how smaller systems function can inform the basic needs for larger systems. It is hoped that this case-study can inform future research into the broader food system resilience of the City.

This case study aims to assess the vulnerabilities and resilience of three food service operations providing meals to the public in Vancouver, in the presence of hazardous events. A food service operation sets the menu, purchases, prepares and serves food at a facility or institution. The City of Vancouver funds three low-cost meal programs (LCMPs) that offer affordable meals (\$2-4) 3 times a day, 365 days a year to the public. The LCMPs are food service operations. The LCMPs are in areas of the city where there are many people who are homeless and people on low incomes living in single room occupancy residents with no kitchens. The LCMPs are one measure to address the day to day food insecurity of community members by lowering the economic barriers to food access. This case-study analyzes food availability provided by the LCMPs when they are exposed to hazards by assessing the vulnerabilities and resilience of the programs. The two hazards chosen for the research are an extreme weather event and an earthquake.

The research questions and sub-questions that emerged from this process are:

1. Using an extreme weather event and an earthquake as examples: How vulnerable are the programs to the hazards?
 - i. What are the characteristics of the LCMPs that may make them vulnerable to hazards?
2. What are attributes of a resilient food system?
 - i. What are the characteristics of the LCMPs that may make them more resilient to hazards?

Chapter 4. Methods

In this chapter I will describe the development of this research topic and project. I begin by detailing the conceptualization of the topic, then highlight the literature scan conducted to situate the research within the current thinking of this topic. I then outline the interview process and selected interviewees for the project. The chapter finishes with a detailed description of the Food Service Operations Vulnerability Assessment Framework developed through this research to assess the vulnerabilities and resilience of the low-cost meal programs.

4.1. Research Topic Development

Conceptualization of this research project began in April 2018, with an initial meeting between me, City of Vancouver staff and Metro Vancouver staff (collectively referred to as the Food Resilience Steering Committee). The topic of food system resilience within the City of Vancouver emerged as an area of interest for all parties involved during the initial meeting. Through dialogue with the Food Resilience Steering Committee, the scope of the research was narrowed into a manageable project for my master's research. The entirety of Vancouver's food system could not be analyzed as has been done in other cities, but a case study relating to one part of the food system emerged as a useful project to complement the City of Vancouver's food system resilience work. The three low-cost meal programs in the City of Vancouver were chosen for the case study analysis because they are City-run programs and therefore relationships with city staff and program managers already exist. Additionally, the programs are important food providers in the communities where they are located. The Food Resilience Steering Committee met 2 times in person and had many exchanges over email to provide advice on research direction and feedback on draft documents, from conceptualization to the final product.

4.2. Food System Vulnerability and Resilience Literature Scan

The first stage of the research was to scan the literature for work or information on food system vulnerability and resilience from other cities or regions. Academic

studies, government reports and non-governmental organization documents were all included in the scan to gain a broad understanding of research being done on the topic. The following phrases were used to scan the literature: resilient food system, food system resilience assessments, operational resilience, resilient system characteristics, food system vulnerabilities, vulnerability assessment. Included in the scan were food system resilience studies completed by other cities, including Baltimore, Toronto, Boston, and New York. The processes and frameworks they used were incorporated into the Framework resulting from this project. The aim of the scan was to understand what conditions and characteristics influence vulnerability and what attributes make a system resilient. Literature from the ecological and natural resource management areas of study have identified attributes that make a social-ecological system resilient. Cornerstones of resilient systems include capacity for learning, adaptation, self-organization and maintaining diversity and redundancy as well as many other attributes (Biggs et al., 2012). These qualities were used in this research since they are useful descriptive attributes of the resilience of any system

4.3. Interviews

Results from the literature scan and feedback from Sarah Carten (a Social Planner from the City of Vancouver who helped initiate this research project) and Evelyn Pinkerton (senior supervisor) informed the development of the interview questions for the kitchen managers and program operators of the LCMPs (Appendix A). Interview participants were selected in partnership with Sarah Carten. Participants interviewed were chosen because of their intimate knowledge of the functioning and daily operations of the low-cost meal program.

Interviews were conducted in person between June and August of 2018. Four interviews were conducted with kitchen managers and program operators of the low-cost meal programs. All interviews were audio recorded to allow for a more natural conversation. All interviews lasted approximately one hour and were conducted in accordance with the ethics protocol approved by Simon Fraser University, study number 2018s0253 (Appendix B). Interviews were transcribed manually to allow for full quotations to be available. Interview transcriptions were organized by question themes and specific types of questions; the data was then compared across the three low-cost meal programs using excel. Preliminary findings of the research were reported and

feedback was received during a meeting in October 2018 with the LCMP managers and City of Vancouver staff. Results were provided to the City of Vancouver and the LCMPs in a summary document in March of 2019.

The intent was also to interview food distributor companies from which the low-cost meal programs order food. Interviews with the low-cost meal program employees revealed which food distributors supply food to each of the LCMPs. The purpose of interviewing food distributor companies was to reveal characteristics about the food flowing from the distributor company to the low-cost meal programs (e.g., transportation routes to the low-cost meal programs taken by food delivery trucks, volumes of perishable vs. non-perishables foods, origin of foods, etc.). Appendix A includes a list of the questions developed to ask of the food distributor companies. Nine food distributors were contacted with an interview request. The companies were contacted via email for an interview request and then followed up with a phone call. One company responded with partial answers to the interview questions over email. The eight other companies either declined the request for an interview or never responded to the interview request. Due to the lack of information received from food distributors, only the locations of the companies and their assumed transportation routes to the LCMPs were used in the analyses of this research.

4.4. Food Service Operations Vulnerability Assessment Framework Development

Results from the literature scan informed the development of the 'Food Service Operations Vulnerability Assessment Framework' (the "Framework"). A framework for assessing the vulnerability and resilience of the LCMPs was formulated because most of the current frameworks in the literature focus on the whole food system, and not from the perspective of a food service operation. The processes and components of frameworks from the literature were incorporated, adapted and expanded upon to create the Framework developed and used in this research. Many of the current frameworks follow the same process for assessing vulnerabilities and resilience of a system. The following section will describe the Framework and provide instructions on how it can be used to support post-disturbance vulnerabilities.

Framework Steps

1. Define the scope
 - a. Vulnerability of what? – Define the subject of study
 - i. Outline the spatial and temporal boundaries of the assessment
 - ii. Describe the operational details of *how* the food service operation provides food *before* a disruption occurs
 - b. Vulnerability to what? – Define the hazards
 - i. Identify hazards with the potential to disrupt food service operations
 - ii. Describe scenarios and assumption of impacts from hazards
 - c. Describe the desired state of the food service operation during and after the hazard
2. Vulnerability Assessment
 - a. Identify exposure to impacts
 - b. Describe sensitivity to impacts
 - c. Identify resilience attributes of food service operations
 - d. Evaluate vulnerability by considering exposure, sensitivity and resilience factors

4.4.1. Define the scope

To assess the vulnerability of the food service operations to a hazard event, three aspects need to be determined. First, outline the spatial and temporal boundaries of the system, to define the scope of the vulnerability assessment (the vulnerability *of what*) (Brzezina, 2016; Resilience, 2010). Second, define the relevant hazards of the assessment (the vulnerability *to what*) (Brzezina, 2016; Resilience, 2010). Third, identify the desired state of the system during and after the hazard (Brzezina, 2016).

1a. Vulnerability of what? – Define the subject of study

i. Outline the spatial and temporal boundaries of the assessment

Determined what aspects of the food service operations are to be included in the assessment. What is the spatial scope of food provisioning? For example, are all steps of the food system included in the assessment? What is the geographic area of the study? Defined the temporal boundaries of the assessment. The temporal boundaries will depend on the hazard event being analyzed. For how long does the hazard and its associated impacts occur?

ii. Describe the operational details of how the food service operation provides food before a disruption occurs

In this section define the characteristics of the food service operations that are needed to provide food. Describe how the food service operations function under normal conditions. Key characteristics might include infrastructure properties, utilities, economic considerations, staffing and social dynamics (Resilience, 2010).

1b. Vulnerability to what? – Define the Hazards

i. Identify hazards with the potential to disrupt food service operations

Hazards have the potential to create challenges for a food service operation to function. The types of disturbances or hazards a food system experiences will shape the effects on the system. Various types of hazards exist, and characteristics of hazards can fall within multiple categories. Hazards can be 'natural' and 'non-natural' and they can be 'chronic stresses' or 'acute shocks'. Natural hazards are naturally occurring events, such as earthquakes and storms (although anthropogenic climate change may influence their severity and frequency), that threaten normal functioning of lives, property, infrastructure and other assets (Biehl et al., 2017). Non-natural hazards are disruptive events that result from a failure in a human-created system or infrastructure component, such as a technological failure, contamination, civil unrest, resource shortages, economic recession, political changes (Biehl et al., 2017). Hazards can be acute shocks, meaning the event is short-term, severe and dangerous; or chronic stressors, meaning the event is present over a long period of time, for example, rising food and gas prices or persistently low levels of income (Barrett & Headey, 2014). The choice of hazards to consider and the impacts of those hazards on the food system when performing an analysis of a food service operation's vulnerabilities and resilience will influence the outcome of the analysis.

ii. Describe scenarios and assumption of impacts of hazards

Once hazards are chosen, created the hypothetical scenarios of the hazard events based on, or adapted from, existing hazard modelling. How long does the hazard last? How severely does it impact the systems surrounding the food service operations that are included in the scope of the study? Describe assumptions of impacts on critical

operational components of the food service operations. For example, does the hazard cause a power outage or flooding?

1c. Describe the desired state of the food service operation during and after the hazard

In this section, identify the desired output from the service operation. Is the desired state to continue to provide food in the same quantity as under 'normal' conditions? Is the desired state to provide half the amount of food? Is the desired condition to provide more food than normal to meet increased demand in an emergency? Identifying the desired state of the system has implications for understanding what adaptation or mitigation strategies are needed to maintain that state during and after a hazard.

4.4.2. Vulnerability Assessment

In this section, the definitions of vulnerability are stated to provide food service operations a clear understanding of these terms. Characteristics of food service operations that influence vulnerability of the organizations are provided but can also be expanded upon and modified to suit the relevant context. The assessment then walks the food service operations through the process of identifying the factors that influence vulnerability and, finally, evaluate the vulnerability of the system to a hazard.

Vulnerability is the degree to which a system is susceptible to or unable to cope with a disturbance (City, 2012). The conditions determined by the physical, social, economic and environmental characteristics of the system and surrounding systems influence the degree or susceptibility of the system to the impacts of hazards or disturbance (United, 2017). Vulnerability is a function of exposure, sensitivity and resilience to a certain hazard, and when these three factors are combined they influence the overall response of a system (Lengnick, 2015; Prospero, 2016). The characteristics and magnitude of the hazard experienced by a system will influence the system's exposure to the hazard. Sensitivity is the degree to which the system is affected (City, 2012). Resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including ensuring the preservation, restoration, or improvement of its essential

basic structures and functions (IPCC, 2012). This vulnerability assessment will consider the exposure, sensitivity and resilience of the food service operations to the identified hazards.

As summarized in Table 1, past studies have identified certain characteristics of food systems that influence vulnerability (Biehl, 2017; Nijhuis, 2015; Zeuli, 2017). The characteristics of the food service operations identified in Section 4.4.1 should be compared with the characteristics described in Table 1. These characteristics can be used to understand the exposure, sensitivity and resilience of the food service operations to the hazards in the next sections of the Framework. Table 1 is not an exhaustive list and additional characteristics of food service operations can be added to the list through future research.

Table 1 Characteristics of the food service operations and their food distributors that increase vulnerabilities and why these characteristics can make the systems surrounding food service operations more vulnerable².

| Characteristics that influence vulnerability | Why characteristics influence vulnerability |
|---|---|
| Buildings | |
| Buildings in physical location of areas affected by the hazard | Potential damage to buildings and infrastructure needed to maintain building, which may damage food and ability to distribute food |
| Concentration of distributors in similar geographic locations | If all distributors are located in areas impacted by hazard, may decrease ability to distribute food |
| Consolidated fresh food distribution: a small number of companies supply food | If the businesses cannot operate due to damage from hazard, food distribution is reduced if there are no alternative distributors |
| Capacity of food storage on site (perishable and non-perishable) | Low levels of food storage mean a reduction in number of meals served if food distributors cannot arrive at program |
| Transportation | |
| Food distribution system uses bridges and tunnels and roads are under vulnerable overpasses | Bridges and tunnels may be more susceptible to damages from hazards, and are points of congestion for truck distribution which negatively impacts the ability to distribute food. During a disturbance like an earthquake overpasses may become unstable and damage underlying roads. |

² Characteristics retrieved, compiled and expanded upon from Biehl et al., 2017; Nijhuis et al., 2015; Zeuli & Nijhuis, 2017.

| Characteristics that influence vulnerability | Why characteristics influence vulnerability |
|---|--|
| Physical condition of roads and transportation infrastructure | Poor quality of road conditions from hazard may reduce ability to distribute food. |
| Availability of local gas supplies | Hazard may decrease availability of gas supply needed to power the delivery trucks. |
| Availability of public transportation | Reduction in availability of public transportation may reduce staff's capacity to arrive at work |
| Reliance on one transportation method for food supplies | If, all food is delivered by truck, and if road conditions do not allow travel by trucks, food cannot be delivered to the institutions |
| Power | |
| Availability of back-up power source | Hazard may disrupt power supply; no back-up power may indicate a suspension in both food delivery and food provision |
| Water | |
| Availability of back-up water source | Hazard may disrupt water supply; no back-up water may indicate a suspension in food production |
| Communication | |
| Dependence on cyber and phone technology | Hazard can reduce ability to communicate between institutions and distributors and institution's staff members, food cannot be ordered from distributors and staff cannot be called into work |
| Logistical | |
| Key staff member(s) needed for operations | If key staff member who runs program is unable to arrive or be present in anyway, potential for loss in coordination and reduction of food availability |
| Stability of funding | If funding sources change could impact amount of food served or institutions ability to remain operational |
| Cumulative Impacts | |
| Interdependency of characteristics | Many characteristics that influence vulnerability are dependent on one another which compounds potential influence on food availability - i.e. if one is impacted, the other will be as well, e.g. if roads are blocked, staffing capacity may be reduced. |

2a. Identify exposure to impacts

The exposure of the food service operations to impacts from hazards will depend on the assumptions of the hazards and the characteristics of the food service operations. For example, the location of a food service operations may be in the floodplain of a river

that floods. Exposure could be identified as a dichotomous yes or no, or there could be varying degrees of exposure to an impact.

