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Growing Resilient: The potential of urban agriculture for increasing food security and improving earthquake recovery

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Following an earthquake, urban agriculture has been shown to improve recovery by increasing food security and providing numerous community and social benefits. However, many communities often do not consider urban agriculture within their earthquake or disaster preparedness programs. This work explores the intersection between those two realms, considering how their integration may increase food security and improve resilience following an earthquake. Through a case study focusing on the City of Vancouver, British Columbia, Canada, this research involved a four-step strategic scan of planning and earthquake management documents to determine whether Vancouver has captured the benefit of urban agriculture for earthquake recovery. Results revealed that this benefit has yet to be realized, however there is ample opportunity to do so given the City's advances in urban agriculture. This research seeks to provide planners, city officials and emergency management with insight into the potential of urban agriculture for earthquake preparedness. More broadly, this work seeks to add to the discussion by exploring a tangible integration of two realms that are often planned in isolation, yet could have positive impacts if combined. This paper concludes with specific interventions for how urban agriculture can be utilized for earthquake recovery in order to build resilience.

Keywords: Urban greening, Disaster management, Urban planning, Food system resilience, Local food production, Vancouver Canada

Highlights

- Food security and malnutrition are pervasive issues following an earthquake.
- Urban agriculture can improve food security during earthquake recovery.
- Urban agriculture provides social and community benefits during recovery.
- Earthquake-prone areas should consider urban agriculture in preparedness programs.
- Considering urban agriculture within earthquake management can increase resilience.

1.0 Introduction

Earthquakes are responsible for thousands of deaths and millions of dollars of damage every year. Ground shaking, falling debris, structural collapse, infrastructure damage, tsunamis, fires, power outages, and displacement are just some of the hazards that threaten human life and well-being during and after an earthquake (Cassidy, 2013). The impacts from a large earthquake can last for months and even years following the initial event (French, Birchall, Landman & Brown, 2019). Food security is often an insidious challenge, as outside food lines can be disrupted when critical systems are damaged during an earthquake (e.g. Brown, 2015; Barthel & Isendahl, 2013; Biehl, Buzogany, Baja & Neff, 2018).

Earthquakes also create greater rates of poverty, which further compounds the issue of food access and security (Tirivangasi, 2018). Thus, ensuring a resilient food system before, during and after a disaster event is critical for effective recovery (Biehl et al., 2018). However, many communities often do not consider food systems in their disaster preparedness programs (Biehl et al., 2018).

Scholars argue that planning for resilience can help communities develop a more flexible, comprehensive and integrated approach to dealing with impacts from disaster events (e.g., Woodruff, Meerow, Stults & Wilkins, 2018; Poku-Boansi & Cobbinah, 2018; French et al., 2019). Indeed, evolutionary (socio-ecological) resilience ("resilience") is a critical concept for earthquake management, as it speaks to the capacity of a community to learn from the disruption, improve functioning, and ultimately become more resilient to future disruptions through transformation in response to stress and strains (Moench, 2014; Davoudi, 2012). Similarly, food system resilience can be understood as the ability of a food system to readily adapt to changes in internal and external conditions and adjust to shocks and stressors (Toth, Rendall & Reitsma, 2016). Redundancy is a key concept in resilience as it can create spare capacity to respond to increasing pressure during emergencies (French et al., 2019). This may be critical in addressing food insecurity and aiding recovery following an earthquake as greater pressure is placed on food systems. Distribution and grouping and accessibility are also important considerations, as they encourage strategic and accessible co-location of important uses that earthquake survivors can utilize and access (French et al., 2019).

Food system resilience is regarded as an emerging field for urban planners, and they have become more involved in local food production in the past decades (Biehl et al., 2018; Horst, McClintock & Hoey, 2017). Because urban planners have influence at the local level (Biehl et al., 2018), there are opportunities to focus on effective strategies for building strong local food systems. Common strategies have involved adopting supportive policies and removing regulatory barriers, as well as offering land and infrastructure (Horst et al., 2017).