2b. Describe sensitivity to impacts

The sensitivity of the food service operation is determined by identifying the magnitude of each impact and assessing how the functionality of the program would be affected if the impact were to occur (City, 2012). This section is where the desired state of the system as described in Framework Step 1c will be considered. For example, if the power goes out and the food service operation needs power to function, the food service operation would be sensitive to that impact. It is up to the assessor how to quantify sensitivity of a food service operation to an impact.

2c. Identify resilience attributes of the food service operations

The resilience of the food service operations is assessed in this section as the third factor of vulnerability. How the food service operations prepare, adapt and respond to the impacts from hazards influence how vulnerable they are to the hazard. The first step to understanding and analyzing resilience is to define it. Resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012). The “essential basic structures and functions” in the above definition can be thought of as the desired state of the system identified in Framework Step 1c. Is the food service operation able to maintain its function during a hazard? To answer this question, resilience of the system is measured.

There are common attributes that occur in the literature when discussing resilience of food systems. Table 2 captures the most common and informative attributes (see Appendix C1 for frequency of resilience attributes in literature sampled). Indicators can be used to help determine if the food service operation system being studied exhibits the resilience attributes.

Table 2 Attributes of a resilient system. Attributes have been compiled from the literature (Table C1, Appendix C).

| Attribute | Description |
|-----------|-------------|
|-----------|-------------|

| | |
|-------------------|--|
| Flexibility | The ability to change operational components while continuing to provide the outcomes. The capacity of the decision-makers to adapt and reorganize program components in response to changing conditions (Smith & Lawrence, 2018). |
| Redundancy | The system has elements which are replaceable, they have a degree of functional overlap and can mitigate negative impacts of disturbances (Tendall et al., 2015). |
| Adaptability | The system is exposed to small disturbances, which “tests” the system’s ability to cope with stressors and shocks (Cabel et al., 2012). |
| Capacity to learn | Ability to learn from past experiences. Changes made after disturbances have occurred to address areas of vulnerability (Lengnick et al., 2012). |
| Preparedness | Planning for disturbances by predicting and preparing for them in order to adapt to their potential threats (Ganin et al., 2016). |
| Robustness | The ability to withstand a certain level of stress from a disturbance without suffering adverse impacts or loss of function (Bruneau et al., 2003). |
| Resourcefulness | The capacity to identify problems, establish proprieties and mobilize resources when conditions exist that threaten to disrupt a system (Bruneau et al., 2003). |
| Rapidity | The capacity of a system to minimize losses and return to normal functioning in a timely manner (Bruneau et al., 2003). |

2d. *Evaluate vulnerability by considering exposure, sensitivity and resilience factors*

This section brings together the three factors of vulnerability (exposure, sensitivity and resilience) to analyze the overall vulnerability of the food service operation to the hazard. It may be helpful to create a scale of how vulnerable the food service operation is to each impact from the hazard. The qualitative scales can identify which impacts and characteristics of the food service operations are the most crucial for maintaining the desired state of the system. The result of this final section will highlight areas of vulnerability of the food service operations.

4.5. Applying the Food Service Operations Vulnerability Assessment Framework – LCMP case-study

The Food Service Operations Vulnerability Assessment Framework developed through this research is used to analyze the case study of the low-cost meal programs in the City of Vancouver. The vulnerabilities and resiliency of the LCMPs to two hazard scenarios are identified through the Framework process. Responses from the interviews with low-cost meal program employees are used to identify vulnerabilities of the LCMPs

and to assess the resiliency of the programs. The decision about which hazards to use in this analysis was done in consultation with the Food System Resilience Steering Committee, to ensure the hazards are relevant to Vancouver. The hazards chosen were an extreme weather event and an earthquake event. To use these hazardous events in the Framework, assumptions about the extent of impacts to the food system were determined. Literature was scanned to gather data and information on the characteristics of these hazardous events and the assumptions about impacts on the food system in the Vancouver area. City of Vancouver employees working on climate change adaptation and earthquake management were contacted to gather information about these two scenarios to align this research with other work being done across City departments. The results of this data collection are described in the case study in the next chapter.

Chapter 5. Results

In this chapter I use the Food Service Operations Vulnerability Assessment Framework to understand the vulnerabilities and resilience of the three low-cost meal programs to the extreme weather event and the earthquake event. The structure of this chapter will follow the steps of the Framework outlined in Section 4.4. In some steps, each of the three LCMPs will be analyzed as individual operations while in other steps they will be analyzed together. The next chapter will discuss the implications of the Framework results.

5.1. Define the scope

This case study is considering how vulnerable and resilient the LCMPs are to hazards that may occur in the region to understand how food *availability* may be impacted. Food availability in this research is the availability of food to consumers provided by the low-cost meal programs. There are two components of food availability in this case study. The first is the availability of food from the food distributors to the LCMPs, specifically the characteristics of the transportation routes - how food moves to the LCMPs. The second is the availability of food to the consumers provided by the LCMPs - the operational ability of the LCMPs to prepare and serve food. The operational characteristics analyzed in this research include: power and water sources, building stability, communication systems, staffing and volunteer characteristics, food storage and the interdependencies of these operational characteristics. Figure 3 shows the pathways of food availability within the scope of the research that may be affected if a hazard occurs and negatively impacts the LCMPs. The other two aspects of food security - accessibility and acceptability - were not incorporated into this research due to limitations of time and resources.

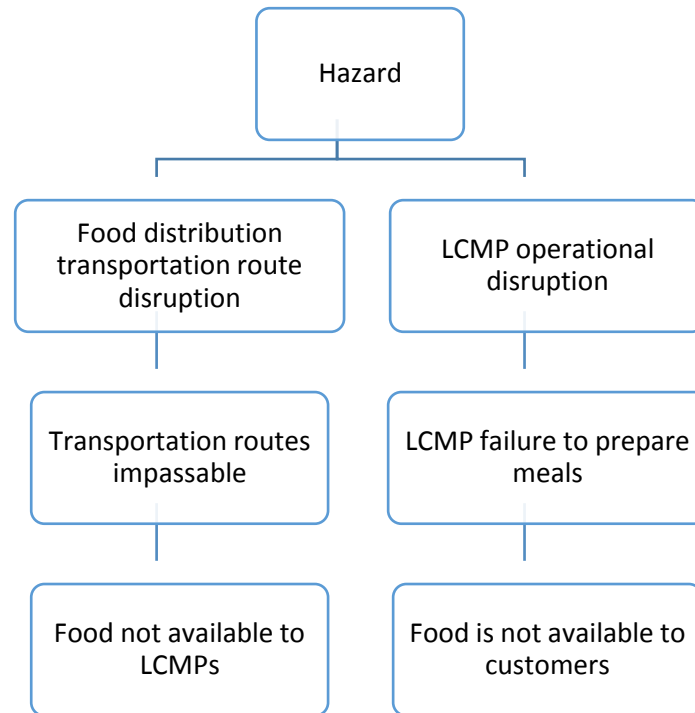


Figure 3 Reasons for food unavailability to the LCMPs within the scope of this study.

5.1.1. Vulnerability of what? – Define the subject of study

Outline the spatial and temporal boundaries of the assessment

This case study will use two hazards, an extreme weather event which has short-term impacts and an earthquake event which has longer-term impacts. The temporal boundaries of this case study are from when the hazards start (e.g., when the impacts of the extreme storm begin) to when the impacts of the hazards have passed (e.g., when the power has returned to the LCMPs).

The spatial boundaries of this case study include the operational characteristics of the three LCMPs funded by the City of Vancouver and their food distribution transportation routes. Not all steps of the food system surrounding the LCMPs will be studied in this research. The steps of the food system considered in my research will be the final three steps from Figure 1 - the wholesalers and distributors, the food service operator, and the institution or facility. The wholesaler and distribution companies will be referred to as the ‘food distributors’ to the low-cost meal programs. The food distributors

are the companies who transport the food directly to the programs from food warehouses in the region. The other two steps of the food system within the scope of this report are grouped together as the Low-Cost Meal Programs and called “food service operations” throughout the report since they are the organizations making food available to customers. The organization of the three LCMPs differs slightly: for one program, the City of Vancouver contracts meal services to an external a food service operator while the other two LCMP are run by City of Vancouver staff. It was beyond the scope of this research to include the producers, processors and manufactures of the industrial supply chain.

Describe the operational details of how the food service operation provides food before a disruption occurs

This section will describe the operational characteristics of the LCMPs to provide the necessary context for the assessment. The LCMPs are funded by the City of Vancouver to provide food at a low cost to the public 3 meals a day, 365 days of the year. The three programs have the same objective which is to provide food at a low cost to the public, but each program has slightly different operational characteristics. This section will outline the similarities in operational characteristics between the three programs and then describe the differences.

Similarities

The LCMPs have been providing meals to the public for over 20 years. All three LCMPs offer breakfast, lunch and dinner to the public at costs ranging from \$2.00/meal to \$3.75/meal. The City of Vancouver subsidizes the remaining cost of the meals as one of their key food supports for the community members of the neighbourhood. Each facility offers all three meals, 365 days of the year: there are no days of the year when meals are not served. The meals typically contain a serving of vegetables/fruits, protein and carbohydrates (Figure 4). General similarities are described in Table 3. All three LCMPs have hot water tanks that provide hot water to the programs. Water tanks at two of the programs are heated by natural gas while the other program has electric powered hot water tanks. The natural gas hot water tanks rely on electricity to operate some components (e.g. the drive motor) of the tank for heating water.



| LUNCH \$2.75 | DINNER \$3.75 |
|--|-------------------------------------|
| Monday | Monday |
| <i>Smoked Salmon, Potato and Cream Cheese Frittata</i> | <i>Pasta with Bolognese Sauce</i> |
| Tuesday | Tuesday |
| <i>Ethiopian Fu'l</i> | <i>Jamaican Pulled Pork</i> |
| Wednesday | Wednesday |
| <i>Chicken Pot Pie Home Made</i> | <i>Lebanese Hashweh Spiced Beef</i> |
| Thursday | Thursday |
| <i>Pork Mapo</i> | <i>Meatloaf with Mushroom Sauce</i> |
| Friday | Friday |
| <i>Spiced Black Beans with Rice</i> | <i>Seafood Dinner</i> |
| Saturday | Saturday |
| <i>Bavarian Smokies</i> | <i>Beef Chow Mein</i> |
| Sunday | Sunday |
| <i>Beef Burger with Cheese</i> | <i>Creamy Bombay Butter Tofu</i> |

Figure 4 Example of meals served at the LCMPs.

Table 3 Operational Similarities of the three LCMPs.

| |
|--|
| Operations |
| Each has its own commercial kitchen and cafeteria room(s). Each have onsite cold (fridge and freezer), and dry food storage. All food arrives by truck to the programs. All need power, water and natural gas to operate. |
| Food/Meals |
| Food is ordered fresh from distributors each week. Meals are prepared onsite. They serve similar types of meals for the public. Very little food is wasted. Most customers accessing the meals come from the nearby areas and a large percentage of the customers are daily reoccurring customers. |
| Staffing |
| Each have cooks, servers and managers on staff. Most staff are full time, union employees. |

Differences

There are a few notable differences between the three LCMPs low-cost meal programs. While they each perform the same function of providing meals to the public, the way they are managed differs slightly. Program B and C are managed by City employees while Program A has been contracted out to an external organization. As such, the number of food distributors, how food is ordered from distributors and delivery schedules to the programs differ from program to program. The number of meals served per day at each program differs: Program A serves 900-1000, Program B serves 720, and Program C serves 550-650. The number of staff and volunteers at each meal time differ between programs as well. Table C2 in Appendix C highlights the differences between the LCMPs. The influence of these differences of the LCMPs will be analyzed in the assessment to understand how they may impact vulnerability.

5.1.2. Vulnerability to what? – Define the Hazards

For this case study, two hazards causing disruptions of different magnitudes are used to assess the vulnerabilities and resilience of the low-cost meal programs. The hazards are: 1) an extreme weather event and, 2) a moderate earthquake. The two hazards have been chosen because they illustrate a short-term disruption (extreme weather event) and a long-term disruption (earthquake) and these hazards are likely to occur in Vancouver in the future. The two hazards of different scales are likely to reveal differences in vulnerabilities and resiliency. This section will outline the rationale behind choosing the two hazards, provide historical context to the hazards, and outline assumptions of the events that are used in this analysis.

Identify hazards with the potential to disrupt food service operations

Extreme Weather Event Hazard

Vancouver and the surrounding areas that make up Metro Vancouver, have experienced many extreme rain and wind storm events of different magnitudes. Windstorms and heavy rain storms are the most common form of natural disturbance in the Metro Vancouver area (Needoba et al., 2017; Read, 2015). Climate change models predict that there will be an increase in intensity and frequency of extreme rain storms as the century progresses (City of Vancouver, 2012). There will be a 17% increase in

precipitation on the wettest single day of the year by the 2050s, and a 32% increase by the 2080s (Metro, 2016). The amount of rain in the wettest 5-day period will increase by 12% by the 2050s, and 25% by the 2080s (Metro, 2016). The increase in precipitation will put pressure on the City's sewerage and drainage systems and during intense rainfall events, storm sewers and urban streams can overflow to cause overland flooding (Metro, 2016). While the consensus on whether windstorms will increase with climate change is not settled, wind storms will continue to occur in the Metro Vancouver area (Needoba et al., 2017). An extreme storm event with strong winds and heavy rains was chosen for this study because of the likelihood of occurrence and projected increase and intensity of extreme rain events.

Earthquake Event

There is a 1 in 4 chance that British Columbia will experience a major earthquake within the next 50 years (City of Vancouver, 2018). The earthquake is expected to cause major damage to buildings and infrastructure, damage to transportation and electricity systems and force many people from their homes. In 2013, the City of Vancouver developed an Earthquake Preparedness Strategy to address the potential impacts of an earthquake in Vancouver. Work is ongoing to understand the risks of an earthquake in Vancouver. The earthquake scenario used by Emergency Management BC (part of the BC Provincial Government) to model the impacts of an earthquake to Vancouver was produced in a 2015 report by Natural Resources Canada. The same earthquake scenario is used in this research to model the impacts from the earthquake event on the LCMPs.

Describe scenarios and assumption of impacts from hazards

Extreme Weather Event Scenario

The following three historical storm events are presented to help qualify the type and extent of storm impact on the region's infrastructure.

1. In November of 2006 there were a series of intense rain events in Metro Vancouver. In some areas 10 to 15 mm of rain per hour fell for 15 consecutive hours (Environment, 2017). The rain events caused landslides to occur in the watershed surrounding Vancouver that provide drinking water to

the City. This increased the turbidity levels in the water treatment system which triggered boil water advisories for two million residents: there was an increased risk of bacteria and viruses in the water supply, and health officials declared tap water unsafe for drinking, brushing teeth or washing fruits and vegetables (Environment, 2017). The advisory was partially lifted the next day for some residents, but it remained in effect for nearly a million residents in parts of Vancouver, Burnaby and the North Shore for another 10 days (Environment, 2017).

2. In December of 2006, Metro Vancouver was hit with an intense wind storm. Wind gusts of up to 158km/hour occurred which uprooted thousands of trees, blocking roads and damaging power lines (Zeidler, 2016). Almost 250,000 customers were without power due to the storm, it was the worst power outage event BC Hydro has experienced to date (Figure 5) (BC Hydrp, 2015b).

| | DECEMBER 11, 2006 |
|---|-------------------|
| Peak number of customers without power | 240,300 |
| Number of customers out after 24 hours | 78,794 |
| Number of customers out after 72 hours | 4,474 |
| Number of damaged transmission circuits | 12 |
| Days required for complete restoration | 10 |
| Cost | \$15.4 million |

Figure 5 Power system impacts from windstorm (BC Hydro, 2015c).

3. On August 29th, 2015 a storm with wind gusts of up to 115 km/hour and rainfall above 100mm in certain locations hit the Metro Vancouver area (BC, 2015a; Pacific, 2015). Trees fell across roads and powerlines, causing more than 700,000 homes and businesses to lose power in the Lower Mainland and Vancouver Island, beating the 2006 storm for the worst power outage in BC Hydro's history (BC, 2015a, BC, 2015b). Localized areas of street

flooding caused some roads to be temporarily blocked and caused delays for public transportation and at the peak of the power outage 140 intersections with traffic lights were without power (CBC, 2015). BC Hydro reports that power was returned to almost all the houses and businesses within 72 hours (BC, 2015a).

These extreme weather events illustrate just a few examples of intense storms experienced by Metro Vancouver in the past and potential impacts caused by the storms. The historical context of past storms and climate change predictions are used to create a scenario of a future extreme weather event that is likely to occur and to impact the LCMPs.

The assumptions used in this case-study of the characteristics of the extreme weather event are as follows:

- It is mid-October, high amounts of rain have been falling for three consecutive days in the Metro Vancouver area. On the third day there are periods of the most intense rainfalls during the morning hours.
- The morning of the third day also sees very strong gusts of winds in Metro Vancouver, with enough force to blow down trees.
- After the strong winds and heavy rains on the third morning, the winds die down and the rains turn into a light drizzle for the next few days.

The assumptions of the impacts to Metro Vancouver infrastructure are as follows:

- The large amounts of rainfall have created flash flooding along some streets, some sections of roads are temporarily impassible.
- The high winds have knocked down thousands of trees onto powerlines, roads and buildings in the Metro Vancouver area - causing widespread power outages, some damage to building infrastructure and some roads have become temporarily impassible.

The magnitude and assumptions of the extreme wind/rain event have been chosen to model the impacts listed in Table 4. For this scenario we are aiming to understand vulnerabilities and resilience of low-cost meal programs when power, roads and communication methods are negatively impacted. Variations in severity and length of storm may lead to different impacts than the ones listed in Table 4.

Table 4 Timeline of assumed impacts with respect to the LCMPs

| | Day 1 (morning is most intense storm period) | Day 2 | Day 3 | Day 4 |
|---|---|---|---|--|
| Electricity | Electricity goes out in LCMPs building early morning and is out all day. No lights or heating in buildings. | Electricity is out all day. No lights or heating or hot water in buildings. | Electricity is out all day. No lights or heating or hot water in buildings. | Electricity comes back on by mid afternoon |
| Roads | Large numbers of roads, including main road arteries into the City of Vancouver have been blocked by trees and flash flooding | Main thoroughfare routes have been cleared by morning, many secondary roads are still blocked | Most roads are cleared of major debris and water | Most roads are cleared of major debris and water |
| Communication: Phone lines and internet access | Phone lines in the LCMPs are down all day. Internet access is reduced. Cell phone service is functioning. | Phone lines are down all day. Internet access is reduced. Cell phone service is functioning. | Phone lines start to function at the beginning of the day. Internet access is back to normal. | Normal functioning |
| Public Transportation | Some bus routes have delays and some routes are cancelled. | Some bus routes have delays and some routes are cancelled. | Busses and return to normal functioning. | Normal functioning |
| Water supply | Not impacted | Not impacted | Not impacted | Not impacted |
| Natural gas supply | Not impacted | Not impacted | Not impacted | Not impacted |
| Buildings | Not impacted | Not impacted | Not impacted | Not impacted |

Earthquake Scenario

The earthquake scenario used in this case-study is produced by Natural Resources Canada and used by Emergency Management BC to outline Provincial coordination between Ministries, other levels of governments and relevant organizations. The scenario represents a worst-case scenario for Vancouver and Metro Vancouver and has been used in this study because of data availability and to align this food system case study with scenarios used by other governments.

The assumptions of the earthquake scenario are taken from the BC Immediate Response Plan (Province of British Columbia, 2015):

- It is early January and southwestern BC has experienced 3 days of intense rainfall (180-300mm) and increase in temperatures at high elevations which has led to rapid melt of snow packs, increase water volume in Northshore watersheds.
- The 7.3 magnitude shallow crustal earthquake hits Vancouver and the lower mainland in the afternoon with 10-20 seconds of shaking, causing buildings to sway, roads to crack, liquefaction on softer soils, and landslides. Fires start throughout the area from damaged electrical power and gas lines and some buildings collapse or shift and crack. Aftershocks are to be expected in the following days, weeks and months, causing additional damage.

The assumptions of impacts on Metro Vancouver:

- The near-surface earthquake results in high frequency shaking which is most hazardous to short buildings. Unreinforced masonry and unreinforced concrete buildings may suffer the greatest damage, including collapse and inhabitability.
- 18 per cent of buildings in Metro Vancouver are most likely to receive extensive damage and 12 per cent are most likely to receive complete damage.
- Injuries will far exceed fatalities and first responders and medical facilities will be overwhelmed.
- Major transport routes may be damaged or partially functional at a much-reduced capacity for an extended period (weeks to months). Many road surfaces may be damaged, some bridges may be closed due to damage and large debris (glass, concrete, etc.) may block routes.
- Disruption to potable water systems and poor sanitation is expected for several months following the event. Lack of water/wastewater may severely impact facilities and reduce operations.
- Many gas lines may have ruptured and ignited, destroying buildings, impacting transportation routes and causing injuries and death.
- Common communication service providers may be impacted, regardless of communication technology provided, including cellular, landline, radio and satellite. If service is available, the network may be overloaded, making communication extremely challenging.

The impacts from the earthquake are presented in Table 5. Vancouver could experience earthquakes of varying degrees, which may differ in severity and length, changing the impacts listed in Table 5. This assessment acknowledges that an earthquake of this magnitude would disrupt all normal routines of citizens, would disrupt all transportation routes, cause mass damage to infrastructure and require increased

need for medical assistance. The impacts listed in Table 5 are relevant for the time period after the initial shock has subsided, in which major medical emergencies have been addressed and staff of the LCMP could potentially return to work. In this scenario we are aiming to understand vulnerabilities and resilience of the low-cost meal programs when all major utilities and infrastructure are impacted for an extended period. Detailed data to support the assumptions are not available due to limitations of time, resources and availability.

Table 5 Timeline of assumed impacts with respect to the LCMPs.

| | Day 1 (afternoon just after earthquake hits) | Day 2 – 7 | Day 8 - 21 | 1 – 3 months after the earthquake |
|---|--|--|---|--|
| Electricity | Electricity goes out in LCMPs building and most parts of the city and is out all day. | Electricity is out in the city. | Electricity is restored to some parts of Vancouver and Metro Vancouver. | As the months progress electricity is restored to most parts of the lower mainland |
| Roads | Most of the main routes leading to downtown Vancouver are damaged and impassible, bridge and tunnel infrastructure have been damaged. | Most of the main routes leading to downtown Vancouver are damaged and impassible, bridge and tunnel infrastructure have been damaged. | Some roads are cleared of major debris and water. Some main roads have been repaired and there is some access into the downtown area. | Most main roads are cleared of major debris and water by the end of the third month. Secondary roads may still be partially blocked. |
| Communication: Phone lines and internet access | Phone lines in the city are down all day. Internet access is reduced. Cell phone service is very limited. | Phone lines in the city are down. Internet access is reduced. Cell phone service is very limited. | Some access to phone and internet services at the end of the week. | By the end of the third month, all phone and internet services are repaired. |
| Public Transportation | Most bus routes in the downtown core are cancelled due to poor road quality. Some Skytrain infrastructure has also been damaged, cancelling and delaying routes. | Most bus routes in the downtown core are cancelled due to poor road quality. Some Skytrain infrastructure has also been damaged, cancelling and delaying routes. | Most bus routes are still delayed or cancelled due to damaged roads. | Near the end of the third month, major public transit routes are operational, but secondary services are still reduced. |

| | | | | |
|---|--|--|--|--|
| Buildings | The structural stability of all the LCMPs buildings are compromised and it is unsafe to enter the buildings. | All the LCMP buildings have been severely damaged and it is unsafe to enter the buildings. | Inspections have been done for the LCMP buildings that were damaged and they will have to be reinforced, renovated or rebuilt. | -- |
| Water supply | No access to water in most areas of Metro Vancouver. Wastewater system has also been damaged. | No access to water in most areas of Metro Vancouver. Wastewater system have also been damaged. | Water is returned to some areas and some wastewater systems are functional. | Water is returned to some areas and some wastewater systems are functional. |
| Natural gas and petroleum supply | No access to natural gas in most areas of Metro Vancouver. Gas stations are unsafe to access. | No access to natural gas in most areas of Metro Vancouver. Gas stations are unsafe to access, the ones that are accessible have run out of fuel. | Most areas still have no access to gas, some lines in metro Vancouver have been restored. Limited supply of fuel in some gas stations. | Most areas still have no access to gas, some lines in metro Vancouver have been restored. Limited supply of fuel in some gas stations. |

5.1.3. Describe the desired state of the food service operation during and after the hazard

The desired state is to maintain the normal operating level of food availability for the customers of the LCMPs. This state means the LCMP system continues to provide the same number of meals per day (or close to) at the start of, during and after a hazard event. How resilient the LCMPs are to the hazards will be evaluated based on the number of meals they could provide when experiencing the hazards.

5.2. Vulnerability Assessment

5.2.1. Identify exposure to impacts and describe sensitivity to impacts

The LCMPs' vulnerability to an impact from a hazard is a function of exposure, sensitivity and resilience factors. This section describes the exposure and sensitivity

factors as they relate to the extreme weather event and the earthquake event. The exposure is a function of the assumptions for the hazards that are made for each scenario. The sensitivity of the LCMPs is determined by the magnitude of each identified impact and assessing how the functionality of the program would be affected if the impact were to occur (City of Vancouver, 2012). Both the impacts to the food distribution transportation system and the LCMPs operational characteristics are analyzed. Due to the assumptions of the hazard events, there are no major differences in how the three low cost meal programs will be exposed to impacts. Therefore, the exposure and sensitivity of all three LCMPs are described as one in Table 6 for the extreme weather event and Table 7 for the earthquake event.