While the issue of food security is a broad concept, research has shown that improving a community's localized food production (e.g., urban agriculture) may contribute to resilience through providing healthy food after a natural disaster and filling the nutrition gap created by long-term reliance on emergency rations (e.g., Sioen, Sekiyama, Terada, & Yokohari, 2017; Brown, 2015). Further, following disaster events, studies have shown that urban agriculture can provide social empowerment and safe gathering spots, and help to re-establish a sense of normalcy for residents (Shimpo, Wesener & McWilliam, 2019).

Scholarship considers urban agriculture to be a powerful tool in contributing to long-term food security and increasing the capacity of cities to mitigate and respond to natural disasters (Fletcher & Collins, 2020; Zasada, Weltin, Zoll & Benninger, 2020; Barthel & Isendahl, 2013). Forms of urban agriculture, community gardens in particular, can be understood as "silent infrastructure systems" that run in the background and get activated when disaster strikes (Wesener, 2020). The inherent benefits of community gardens include making diverse people feel welcome, providing opportunities for social cohesion and collective action, providing healthy food, and encouraging the learning of new skills, all of which can contribute to recovery after an earthquake (Wesener, 2020; Camps-Calvet et al., 2015).

While it is unlikely that urban agriculture could independently sustain a community following an earthquake, there is evidence that it can contribute essential nutrients to emergency diets and fill gaps created by food network disruptions and long-term recovery periods (Sioen et al., 2017). For example,

in the Nerima ward of Tokyo, researchers found that urban agriculture would provide 20,503 evacuees (out of 3,390,000) with immediate access to sufficient nutrients from within the disaster struck area, and could continue to provide a source of nutrients long term (Sioen et al., 2017). A 2012 study following a rural community garden project in Oregon found that vegetable intake increased fourfold and that feelings of food insecurity decreased from 31% to 3% compared to before the project was developed (Brown, 2015). In Christchurch, New Zealand, community gardeners cited the availability of healthy food as a reason to keep coming back to the New Brighton Garden after a major earthquake (Shimpo et al., 2019). Lastly, and perhaps most famously, during World War I the number of allotment gardens in Britain grew from 600,000 to 1,500,000 to supply residents with food and other ecosystem services during supply chain disruptions (Camps-Calvet et al., 2015; Barthel et al. 2010).

Despite the benefits, evidence suggests that food production through urban agriculture is underutilized and could play a more significant role following earthquakes and other disasters (Wesener, 2020; Brown, 2015). This presents an opportunity for planners to incorporate more local food production within the urban fabric and throughout relevant, widespread policy (Wesener, 2020; Dubová & Macháč, 2019). Indeed, the extensive food insecurity following earthquakes—particularly for vulnerable populations—has led to growing interest in incorporating food system risks in disaster recovery plans (Masterson, 2020). Integrating urban agriculture within preparedness plans is one approach for addressing this risk. Indeed, this can lead to more robust strategies, and help to safeguard these uses as important local resources for a recovering community. As an example, in 2018, Baltimore updated their Disaster Preparedness and Planning Project to include food system resilience and commercial urban agriculture considerations (City of Baltimore, 2018). While the plan stipulates that urban agriculture is insufficient to feed the city's population, it is highlighted as a key part of food resilience in disaster preparedness planning (City of Baltimore, 2018).

This research employs a strategic document scan to explore the intersection between urban agriculture and earthquake preparedness in Vancouver, British Columbia, Canada. The objective of this study is to understand whether Vancouver has captured the benefit of urban agriculture for earthquake recovery, specifically through integrating urban agriculture within earthquake preparedness. Vancouver has undergone earthquake planning and taken great strides in urban agriculture planning, yet there is an opportunity to increase resilience and improve long-term recovery through the integration of these two realms. While this research is focused on a single community, the hope is to add to a growing discussion on urban food security, and in particular, its intersection with earthquake management. This is an area that has received relatively little attention in scholarship, but is of utmost importance for increasing resilience in earthquake-prone communities (Biehl et al., 2018). While the integration of urban agriculture within earthquake and disaster preparedness may seem self-evident, there is little information on the integration of these realms in a policy and urban planning context. As such, in addition to its scientific contribution, insights and interventions from this study will be useful to practitioners and policy makers involved in earthquake preparedness specifically, and disaster risk reduction more broadly.