Table 6 Exposure and sensitivity of LCMPs to impacts from the Extreme Weather Event Scenario. N/A (not available) indicates no information could be found, statements made about sensitivity impacts are assumed to be a likely possibility. ‘Critical’ indicates that the impact on the LCMP would mean the program could not serve meals.

| Exposure – Assumed impact from hazard | Sensitivity – Impact on program | |
|--|--|--|
| | Food distribution | LCMP |
| Power | | |
| Reduction in power source for 3 days | Not Available – presumed to reduce ability to distribute foods and potentially negative impact to perishable foods from loss of power | Critical - Need power to see while cooking and for safety reasons; and for hot water |
| Transportation | | |
| Damage to roads, bridges and tunnels for 1-3 days | All the food is distributed by trucks and 4 of the 8 food distributors use bridges and/or tunnels so may have reduction in food deliveries | Some staff who drive may not be able to drive into work. Key staff member who open/runs the program may not be able to arrive at work. |
| Reduction in availability of public transportation | Not Available – presumed that food distribution staff may not be able to arrive at work | Potential that staff members may not be able to arrive at work |
| Communication | | |
| Damage to phone and internet systems | Food distributors may not be able to communicate orders/deliveries with LCMPs | Staff members of the LCMP may have reduced contact with LCMP manager about work schedules. |
| Cumulative | | |

| | | |
|---|---|--|
| Impacts to power, water, buildings, natural gas, transportation and communication will influence each other, resulting in an amplified negative impact and/or impacts that last longer. | Not Available – presumed that cumulative impacts would reduce food deliveries | Assumed to have a negative impact on meal production. For example, when the power goes out, hot water is only available for a limited time before hot water runs out– hot water is needed for proper sanitation of hands and dishes. |
| Buildings | Assumed no impacts | Assumed no impacts. |
| Water Supply | Assumed no impacts | Assumed no impacts |
| Natural Gas Supply | Assumed no impacts | Assumed no impacts |

Table 7 Sensitivity of LCMPs to impacts from the Earthquake Event Scenario. N/A (not available) indicates that no information could be found, statements made about sensitivity impacts are assumed to be a likely possibility. ‘Critical’ indicates that the impact on the LCMP would mean the program could not serve meals.

| Exposure – Assumed impact from hazard | Sensitivity – Impact on program | |
|--|--|---|
| | Food distribution | LCMP |
| Buildings | | |
| Structural stability of buildings have been compromised, as such it is unsafe to enter the buildings | Assumed severe damage to local food distributor buildings | Critical – Staff cannot enter building to access kitchen |
| Power | | |
| Reduction in power source for potentially over a few weeks | Likely to reduce food distributors’ abilities to deliver food to LCMP | Critical - Need power to see while cooking and for safety reasons; and for hot water |
| Water Supply | | |
| Reduction in water supply for potentially over a few weeks | Not Available | Critical - Need water supply for sanitation, food safety and to cook |
| Transportation | | |
| Damage to roads, bridges and tunnels for potentially over a few weeks | All the food is distributed by trucks and all but one distributor uses bridges and/or tunnels so likely reduction in food deliveries | Likely that staff who drive may not be able to drive into work. Key staff member who open/runs the program may not be able to arrive at work. |
| Reduction in availability of public transportation potentially over a few weeks | Not Available | Likely that staff members who use transit may not be able to arrive at work |

| | | |
|--|---|---|
| Reduction in local petroleum supplies potentially over a few weeks | If trucks can pass damaged road system, may find reductions in petroleum distributors to operate trucks | Staff who drive to work may find it difficult to access petroleum supplies for cars |
| Natural Gas | | |
| Reduction in natural gas supply for potentially over a few weeks | Not Available | No hot food could be served as stoves/ovens use natural gas to cook food. Critical – LCMPs B and C with natural gas water heaters cannot heat water for sanitation. |
| Communication | | |
| Damage to phone and internet systems for potentially over a few weeks | Likely that food distributors will not be able to communicate orders/deliveries with LCMPs | Staff members may have reduced contact with LCMP manager. |
| Cumulative | | |
| Impacts to power, water, buildings, natural gas, transportation and communication will influence each other, resulting in an amplified negative impact and/or impacts that last longer | Not Available – presumed that cumulative impacts would reduce food deliveries | When the power goes out, hot water is only available for a limited time before hot water runs out– hot water is needed for proper sanitation of hands and dishes. Assumed that simultaneous power outage, road blockage, reduction in communication and natural gas, etc. would increase probability that meals would not be able to be served. |

5.2.2. Identify resilience attributes of food service operations

The resilience of the food service operations is assessed in this section as the third function of vulnerability. This section will describe the indicators used to assess the resilience of the LCMPs, then will describe the resilience assessment for each of the LCMPs independently.

Development of Indicators

Indicators were developed by asking questions during the interviews that related to the attributes of resiliency. The response of the LCMPs to past disturbances can show

whether the programs exhibited the attributes of flexibility and if areas of vulnerabilities have been reduced from learning how to mitigate impacts (Prosperi, 2016). Interviewees were asked for examples of past disturbances and how the LCMPs coped with the disturbances. These questions provide insight into how the LCMPs have responded to disruptions in the past and the lessons learned from those experiences. Overall there have been no major past disruptions to any of the three LCMPs. However, the LCMPs have each experienced small disruptions which are described in Table 8. Hypothetical questions were also posed to the managers of the LCMPs to understand how the managers of the low-cost meal programs think the program would respond to a disruption (Table 9). The responses to the hypothetical questions are useful as the managers know best how the programs function and what impacts disruptions could have.

Table 8 Past disruptions experienced by the LCMPs

| |
|---|
| LCMP A: Dishwasher malfunction |
| The dishwasher has stopped working for short periods of time on multiple occasions. During these events the program switched to paper plates and plastic cutlery and washed larger dishes (e.g., cooking pots and pans) by hand. The same number of meals were served to the public, so there was no impact on food availability. The program always has plastic cutlery and paper plates in stock in case of this disturbance reoccurring. |
| LCMP B: Water Main Break |
| A water pipe supplying water to the program broke and the program had no access to water for several hours. Without water they were unable to wash hands or food and the bathrooms had no water, which is considered a health and safety issue. The program had to stop providing meals to the public due to this disturbance. |
| LCMP C: Dishwasher malfunction and food unavailability |
| The dishwasher broke and wasn't working for 7 days. The program switched to paper plates and plastic cutlery and washed larger dishes (e.g., cooking pots and pans) by hand. There were times when certain food items could not be purchased due to high prices (e.g. lettuce) or disease outbreaks (e.g. chickens). The meal program would substitute foods that are unavailable with similar foods that were available to provide the same number of meals. |

Table 9 Hypothetical questions and responses of LCMPs to assess potential vulnerabilities and resilience of the LCMPs to impacts.

| |
|---|
| “What if the main food distributors to the programs could not deliver the normal amount of food?” |
| The programs have back-up distributors they would contact to order the food. They would change the meal menu to match the food they could access. It has never happened that all of the distributors were unable to deliver food to the programs. |
| “What if no more food could be delivered to the program?” |

| |
|---|
| The programs would use the food they have in stock and could continue to provide meals for around 3-5 days with food in storage on site. Towards the end of those days the meal qualities would decrease as only the non-perishable food would be left, however food could still be served. |
| “What if the power went out?” |
| The LCMPs would make sure all fridges and freezers are sealed to keep food cold and then would have to evacuate the building due to safety concerns over lack of lighting and heat. When the power returns to the buildings, food would be assessed for its safety, and food needing to be used first before it spoiled would be made into meals. |
| “What if some staff cannot come into work?” |
| If a scheduled staff member could not come into work for whatever reason, the programs have on-call lists of staff to contact. If on-call staff could not come in on short notice, managers who are off may have to come into work to help. In the past if no staff could come into work as a substitute, one meal program mentioned they would remove the staff position of the dishwasher and start using disposable cutlery to continue to provide meals. Two LCMPs have volunteer lists which they could call upon if needed. |
| “How do you think the program would respond in a general emergency situation where normal operations of the program may be impacted?” |
| All three programs said they would do as much as they could, if conditions permit, to continue to put food on the table. They mentioned staff are very resourceful and excellent at triage, so would be able to “pull something off” - whether it be serving canned and dried food or working extra time to provide meals in an emergency situation. |

The indicators used to assess the resiliency of the LCMPs are described in Table 10. The full resilience assessments for Program A, Program B, and Program C can be found in Appendix C Tables C3, C4 and C5 respectively. For simplicity sake, a short summary of the resilience assessment is presented here.

Table 10 Indicators developed to assess resilience attributes of the LCMP.

| Attribute | Indicators |
|------------------|---|
| Flexibility | -Ease of changing distributors -Ease of changing menus -Presence and responsiveness of back-up staff and volunteers |
| Redundancy | -Number of distributors that supply same type of food -Types of communication methods between distributors and LCMPs and LCMPs and staff/volunteers -Modes of food distributor transportation to LCMPs -Number of food distributor transportation routes to the LCMPs -Presence and capacity of back-up power supply and water supply -Presence of a variety of cooking instruments relying on different power sources (e.g. gas ovens, electric ovens, propane burners, hand-powered) |
| Adaptability | -How did the LCMPs cope in the past when operations didn't run as planned due to a disturbance? |

| | |
|-------------------|---|
| | -How do LCMPs employees think the program will react if disturbances do happen? |
| Capacity to learn | -Examples of past responses to disruptions: were changes made to reduce vulnerability to future disruptions? |
| Preparedness | -Presence of an emergency plan: What does the plan cover? -Emergency preparedness training for employees -Number of days of food storage -Number of days of disposable serving ware, plates, cutlery |
| Robustness | -Examples of impact to meal production from past disturbances |
| Resourcefulness | -How have LCMP employees managed past disturbances? |
| Rapidity | -How fast did meal production return to normal after a disruption? |

Resilience Assessment for Low Cost Meal Program A

The full resilience assessment for LCMP A is outlined in Table C3 in Appendix C. Overall LCMPs A exhibits many attributes of resilience. The program can be flexible in changing menus to what food is available, the staff of the program have adapted to a past disruptive situation and have learned from that disruption. In situations where normal operations may be disrupted by a hazard, employees will do what they can to maintain food production in a safe way for the staff and the customers. Characteristics of the LCMP that may reduce resiliency are described in Table 11.

Table 11 Characteristics of LCMP A that may reduce resiliency.

| Attribute | Characteristics |
|--------------|---|
| Flexibility | Back-up staffing capacity may be a concern as employees are full-time so back-up staff rarely get called in to cover shifts. This means a high rate of lost back-up staff as they find other jobs |
| Redundancy | Only method of communication with distributors is over the internet No back-up water or power supply Food arrives only by one method of transportation, by truck |
| Adaptability | No major disruptive events have occurred in the past, so no experiences in dealing with major disruptions to program operations to inform best operational practices during a future disruption |
| Preparedness | Researcher is unsure of what employees are trained on with respect to different emergency situations (e.g. floods, earthquakes) |

Resilience Assessment for LCMP B

The full resilience assessment for LCMP B is outlined in Table C4 in Appendix C. The program is flexible and redundant with food distributors as it has many distributors

which it could order from if the main distributor could not deliver food orders. The program's staff and volunteers are responsive to last minute calls in to work. The program is well prepared to deal with safe building evacuations and has food in storage for many days of meals if food cannot be delivered to the program. The program could be resourceful and creative in meal production if food from distributors were limited. Ultimately, the employees would do what they can with the resources available to cook as much food as possible for customers in a disruptive situation if needed. Characteristics of the LCMP that may reduce resiliency are described in Table 12.

Table 12 Characteristics of LCMP B that may reduce resiliency.

| Attribute | Characteristics |
|------------------|---|
| Redundancy | No back-up water or power supply Food arrives only by one method of transportation, by truck |
| Adaptability | No major disruptive events have occurred in the past, so no experiences in dealing with major disruptions to program operations to inform best operational practices during a future disruption |
| Preparedness | Researcher is unsure of what employees are trained on with respect to different emergency situations (e.g. floods, earthquakes) |

Resilience Assessment for LCMP C

The full resilience assessment for LCMP C is outlined in Table C5 in Appendix C. The operational characteristics of LCMP C exhibit many attributes of resilience. They have a large number of distributors to choose from which increases flexibility and redundancy, they communicate in many different ways with these distributors and their staff and they have experienced disturbances in the past which has not reduced meal production. The program has access to a back-up generator; however, it is uncertain what capacity the generator has to maintain power to the kitchen during an outage. Work is being done at the City of Vancouver to identify generator capacity in emergency situations. Characteristics of the LCMP that may reduce resiliency are described in Table 13.

Table 13 Characteristics of LCMP C that may reduce resiliency.

| Attribute | Characteristics |
|------------------|--|
| Redundancy | No back-up water supply Food arrives only by one method of transportation, by truck |

| | |
|--------------|---|
| Adaptability | No major disruptive events have occurred in the past, so no experiences in dealing with major disruptions to program operations to inform best operational practices during a future disruption |
| Preparedness | Researcher is unsure of what employees are trained on with respect to different emergency situations (e.g. floods, earthquakes) |

5.2.3. Evaluate vulnerability by considering exposure, sensitivity and resilience factors

This section will bring together the exposure, sensitivity and resilience assessments to analyze the overall vulnerability of the low-cost meal programs to the hazards. The vulnerability of the LCMPs to the extreme weather event are analyzed separately for each LCMP and the results are in Tables 14, 15 and 16. The vulnerability of the LCMPs to the earthquake event are analyzed together (Table 17) as there are no major differences between overall vulnerabilities of the program to the earthquake. A summary of the vulnerability of the LCMPs to each event are included below the tables.

A scale of low, medium and high are used to measure the vulnerability of the LCMPs to each impact caused by the hazards. The scale was chosen to illustrate the severity of an impact's influence on food availability. Low indicates the program can likely serve almost the same number of meals as under normal circumstances. Medium indicates the program can serve meals, but the number of meals is likely to be significantly reduced. High indicates the program cannot serve any meals. Each impact is evaluated as independent of the other impacts (except the cumulative impacts section).

Table 14 Vulnerability of LCMP A to the extreme weather event.

| Impact from hazard | Vulnerability of LCMP: Exposure + Sensitivity + Resiliency | Impact on food availability for duration of the hazard |
|--------------------------------------|--|--|
| Power | | |
| Reduction in power source for 3 days | Power has gone out and there is no back-up power supply. There is no lighting so meals cannot be cooked and there is no hot water. | High |
| Transportation | | |

| | | |
|--|--|---------------------|
| Damage to roads, bridges and tunnels for 1-3 days | As the only method of transportation, trucks may not be able to deliver food to the program. However, there is enough food in the storage onsite that meals could still be served for 1-3 days without food delivery. If there are not enough staff members to arrive at work, and a key staff member with ability to unlock/run program, number of meals may be reduced. | Medium |
| Reduction in availability of public transportation | If there are not enough staff members to arrive at work, and a key staff member with ability to unlock/run program, number of meals may be reduced. | Medium |
| Communication | | |
| Damage to phone and internet systems | While there may be reduced communication with food distributors, there is enough food in storage to provide meals for the duration of the event (3 days). If cell phones are functional, they could be used to communicate between staff members. If cell service is disrupted or not functioning there would be limited communication for the duration of the hazard. Staff have set schedules so could assume they would try to be at work if they could, regardless of reduced communication. | Low |
| Cumulative Impacts | | |
| Power loss negatively impacts water availability | Power has gone out which means water cannot be pumped or heated to a temperature that is required for food safe practices. | High |
| Buildings | Assumed no impacts | Assumed no impacts. |
| Water Supply | Assumed no impacts | Assumed no impacts |
| Natural Gas | Assumed no impacts | Assumed no impacts |

Table 15 Vulnerability of LCMP B to the extreme weather event.

| Impact from hazard | Vulnerability of LCMP: Exposure + Sensitivity + Resiliency | Impact on food availability for duration of the hazard |
|--------------------------------------|--|--|
| Power | | |
| Reduction in power source for 3 days | Power has gone out and there is no back-up power supply. There is no lighting and meals cannot be cooked and there is not hot water. | High |
| Transportation | | |

| | | |
|--|---|---------------------|
| Damage to roads, bridges and tunnels for 1-3 days | As the only method of transportation, trucks may not be able to deliver food to the program. However, there is enough food in the storage onsite that meals could still be served for 1-3 days without food delivery. If there are not enough staff members to arrive at work, and a key staff member with ability to unlock/run program, number of meals may be reduced. List of volunteer and back-up staff is robust and could be called upon to get meals served. | Medium |
| Reduction in availability of public transportation | If there are not enough staff members to arrive at work, and a key staff member with ability to unlock/run program, number of meals may be reduced. List of volunteer and back-up staff is robust and could be called upon to get meals served. | Medium |
| Communication | | |
| Damage to phone and internet systems | While there may be reduced communication with food distributors, there is enough food in storage to provide meals for the duration of the event. If cell phones are functional, they could be used to communicate with distributors and between staff members. If cell service is disrupted or not functioning there would be limited communication for the duration of the hazard. Staff have set schedules so could assume they would try to be at work if they could, regardless of reduced communication. | Low |
| Cumulative Impacts | | |
| Power loss negatively impacts water availability | Power has gone out which means water cannot be pumped or heated to a temperature that is required for food safe practices. | High |
| Buildings | Assumed no impacts | Assumed no impacts. |
| Water Supply | Assumed no impacts | Assumed no impacts |
| Natural Gas | Assumed no impacts | Assumed no impacts |

Table 16 Vulnerability of LCMP C to the extreme weather event.

| Impact from hazard | Vulnerability of LCMP: Exposure + Sensitivity + Resiliency | Impact on food availability for duration of the hazard |
|--------------------------------------|---|--|
| Power | | |
| Reduction in power source for 3 days | Power has gone out but there is a back-up generator. The generator uses diesel to operate. At the moment, the capacity of the generator to power lights, kitchen appliances and water heaters is uncertain. | Medium |
| Transportation | | |

| | | |
|---|---|---------------------|
| Damage to roads, bridges and tunnels for 1-3 days | As the only method of transportation, trucks may not be able to deliver food to the program. However, there is enough food in the storage onsite that meals could still be served for 1-3 days without food delivery. If there are not enough staff members to arrive at work, and a key staff member with ability to unlock/run program, number of meals may be reduced. List of volunteer and back-up staff is robust and could be called upon to get meals served. | Medium |
| Reduction in availability of public transportation | If there are not enough staff members to arrive at work, and a key staff member with ability to unlock/run program, number of meals may be reduced. List of volunteer and back-up staff is robust and could be called upon to get meals served. | Medium |
| Communication | | |
| Damage to phone and internet systems | While there may be reduced communication with food distributors, there is enough food in storage to provide meals for the duration of the event. If cell phones are functional, they could be used to communicate with distributors and between staff members. If cell service is disrupted or not functioning there would be limited communication for the duration of the hazard. Staff have set schedules so could assume they would try to be at work if they could, regardless of reduced communication. | Low |
| Cumulative Impacts | | |
| Power loss may negatively impact water availability | If the generator cannot power hot water heater than water cannot be heated to a temperature that is required for food safe practices. | Medium |
| Buildings | Assumed no impacts | Assumed no impacts. |
| Water Supply | Assumed no impacts | Assumed no impacts |
| Natural Gas | Assumed no impacts | Assumed no impacts |

Table 17 Vulnerability of all three LCMPs to impacts from the earthquake event.

| Impact from hazard | Vulnerability of LCMP: Exposure + Sensitivity + Resiliency | Impact on food availability for duration of the hazard |
|--|---|--|
| Buildings | | |
| Severe damage to LCMP buildings, unsafe to enter the buildings | Major damage has occurred which impacts kitchen and building stability, no meals could be served if access to building is not possible. | High |
| Power | | |

| | | |
|---|---|--------------------------------------|
| Reduction in power source for potentially over a few weeks | No power means no meals can be served. Program C with back-up generator may be able to provide power for a short period of time but fuel sources for generator are likely to be reduced. | High |
| Water Supply | | |
| Reduction in water supply for potentially over a few weeks | No back-up water supplies for the programs exist, so if there is no water, no meals can be served. | High |
| Transportation | | |
| Damage to roads, bridges and tunnels for potentially over a few weeks | No or very limited access to the LMCPs by roads would reduce capacity of staff and key staff members to arrive at work, high potential that no one could arrive at work, so no meals can be served. | High |
| Reduction in availability of public transportation potentially over a few weeks | No transit or highly reduced public transit would limit meals served as staff and volunteer may not be able to reach the LCMPs. | Medium |
| Reduction in local petroleum supplies potentially over a few weeks | Reduced petroleum supplies to fuel trucks and staff vehicles, and reduced diesel for generators would reduce number of meals served, food in storage could be used until it runs out to serve some number of meals. | Medium |
| Natural Gas | | |
| Reduction in natural gas supply for potentially over a few weeks | No gas to the programs means gas stoves cannot be used to cook food, however, cold meals could be served from food in storage for a limited time. Natural gas water heaters would not be able to heat water needed for proper sanitation practices. | Medium – LCMP A High – LCMP B & C |
| Communication | | |
| Damage to phone and internet systems for potentially over a few weeks | While there may be reduced communication with food distributors, there is enough food in storage to provide meals for 3-7 days. If cell phones are functional, they could be used to communicate between staff members. However, it is likely that cell service will be interrupted for a period of time due to damages to cell infrastructure and/or congested networks. Staff have set schedules so could assume they would try to be at work if they could, regardless of reduced communication. | Medium |
| Cumulative Impacts | | |
| Power loss may negatively impact water availability | When the power goes out, hot water is only available for a limited time (water already heated in the water tank may remain hot for several hours) before hot water runs out. | Medium |

Chapter 6. Findings and Discussion

This chapter begins with discussing the overall findings from the Food Service Operations Vulnerability Assessment LCMP case-study. I will discuss the similarities and differences in findings from the two scales of hazards and identify the crucial operational characteristics of the LCMPs identified by the Framework analyses. The complex nature of resilience will be discussed in relation to the LCMP systems and how the broader resilience research has influenced food system resilience work. I will describe the limitations of the Framework and of the LCMP case study. Finally, I will end with recommendations for future research and an overall concluding remarks about the case-study and general thoughts on vulnerability and resilience assessments.

6.1. Findings from Food Service Operations Vulnerability Assessment Framework case-study

All three LCMPs are vulnerable to the impacts from an extreme weather event in similar ways. Damage to roads and loss of power are both likely to negatively impact the number of meals served by the programs. Power is critical for program operations as it is needed for lighting and the hot and cold water supply which is required for sanitation. The LCMP C has a back-up generator, but it is uncertain at this time the capacity of the generator to power the facilities necessary to maintain power and therefore provide the meal service. Communication during the extreme weather event is may influence the meal service as power impacts internet service and may impact cell phone use (if cell phones cannot be charged). The use of land-lines by the LCMPs may provide some resilience to their communication channels with their staff members and food distributors. The quantity of food stored onsite at the LCMPs and the staff's flexibility to change meal planning based on food availability decrease vulnerability of the programs if food distributors cannot deliver food for several days. Overall, if the power does not go out, it is highly likely that the LCMPs can serve meals to clients and the number of meals served would depend on staff availability/ability to arrive at work and food quantity in storage.

The earthquake scenario highlights the importance of structural stability of the LCMP buildings and their water supply. The structural stability of the buildings is

currently unknown, two of the programs are in older buildings and the managers are unsure if the buildings have been retrofitted for seismic upgrades. The City of Vancouver is working on modelling the specific impacts of the 7.3M earthquake on the city; the information gained from these studies would provide better data to determine the structural stability of the LCMPs' buildings. Water is needed for safe handling of food and to cook meals. If hands and food cannot be washed and the bathrooms are not functioning, then the staff cannot provide meals to the public. The supply of natural gas to the LCMPs was also identified to be a factor in meal production. All the LCMPs use gas stoves and ovens to cook the meals; with no natural gas supply, only cold meals could be prepared. Natural gas is also used for heating water in two of the programs, a reduction in natural gas supply would negatively impact hot water availability and sanitation. This earthquake scenario models a long-term impact, meaning it is very possible that food in storage at the LCMPs would run out before food distributors would be able to deliver more food to the program. Overall, the structural stability and subsequent safety of the building followed by the water and power supply are the main factors affecting the LCMPs' ability to serve food in an earthquake event.

Operational characteristics of the LCMPs

The results from the Framework assessment highlighted common operational characteristics necessary for the functioning of the LCMPs, regardless of hazard type. The chart in Figure 6 describes the immediate questions to address following the start of a shock to the LCMPs system to determine if food can be made available. Figure 6 assumes food in storage at the LCMPs is accessible and safe for consumption and is enough for 3-5 days of full meal service. Other questions to consider but not included in the chart include: What is the staff capacity to reach the meal programs to cook/serve the food? Are food suppliers able to deliver food to the programs? Is there communication capacity between staff and food suppliers? Answers to these questions will also influence the ability of the LCMPs to serve meals.

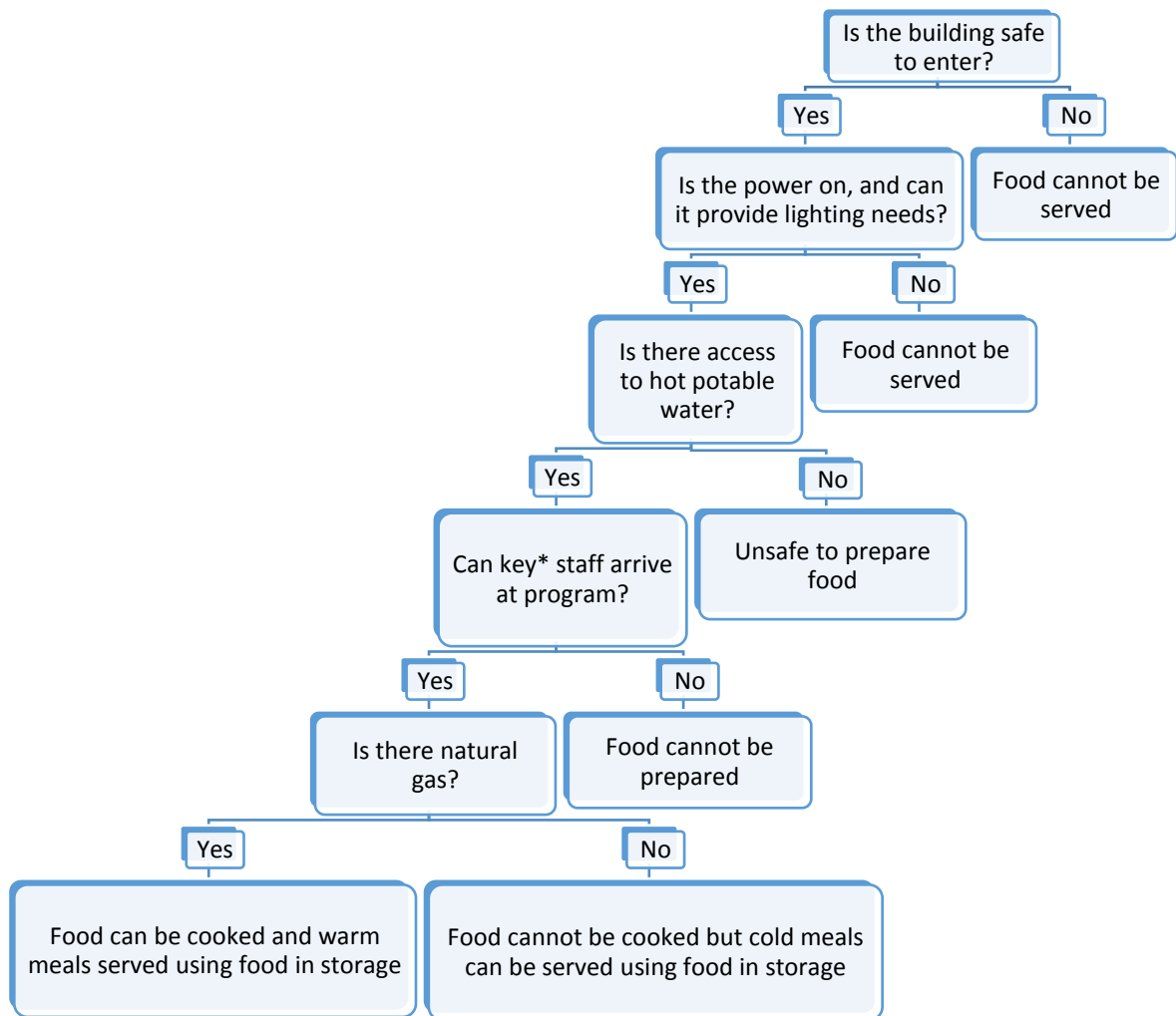


Figure 6 Operational characteristics necessary for normal meal production. (*key staff could mean staff member with keys to building, knowledge of managing the program, food safe training, ability to lead program, etc.)

Cumulative Impacts

Hazards often cause multiple disturbances to systems that interact with one another to create cumulative impacts (Tendall et al., 2015). Cumulative impacts are influenced by the sum of the conditions preceding the hazard, the characteristics of the hazard and the system’s coping responses to the hazard (Cutter et al., 2008). The hazards analysed in this research illustrate many cumulative impacts to the LCMPs. The damage to the road infrastructure reduces public transit which may decrease the number

of staff able to get to the LCMPs to prepare and serve meals. In the extreme storm event, the water supply to the LCMPs is not damaged but the loss of power from the storm stops the water system from functioning which subsequently reduces the LCMPs ability to serve meals. Power is also needed to heat the water at all three LCMPs. The loss of hot water means food safe practices cannot occur. Identifying cumulative impacts recognize that one negative impact may have a feedback effect on other impacts which can then inform targeted mitigation efforts. For example, targeting clearing the roads will mitigate the impact of public transit reduction which means staff can arrive at the LCMP. In a complex system such as the food system surrounding the LCMPs, determining the potential for cumulative impacts is crucial in understanding the vulnerabilities of the systems.

Food Safety Considerations

Water supply and quality and food sanitation are a crucial concern in emergency situations after natural disasters. Risks to food safety during hazards are mainly linked to unsafe food storage and cross contamination from the environment or from people during food handling and preparation (Tirado et al., 2010). Food safety was a prominent topic that arose in the interviews and in consultation with Steering Committee members during the project process. The LCMP staff and managers are all trained in safe food handling and are aware of threats to food safety in the event of a disruption to normal operations. The main threats to food safety from the hazards outlined in this study are: a) physical contamination of foods from debris and flooding; b) nonpotable and no hot water; and c) spoilage of perishable food from loss of power (Vancouver Coastal Health, personal communication, November 20, 2018). The scope of this research was not able to identify detailed threats to food safety and mitigation measures; however, food safety should be considered during future emergency management discussions.

Food Distribution Vulnerabilities

One objective of this research was to assess the vulnerabilities and resilience of the food distribution characteristics of the LCMPs. It was not possible to obtain specific details about the food distribution companies that deliver food to the LCMPs. However, the locations of the food distribution companies were determined, and the locations of bridges and tunnels used to deliver food to the LCMPs are mapped (Figure 7). Of the

eight food distribution companies that deliver food to the LCMPs, at least four have to take bridges or tunnels to arrive at the LCMPs. Each LCMP has between five and nine food distributors. Transportation routes involving bridges and tunnels are identified in the literature as points of vulnerabilities to food transportation systems (Biehl et al., 2017; Nijhuis et al., 2015; Zeuli & Nijhuis, 2017). Bridges and tunnels are more susceptible to failure during major hazards (e.g., earthquakes) and are traffic bottlenecks during high traffic periods. The redundancy in number of distributors supplying the same food products and distributors in different physical locations for the LCMPs may reduce vulnerabilities to bridge or tunnel disturbances. Some bridges within the City of Vancouver have been seismically upgraded or are in the upgrading process (City of Vancouver, 2016). During both an earthquake and an extreme storm, transportation routes can also be disrupted by falling debris on roadways, downed trees and power lines, and isolated flooding. The relatively small number of roads leading to the LCMPs may make the programs more susceptible to a reduction in food deliveries or staff presence due to damages to the transportation routes. The origin of the food arriving at the LCMPs is unknown. However, it can be assumed that some food used by the LCMPs must cross the US border. A wide-spread hazard, like an earthquake, may disrupt normal border crossings, further reducing food availability for the LCMPs.

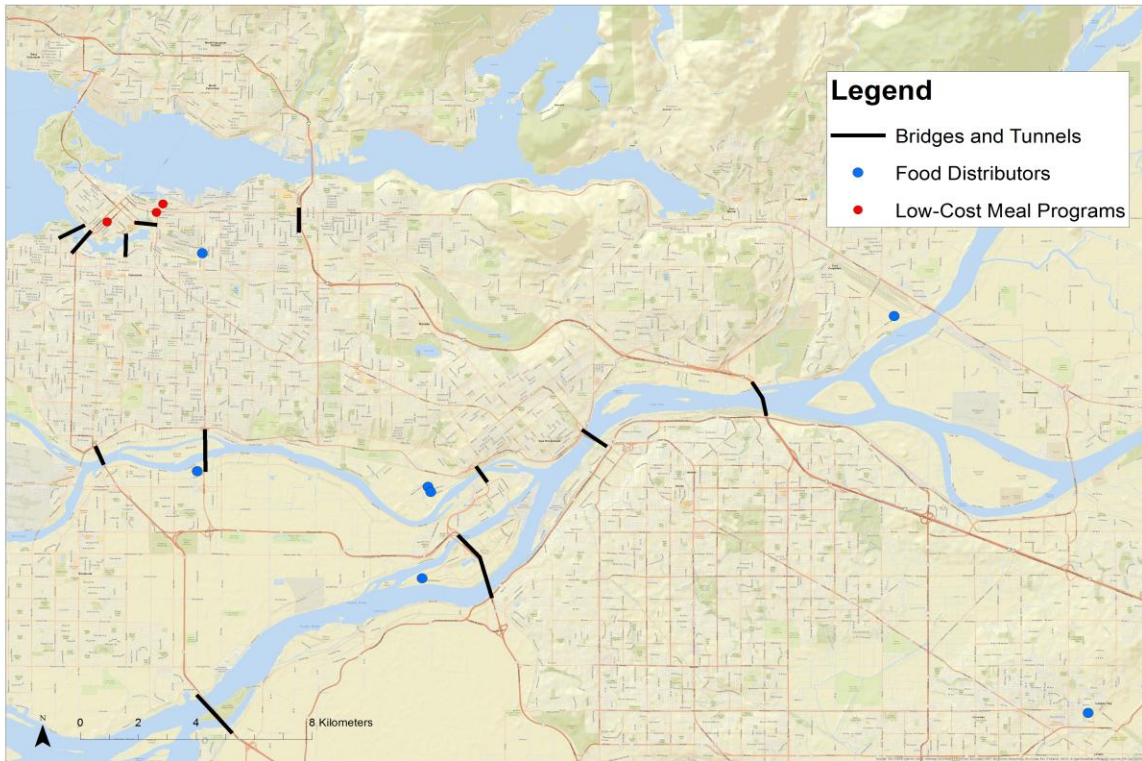


Figure 7 Food Distributor locations and assumed tunnels and bridges trucks cross to deliver food to the LCMPs in Metro Vancouver. Red routes indicate major highways or roads.

6.2. Comments on Resiliency

Two themes emerged from this research about the attributes that make a system resilient. One theme that became clear was the necessity of the social web of relationships surrounding the LCMPs and the organizational capacity of the LCMPs to be flexible and adaptive in situations of disturbances. The literature identifies social relationships as critical in preparing for and recovering from a hazard (Tagtow & Roberts, 2011; District, 2015; Nemex et al., 2014). With respect to the LCMPs, the social characteristics are the relationships between the LCMP staff and food distributors, the LCMP staff and the other staff at the City of Vancouver, and within the LCMP staff and volunteers who work together cooking and serving food. It was stated by all LCMP staff interviewed that the staff at the program would do what they could to serve as much food as possible to the public. The managers and staff are flexible, hard-working and many have worked for long periods of time at the program. In two of the LCMPs, volunteers contribute to the smooth operation of preparing and serving meals. Volunteers have

regular shifts at the programs or can be called in on short notice to help serve meals. The stability and commitment of volunteers during normal operating conditions could imply the volunteers would be willing to increase support to the meal programs during a crisis. While it is hard to determine how the social characteristics of the food service operations translates into number of meals served, it is vital to acknowledge the necessity of cooperative social relationships and long-term experience for maintaining a resilient system.

The second theme to emerge was the necessity of the characteristics involving the economic stability, and technical resilience of the LCMP. The funding for the LCMPs from the City of Vancouver continues to be stable from year to year. Each year the funding for the LCMPs covers the cost of operations not reached by the revenues from the meal sales. The technical characteristics (i.e., the water and gas pipes, the buildings, the power supply, the trucks that deliver the food, the stoves, dishwashers, the roads and bridges, etc.) are the areas of highest vulnerability for the LCMPs. Back-up systems (e.g. generators or water supply) would create redundancy within the programs which would increase the technical resilience of the LCMPs, potentially allowing the LCMPs to continue serving meals during a disturbance.

An aspect of resiliency not analysed in this research is how disturbances may influence the long-term resilience of a system. The resilience of a food system is not static, food systems are constantly going through changes due to external forces such as disturbances from the climate system or economic shocks. How food systems react to the disturbances can create opportunities for continuous learning about how to prepare and respond to disturbances. If learning and adaptation occur after each successive disruption then even negative disturbances can be seen as an opportunity for change to increase the resilience of the system (Tendall et al., 2015). A food system will minimize food insecurity by continuously developing the capacity to deal with being in a changing environment where recurring disturbances are the norm (Tendall et al., 2015). The LCMPs have not gone through any major disturbances over their time in operation but there have been smaller disruptions that have led to minor adjustments within the kitchen management system. These smaller disturbances led to some learning and adaptation within the LCMP systems. A larger disturbance may expose more vulnerabilities within the system, temporarily leading to an increase in food

insecurity, but ultimately creating an opportunity to learn and adapt which can increase resilience of the LCMP system in the longer-term.

6.3. Applicability and Limitations of Framework

The Framework created and used in this research proved useful in identifying the vulnerabilities and resilience of the LCMPs. The Framework structure is based upon and is consistent with vulnerability and resilience assessment frameworks from other fields of research such as the natural sciences, risk management and food system research. The difference in this Framework comes from the focus on specific vulnerabilities impacting food supply chain transportation and operational details of a food service operation providing food to a population. The Framework is intended to be useful for any food service operation or program purchasing, preparing and serving food to the public. Other food institutions such as food banks may also find the transportation, utilities and staffing components of the Framework useful in assessing vulnerabilities in their operations.

Vulnerability and resilience are contextual: they depend on what parts of the systems one is looking at and what questions are being asked about the desired state and the hazards (Quinlan et al., 2016). This Framework can be used iteratively for the same conditions at different times, and/or for different hazards, context and desired system states. In the resilience assessment component, the development of indicators is specific to each food service operation to improve the relevance of the assessment to the unique contexts and situations faced by individual food service operations. Further research can expand upon the Framework to include evaluating the effectiveness of emergency plans to understand preparedness to hazards and focus on describing feedback mechanisms of cumulative impacts.

6.4. Limitations of Case-Study

There are aspects of the food system and food security that were not included in the case-study of this research. To get a more comprehensive understanding of vulnerability and resilience of the LCMPs, all steps along the food system would have to be analysed. Food systems are very interdependent and understanding the impacts to food system supply chain actors from hazards gives a more comprehensive picture of the effects on downstream food service operations (District, 2015). The transportation

network of the food system supply chain actors (the food distributors) was analyzed only at a high-level in this study. The other operational characteristics (for example their food storage capabilities, power and water supplies) of the food distributors was not included in the study due to data constraints. Due to lack of resources and time, only the presumed transportation routes of the food distributors operations were included in this research. The greater emergency planning and response for an earthquake scenario in place by the City of Vancouver was not included in the resilience analysis of this research. For example, the City of Vancouver may have emergency food supplies, a volunteer system and emergency operations centres that will supply food to people unable to access food during an emergency.

Food access and acceptability were not addressed in this research as the other two necessary components of a food secure system. The LCMPs address some aspects of food access as the programs are in their respective neighbourhoods to increase the physical accessibility of intended customers. However, the Framework does not assess the broader economic and social factors that influence food accessibility (for example, the physical or economic ability to purchase desired foods). Customers of the LCMPs were not interviewed to investigate the acceptability of the food provided by the programs. However, LCMP staff mention that compliments are regularly received from customers about the quality of food served.

The assumptions made about the impacts of the two hazards also contain gaps in knowledge relating to the predicted impacts. The scan of the literature and dialogue with subject matter experts, found that there is little data readily available that provides specific scenarios for how neighbourhoods, road systems and power systems could be affected by flooding, earthquakes, power outages, etc. For example, understanding what roads, bridges and buildings may be more susceptible to failure during an earthquake could inform mitigation measure and contingency transportation routes for food distributors. It is possible that the information exists. However, it was not readily accessible. Due to the confidentiality of emergency and contingency plans, information about emergency protocols and preparedness was not obtained. Other studies have assessed contingency plans as a part of resilience research to improve understanding of preparedness and recovery strategies during and after hazards.

6.5. Recommendations

The findings of this research suggest several recommendations to improve the overall resilience of the LCMPs and recommendations for further research into the resilience of the City of Vancouver's broader food system. Should the LCMP buildings be safe for entry and use, then securing sources of back-up power and potable water would be the top priorities to ensure food can be served during a power outage or water disturbance. Any back-up power should allow for basic needs for serving cold meals (e.g. lighting, heating water), but could also consider cooking and refrigeration power requirements. Options for back-up sources of water stored on-site at the LCMPs could be explored, along with methods to ensure potability of back-up water during disturbances. To identify possible threats to food and water quality, testing equipment for water quality could be stored on site, and protocols for post-hazard food safety could be drafted or reviewed with Vancouver Coastal Health (e.g. temperature checks and modified decision making). Further research could be conducted into the possibility and feasibility of alternative methods for the LCMPs to heat and purify water, for cases where water may be available but cannot be heated or may be contaminated. For example, propane burners could be used to heat water if hot water was not available. Ensuring the LCMPs can access power and a potable water supply during disturbances is the most crucial for continued provision of meals to the public. If the buildings are not considered to be useable post-hazard, or if power or water is unlikely to be available, then alternate plans for providing food/meals for these communities could be developed in anticipation of possible hazards.

Broader food systems research within the City of Vancouver and the Metro Vancouver region, could focus on identifying the vulnerabilities of the food distribution system, and particularly from transportation vulnerabilities and power outages. Consider the 2016 New York City study, where food transportation routes were mapped to determine the bridges and tunnels most used for bringing food into the city. The study found that food is brought to only a few food distribution centers before the food is moved into the city. Identifying crucial transportation routes and areas of congregated food warehouses can lead to plans and policies to ensure infrastructure is protected during hazards (e.g. prioritizing road access or enabling food redistribution if power fails). Metro Vancouver is working to understand food flows in the region, and the City of

Vancouver can learn from, and consider building on, this work to understand the impacts on residents and businesses.

During a hazard, such as an earthquake, a wide range of food infrastructure including food distributors/businesses, transportation, communication, and power must continue to function to provide food to the community. Existing food access programs will remain critically important for those who already rely on them for their daily food needs. The City of Vancouver can continue research to assess the vulnerabilities of food programs and the wider food system infrastructure, and subsequently identify ways to ensure food access is maintained post-hazard.

6.6. Concluding Remarks

The vulnerability assessment completed in this research was conducted to understand the vulnerability and resilience of the LCMPs to an extreme weather event and an earthquake event. The low-cost meal programs serve primarily residents living with low incomes and in the event of a hazard it is important that these programs remain operating to provide food for residents who may have limited alternate options. The results illustrate the necessity of strong social networks and redundant physical infrastructure systems in reducing the vulnerability of the LCMPs. The physical infrastructure components of the LCMP exhibited vulnerabilities in the absence of back-up power and water sources. The bridges and tunnels pose potential bottlenecks of the transportation networks to distribute food to the LCMPs in the event of a hazard. The institutional memory provided by many staff of the LCMPs, the minor disruptions experienced by the LCMPs and the overall flexibility and resourcefulness of staff have shown that staff will do whatever they can do to provide meals when faced with a hazard.

A system or program's vulnerabilities and resilience are not static. External and internal conditions that influence the system are continuously changing. As such, measuring vulnerabilities and resilience should be an ongoing and iterative approach to be effective at incorporating appropriate mitigation practices into policies (Quinlan et al., 2016). The interaction of food systems with economic, environmental, political and social systems make food systems especially complex and dynamic. Identifying and

implementing measures to decrease vulnerabilities and increase resilience help to ensure a secure food system that provides food to individuals in times of disruptions.

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Appendix A. Interview Questions

Interview Questions for low-cost meal program employees

Food characteristics

1. What is the volume (or dollar value) of food you receive from suppliers daily? Weekly? Monthly? Yearly? Does this change seasonally?
2. What are the different types of food you receive? Percentage of perishable vs non-perishable? Fruits/veggies/dairy/meats/legumes/grains?
3. What percentage of your food has to be refrigerated?
4. How much storage capacity do you have at the program location? Refrigerated vs dry storage? How many days could you continue to serve meals with this amount?
5. Do you know how much (volume, dollar amount, percentage) of the program's food is local (from B.C)? Do you know the origin of your foods?
6. What is the main barrier for purchasing more local food?

Food suppliers

1. What companies supply food to the program? How many suppliers do you have? Where are they located? How often is food delivered to the program?
2. What volume (percentage) of your food comes from each supplier? Perishable vs non-perishable?
3. How does the food arrive at the program? Truck? Do you know the routes the trucks take to get to the program?
4. Does the food arrive in a refrigerated and non-refrigerated truck?
5. Are there seasonal changes to the number of suppliers? Or type of food provided by each supplier?
6. Do you have contingency or backup suppliers of food if some are not able to meet your food order/wasn't able to deliver food to the program that day (or for an extended period of time)?
7. What are the communication channels between the program and the suppliers? How responsive are suppliers to requests/changes in orders?
8. Do you get any food donated? If so, do you know the volume (or dollar amount, or percentage) of donated food used in the program?

Infrastructure

1. How old is the building where the meals are served? Do you know what building code this building is built to?
2. What are the main utilities needed to run the program? Water, electricity, gas...? If you lost gas or electricity would you still be able to provide food?
3. If the water or power systems are not functioning, are there alternative systems that could provide the water or power? (e.g. back-up generators?)

Program operations

1. How many staff are needed during each meal time?
2. What would be the minimum number of staff needed to provide food?
3. If several staff cannot come into work, are there alternate staff to call upon? What is the likelihood of finding staff to come into work on the day you call them in? Or a day or two in advance?
4. How do the staff communicate with one another? Telephone/email?
5. How many volunteer help with the meal program each meal?
6. Do you need a certain number of volunteers to make and provide the meals each day? In an emergency, how likely is it that volunteer could help with the program same day they are called (or a day or two in advance)?
7. How important is the internet and phone lines to the operation of the meal programs? Could you function without them?
8. Do fluctuations in food prices impact the program's ability to provide food? If so, how and what responses do you have to food prices? Similar for electricity or gas prices (cooking or transportation costs)?
9. Is the financing/funding for the program stable from year to year? Is there a cost of living increase provided for in program budgets annually (e.g. increases in staff salary to meet cost of living)?

Emergency/Program Continuity Plans

1. Does the program have any emergency plans or contingency plans in place? If so, when was it created and when was the last time it was updated?
 - What types of hazards are detailed in the emergency plans? (e.g. earthquakes, storms)
 - How effective do you think your plan is at addressing certain hazards? Is it more effective at addressing certain interruptions (e.g. power outages or transportation disruptions) than others?

- Are there certain people responsible for implementing the plan during an emergency?
- Do staff know about the emergency plan? Are staff trained on the procedures in the emergency plan?
- Do you regularly update emergency plans? And practise the emergency protocols within the plan?
- Are there communications plans put in place between the suppliers and the program in-case of an emergency/crisis? Do you think the suppliers ready to deal with an emergency (i.e. still provide food order to the program)?
- Barriers to creating emergency plans/training staff/having backups/testing plans?

If there is no emergency plan:

2. Does the program engage in any informal trainings/protocols related to emergencies? (e.g. know who to call if power goes out, knows what action to take if food order is disrupted)

3. Who do you think would take the lead in an emergency? Is that person always at the program? Would they be available to come in last minute to help in the event of an emergency?

Adaptive Capacity

1. Has the program overcome past events that interrupted meal provisioning? What were the events that interrupted the program? What were the coping strategies used to recover from that event?

2. How long could you keep the refrigerated food cold for in the case of a power outage? Are there plans in place to deal with large quantities of spoiled food?

3. If all suppliers were unable to deliver food to the program, how many more meals could you continue to serve without re-supply?

4. In your opinion, how well would the program cope with: a short-term power outage? A long-term power outage? Losing certain number of suppliers? Staff shortages?

Meal program

1. How many people do you serve per meal? Per day? Per week? Per month?

2. How does your meal accounting system work?

3. Who is accessing the meals? What percentage might be from the immediate neighbourhood?

4. Are the same people accessing the meals each day? Multiple times a day? Around how many people? How certain of you are this estimate?

5. Are there any times food is not served?

6. Do you ever run out of food during the meals?

7. Are you serving the maximum capacity of people you can each day? If there was an influx of more people one day, what is your capacity to serve more meals quickly? Approximately how many more meals could you serve?

Other

1. Would you be willing to put me in touch with your suppliers to ask questions related to their food distribution systems?

2. Do you think there is anyone else I should contact about these questions or other relevant information?

3. Is there any other relevant information you think I should know about your program and emergency management/planning/program operations?

4. Would I be able to follow up about this information with you in the future? If so, what time of day and how should I contact you (email/phone?)

Interview Questions for Food Distribution companies

1. On average, what is the volume of food you distribute that goes into the City of Vancouver each year? (or month? Or whichever timescale is easiest for you to describe)
2. What is the percentage of total food you distribute that goes into the City of Vancouver each year?
3. What methods of transportation does the food take **to your warehouse**? And **from your warehouse** into City of Vancouver? What percentage is the most used form of transportation (i.e. 90% truck, 10% rail...etc.)?
4. What percentage of the food you deliver needs to be refrigerated or frozen?
5. What bridges and/or tunnels do you use to transport food into the City of Vancouver? Which bridge or tunnel is most important for transporting food **into Vancouver** (e.g. what percentage of your deliveries use that infrastructure)?
6. Which bridge or tunnel is most important for transporting food **to your warehouse**? (e.g. what percentage of food that arrives at your warehouse uses that infrastructure)
7. Do you have back-up generators to power operations if the electricity fails? What operations (i.e. warehouses or offices) have back-up power sources to maintain functioning?
8. How much storage capacity do you have onsite? (i.e. how many days of food deliveries do you have in stock?)
9. What percentage of the food you receive to the warehouse comes from British Columbia? Percentage that comes from rest of Canada? Washington? Throughout the United States? Other countries?
10. Where are the locations of your warehouses from which you distribute food?
 - Is your warehouse at the below location? Do you have any other locations from which you distribute food?

Appendix B. Participant Consent Form

Interview Consent Form

UNDERSTANDING THE OPERATIONAL RESILIENCE OF CITY OF VANCOUVER'S LOW-COST MEAL PROGRAMS: HOW FOOD IS MOVED TO THE PROGRAMS AND PROVIDED TO THE PUBLIC

Study Number: 2018s0253

Study Team

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School of Resource and Environmental Management

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Social Policy Planner

This research study is being conducted to fulfill the requirements of a graduate degree in Resource and Environmental Management. This graduating essay will be a semi-public document and may be submitted for publication.

Why are we doing this study?

You are being invited to participate in this study because you are involved in one of the low-cost meal programs offered by the City of Vancouver (Carnegie Community Centre cafeteria, Gathering Place cafeteria, Evelyne Saller Centre cafeteria). We hope that with your participation we can better understand how food is moved to the low-cost programs and how resilient the programs may be to disturbances (e.g. power outages, water and transportation infrastructure failure). It is hoped that by interviewing people knowledgeable about the food distribution for these low-cost meal programs, we can understand how the resilience of these programs may be improved.

Your participation is voluntary

You have the right to refuse to participate in this study. If you decide to participate, you may still choose to withdraw from the study at any time without any negative consequences and the interview transcripts will be destroyed. If you are an employee of a food supply company, please obtain any clearance for permission for this interview from your organization.

What's involved in the study?

The study consists of several semi-structured interviews with employees of the low-cost meal programs and food suppliers to these programs in British Columbia. If you agree to participate, we may ask questions on the following topics:

- a) Characteristics about the food used in the low-cost meal program (e.g. type, volume, transportation routes, perishable vs non-perishable);
- b) Characteristics about the low-cost meal programs (e.g. staffing, organizational structure, how food is served to the public);
- c) Emergency management plans;

Your participation requires one, up to one-hour interview session to cover these topics. Some of the questions may seem sensitive or confidential and you do not have to answer any question if you do not want to. The interview will involve audio-recording in order to accelerate the interview process for your benefit. If I require clarification after the interview on specific topics or questions, then this will take place by email or phone conversation, if you give consent. Email and telephone are not confidential mediums and in-person contact can be arranged if you prefer.

What are the risks of participating?

It is not the intention of this research to cause harm, however, there is a small risk that some questions asked may be confidential to the program or your company and you do not have to answer them if this is the case. Your answers will also remain unidentifiable to the outside community and in circumstances where a statement you say may be identifiable to the public, I will not use that statement in my research report.

What are the benefits of participating?

There is no payment for participation in this study. The information you provide to this study will benefit furthering our understanding of food movement within the City of Vancouver and how resilient the low-cost meal programs are to disturbances. You will have access to my final report which may provide resources on how to improve resiliency of the low-cost meal program.

How will your privacy be maintained?

Your confidentiality will be respected. Information that discloses your identity will not be released without your consent. Participants will not be identified by name in any reports of the completed study. Audio-recording will be transcribed onto word documents and then the audio file immediately destroyed. All documents will be stored on a USB, identified only by a unique code number and kept in a locked filing cabinet. Written and oral consent documentation will be kept in a separate locked filing cabinet and I will maintain sole access to all documents.

Study Results

The results of this study will be reported in a graduate thesis and may also be published in journal articles and books. The main study findings may also be presented at academic or municipal conferences.

Who can you contact about questions of the study?

If you have any questions regarding this study please feel free to contact me, the Principal Investigator, or my Supervisor Evelyn Pinkerton (contact information provided on page 1).

Who can you contact about complaints of the study?

If you have any concerns about your rights as a research participant and/or your experiences while participating in this study, you may contact Dr. Jeffrey Toward, Director, Office of Research Ethics jtoward@sfu.ca or 778-782-6593.

Future use of participant data

Future use of the data collected from this study may include further academic use and publication. Interview data will be uploaded to an online repository of academic data (SFU RADAR) as it consistent with academic best practices. Personal information of participants will not be given out for future use, and only coded data will be accessible to ensure confidentiality.

PARTICIPANT CONSENT AND SIGNATURE

Taking part in this study is entirely up to you. You have the right to refuse to participate in this study. If you decide to take part, you may choose to pull out of the study at any time without giving a reason and without negative consequences. All participants are 20 years or older. The interview will take place at a location of your choosing.

- Your signature below indicates that you have received a copy of this consent form for your own records.
- Your signature indicates that you consent to participate in this study.
- You do not waive any of your legal rights by participating in this study.

Participant Signature

Date (yyyy/mm/dd)

Printed Name of the Participant signing above

Future Contact

I may wish to contact you prior to our interview in order to obtain clarification or follow up on interview discussion pieces that result from the original interview.

Do you consent to this follow-up request?

YES

NO

Participant email: _____

Appendix C. Supplementary Material from the Framework Analysis

The literature was scanned to determine what makes a food system resilient, a total of ten studies were considered in the scan. Table C1 details the number of studies that mentioned each attribute. Some studies mentioned more than one attribute.

Table C1. The number of times a study mentioned each attribute as a characteristics of a resilient food system.

| Attribute | Number of studies | Study |
|-------------------|-------------------|---|
| Flexibility | 4 | Tendall et al, 2015 Nijhuis et al., 2015 Smith and Lawrence, 2018 Lengnick et al, 2015 |
| Redundancy | 5 | Cabel and Oelofse, 2012 Tendall et al., 2015 Nijhuis et al, 2015 Zeuli and Nijhuis , 2017 Ganin et al, 2016 |
| Adaptability | 3 | Cabel and Oelofse, 2012 Tendall et al., 2015 Nijhuis et al, 2015 |
| Capacity to learn | 4 | Cabel and Oelofse, 2012 Tendall et al., 2015 Smith and Lawrence, 2018 Lengnick et al, 2015 |
| Preparedness | 2 | NYCEDC, 2016 Ganin et al, 2016 |
| Robustness | 3 | Anderies et al., 2013 Ganin et al., 2016 Bruneau et al., 2003 |
| Resourcefulness | 2 | Ganin et al., 2016 Bruneau et al., 2003 |
| Rapidity | 2 | Ganin et al., 2016 Bruneau et al., 2003 |

Table C2. The operational differences between the three low-cost meal programs.

| | Program A | Program B | Program C |
|--|--|---|---|
| Food Characteristics | | | |
| Number of meals served per day* | 900-1000 | 720 | 550 |
| Money spent on food/month | \$52,000- 64000 | Around \$37,500 | ? |
| Percentage of perishable foods used in meals | Over 40% | Around 65% | 80-85% |
| Storage capacity in days for dry and perishable foods | 3-7 days *7-10 days during the holiday season | 4 days | 3-5 days |
| Price of meals | \$2 | \$2.25 | \$2 breakfast \$2.75 lunch \$3.25-3.75 dinner |
| Meal planning | 4 weeks in advance | ? | 2 weeks in advance |
| Clientele Served | | | |
| Percentage of people accessing the meals that live in immediate neighbourhood | 90% | 90% | ? |
| Percentage of reoccurring clients each day | 30-40% | Around 90% | 60% |
| Food Suppliers | | | |
| Number of suppliers (for all foods) | 5 | 8 | 9 |
| Percentage of food coming from each supplier | | | |
| Number of deliveries per week | Sysco – 2 days Centennial meats – 1 day Saputo – 3 days Canada Bread – 4 days | No set times, food can be delivered everyday | 2 |
| Methods of communication | All online ordering | Telephone and texting | Online forms, email, phone |
| Infrastructure/Operations | | | |
| Presence of back-up generator | No | No | Yes |
| Presence of Emergency Plans? | Yes, all staff are trained on building evacuation | Yes, all staff are trained on building evacuation | Yes, all staff are trained on building evacuation |
| Staffing | | | |
| Average number of staff per meal time | 10-11 | 3.5? | 6 |
| Minimum staff needed to serve same number of meals | 7 | 3 (move to using disposable dishes) | ? |
| All programs say it would be very hard with this minimum number of staff, people would be very tired, but could they could do it | | | |

| | | | |
|--|--|---|---------------------------------------|
| On-call staff? | Yes, but very small because all employees work 40hrs/week at program | Yes, list is very responsive to calls for shifts | Yes |
| Dependent on Volunteers? | No | No, but would be very busy for staff if no volunteers showed up | Yes, for smooth running of operations |
| Average number of volunteers per meal time | 0 | 2 | 5 |

*This number is averaged over the whole year. During the holidays more meals are served and just before welfare checks are received more people are accessing the low-cost meals.

Table C3 – LCMP A Resilience Assessment

| Attribute | Indicators | Results |
|--------------------|--|---|
| Flexibility | <ul style="list-style-type: none"> -Ease of changing suppliers -Ease of changing menus -Presence and responsiveness of back-up staff and volunteers | <ul style="list-style-type: none"> -An external contracted company has been hired and is responsible for providing meals for the LCMP, as such they have designated food suppliers that food has to be bought from. If the main supplier cannot supply food the manager can find other suppliers through the Aramark website. -Menus are set 4 weeks in advance but managers and cooks can adapt to changes in food supplied and create meals from what food is available. -Aramark employees are unionized and have set 40h work weeks, there are some back-up staff, have had problems in past with not enough back-up staff, in those cases, employees who had the day off may come in. |
| Redundancy | <ul style="list-style-type: none"> -Number of suppliers that supply same type of food -Types of communication methods between suppliers and LCMPs and LCMPs and staff/volunteers -Modes of food supplier transportation to LCMPs -Number of food supplier transportation routes to the LCMPs -Presence and capacity of back-up power supply -Presence of a variety of cooking instruments (e.g. gas ovens, electric ovens) | <ul style="list-style-type: none"> -In normal operations, only have 1 supplier for each type of food, however could go onto Aramark website to find another supplier if main supplier is not functioning. -Communicate with suppliers over the internet, and with staff in person or by phone -Food arrives by truck -Can use at least 2 transportation routes to reach LCMP -No back-up power supply, but there might be in the new building -No back-up cooking instruments but would make meals that don't need stove-top or oven if one method was unavailable to use |

| | | |
|--------------------------|---|---|
| Adaptability | -How LCMPs coped in the past when the LCMP didn't run as planned due to a disturbance? -How do LCMPs employees think the program will react if disturbances do happen? | -there have been no major events that have disrupted meal supply in the 34 years the manager has been working there -a few times the dishwasher has stopped working so they switched to paper plates, plastic cutlery and washed the pots and pans by hand -ES staff are very resourceful, they would produce as many meals as possible in an emergency situation, while making sure the food was safe to eat -"people will do what they have to do" |
| Capacity to learn | -Examples of past responses to disruptions: were changes made to reduce vulnerability to future disruptions? | -They always have paper plates and plastic cutlery on-hand in case dishwasher malfunction occurs again |
| Preparedness | -Presence of an emergency plan: What does the plan cover? -Emergency preparedness training for employees -Number of days of food storage | -There is an emergency plan on how to evacuate the building -all employees are trained on the procedures -they have 3-7 days of food storage during normal times of the year, 7-10 days of storage during holiday season |
| Robustness | -Examples of impact to meal production from past disturbances | -When the dishwasher malfunctioned, they did not reduce the number of meals served |
| Resourcefulness | -How have LCMP employees managed past disturbances? | -Manager has been working in the program for 34 years, they know the program very well and say they could manage situations as they arise |
| Rapidity | -How fast did meal production return to normal after a disruption? | -Meal production was not interrupted in dishwasher situation |

Table C4 : Resilience Assessment for LCMP B.

| Attribute | Indicators | Results |
|--------------------|--|--|
| Flexibility | -Ease of changing suppliers -Ease of changing menus -Presence and responsiveness of back-up staff and volunteers | - Could change suppliers easily if needed - Meals are set the week before and it is very easy to change the menu as there is no set schedule for deliveries, once they see an item getting low in stock they place an order -Have a robust back-up list of staff and volunteers who are responsive to last-minute calls into the program to work |

| | | |
|--------------------------|--|---|
| Redundancy | <ul style="list-style-type: none"> -Number of suppliers that supply same type of food -Types of communication methods between suppliers and LCMPs and LCMPs and staff/volunteers -Modes of food supplier transportation to LCMPs -Number of food supplier transportation routes to the LCMPs -Presence and capacity of back-up power supply -Presence of a variety of cooking instruments (e.g. gas ovens, electric ovens) | <ul style="list-style-type: none"> -Most of their food comes from one supplier, however they have multiple back-up suppliers they could contact -Calling and texting, texting allows for tracking of order history -All deliveries come by truck -Can use at least 2 transportation routes to reach LCMP -No back-up power for program or building in which program is housed -Have gas ovens and stovetops, could use Korean burners in storage if needed and possible |
| Adaptability | <ul style="list-style-type: none"> -How LCMPs coped in the past when the LCMP didn't run as planned due to a disturbance -How do LCMPs employees think the program will react if disturbances do happen? | <ul style="list-style-type: none"> -The program has dealt with a few minor disturbances: power outages, water main brake, evacuation of building incidences; in each case they have maintained meal production if possible, more staff came in if needed and continuous training of evacuation procedures occurs -Employees interviewed said they are "experts at triage" and would be able to "pull something off" with respect to serving food to customers if possible |
| Capacity to learn | <ul style="list-style-type: none"> -Examples of past responses to disruptions: were changes made to reduce vulnerability to future disruptions? | <ul style="list-style-type: none"> -Past disturbances and ability to mitigate their impacts is out of control of the LCMP employees (i.e. water and power loss). However the program recently has been undergoing renovations so the has learned to deal with abnormal circumstances and they have still be able to provide the same number of meals |
| Preparedness | <ul style="list-style-type: none"> -Presence of an emergency plan: What does the plan cover? -Emergency preparedness training for employees -Number of days of food storage | <ul style="list-style-type: none"> -There is an emergency plan to evacuate the building -All employees are trained on the procedures within the plan -Estimate that they have food in storage that could provide meals for 4-6 days |
| Robustness | <ul style="list-style-type: none"> -Examples of impact to meal production from past disturbances | <ul style="list-style-type: none"> -In past disturbances meal production has remained the same when possible or only slightly decreased if disruption happened during meal time |
| Resourcefulness | <ul style="list-style-type: none"> -How have LCMP employees managed past disturbances? | <ul style="list-style-type: none"> -Employees who had the days off would come in to help the program if needed, managers have deep relationships with staff and suppliers which could help in a disruption |
| Rapidity | <ul style="list-style-type: none"> -How fast did meal production return to normal after a disruption? | <ul style="list-style-type: none"> -As soon as it was safe to enter the building after a power outage or water main brake, the staff began preparing meals |

Table C5 - Resilience Assessment for LCMP C

| Attribute | Indicators | Results |
|--------------------------|--|--|
| Flexibility | <ul style="list-style-type: none"> -Ease of changing suppliers -Ease of changing menus -Presence and responsiveness of back-up staff and volunteers | <ul style="list-style-type: none"> - The program has a large number of suppliers with overlapping food types, so could easily order from many suppliers -Employees would adapt meals to what food is available -Have robust back-up lists of staff and volunteers that are responsive to last minute requests |
| Redundancy | <ul style="list-style-type: none"> -Number of suppliers that supply same type of food -Types of communication methods between suppliers and LCMPs and LCMPs and staff/volunteers -Modes of food supplier transportation to LCMPs -Number of food supplier transportation routes to the LCMPs -Presence and capacity of back-up power supply -Presence of a variety of cooking instruments (e.g. gas ovens, electric ovens) | <ul style="list-style-type: none"> -Have multiple suppliers for veggies and meats -Communication is through online ordering, phone and email -All food is supplied by truck to the program - Can use at least 2 transportation routes to reach LCMP -There is a back-up generator, but uncertain as to the capacity of the generator to provides services necessary to maintain meal production - No back-up cooking instruments but would make meals that don't need stove-top or oven if one method was unavailable to use |
| Adaptability | <ul style="list-style-type: none"> -How LCMPs coped in the past when the LCMP didn't run as planned due to a disturbance? -How do LCMPs employees think the program will react if disturbances do happen? | <ul style="list-style-type: none"> - There was a time when there was a chicken disease so couldn't order the usual number of chicken, so switched menu to make tofu and pork meals -Employee interviews said staff are very adept at being flexible and there is good communication between staff and management which would help if a disturbance happened |
| Capacity to learn | <ul style="list-style-type: none"> -Examples of past responses to disruptions: were changes made to reduce vulnerability to future disruptions? | <ul style="list-style-type: none"> -They have had the dishwasher break so used paper plates and disposable utensils to serve the same number of meals, which they always have on hand |
| Preparedness | <ul style="list-style-type: none"> -Presence of an emergency plan: What does the plan cover? -Emergency preparedness training for employees -Number of days of food storage | <ul style="list-style-type: none"> -There is an emergency plan to evacuate the building -Staff have regular training meetings on emergency plan -Estimate that the program has 3-5 days worth of food in storage for 3 meals each day |

| | | |
|------------------------|--|---|
| Robustness | -Examples of impact to meal production from past disturbances | -Meal production did not go down in past situations of disruptions, however because meals changed (e.g. from hot meals to cold meals) customers went elsewhere to access their meals during this time |
| Resourcefulness | -How have LCMP employees managed past disturbances? | -During past disturbances employees knew the protocols to switch to paper plates or substitute foods not available with available foods to maintain meal service |
| Rapidity | -How fast did meal production return to normal after a disruption? | -Disruptions did not impact number of meals produced, steps were taken to continue production throughout the disturbance (dishwasher malfunction and power outage) |