The article is organized around five substantive sections: Section 1.0 provides a grounding in the relevant literature; section 1.1 provides context and justification for the case study. Section 2.0 highlights the methodological approach. Section 3 presents the findings, section 4 discusses the findings, considering impacts on resilience and the importance of integration between urban agriculture and earthquake planning. Lastly, section 5 provides interventions for facilitating integration between urban agriculture and disaster preparedness and capturing the benefit of urban agriculture for building resilience.

1.1 Context: Vancouver, British Columbia

Located on Canada's West coast, Vancouver is at risk from large earthquakes due to its proximity to the Cascadia Subduction Zone, an active fault line where the Juan de Fuca and North American tectonic plates meet. The city of Vancouver is a large, densely populated municipality with a metropolitan population of 631,486 and approximately 2.5 million in the surrounding region (Statistics Canada, 2016). While the populated areas in the region have escaped significant impacts from seismic activity in the past, there is sufficient cause for concern due to the city's elevated earthquake risk (Walker, Schuurman, Swanlund, & Clague, 2021). Damages from earthquakes and the resulting aftershocks pose serious health and safety risks for Vancouver's residents as well as challenges for Vancouver's planners and leadership.

Vancouver was chosen for this study for three key reasons: First, the region is prone to frequent seismic activity (Walker et al., 2021) and could therefore benefit from proactive and innovative approaches to earthquake preparedness in order to increase resilience. Second, and perhaps most importantly, Vancouver has developed both earthquake and urban agriculture policies, but they have not yet integrated them. The city presents the case of a community that could benefit from integrating urban agriculture with earthquake preparedness strategies. Third, Vancouver's temperate and humid climate allows for nearly year-round gardening—increasing the viability of urban agriculture as a supplementary food source and prime tool for recovery following an earthquake.

2.0 Methods

This research is qualitative in nature in order to develop an understanding of how Vancouver prioritizes urban agriculture and earthquake management within different dimensions of policy and planning.

A case study approach is used to investigate how Vancouver approaches urban agriculture and earthquake planning and whether the benefit of urban agriculture has been considered in earthquake preparedness. Case study research has elicited disapproval from positivists for lacking generalizability; yet interpretivists emphasize the value of single case research, in particular as it relates to potential for rich contextual insight (Noor, 2008; Yin, 2014; Brower et al., 2000).

A scan was conducted of Vancouver's strategic planning documents; documents included reports, guidelines, strategies, policies, and toolkits. These were chosen to explore both Vancouver's high-level goals as well as more granular actions and tactics. The purpose was to elicit meaning and develop an understanding of what is present and not present in the data (Baum et al., 2018). The main documents and policies reviewed, along with focus areas, are summarized in Table 1.

The strategic scan involved a four-step process:

Step 1: Select relevant documents related to the topic

A high-level scan of 26 documents was conducted, and 16 documents were identified as having an impact on food system or earthquake planning and flagged for further analysis. Documents were collected primarily from the City of Vancouver website and databases.

Step 2: Determine document relevance to research objectives
The 16 flagged documents were more thoroughly scanned to determine relevance to the research objectives, and 10 documents were identified as being core data sources;

Step 3: Analyze relevant documents to determine research themes
The 10 documents were read in greater detail which led to the emergence of four main themes.

Step 4: Analyze and measure integration between urban agriculture and earthquake preparedness
The documents were cross-referenced with the four main themes to determine where integration exists and how this may contribute to resilience in Vancouver.

Document Title	Year Published	Type	Focus
City of Vancouver: Resilient Neighbourhoods Program	2013	Program / toolkit	Resilience, Emergency Management
City of Vancouver: Earthquake Preparedness Strategy	2013	Policy - Strategy	Emergency Management
Resilient Vancouver Strategy 10.23	2019	Policy	Resilience, food security, disaster preparedness
Vancouver: Greenest City 2020 – The City's Sustainability Action Plan	2015	Policy	Sustainability, urban food systems, climate leadership
City of Vancouver Zoning and Development Bylaw – 3575	2020 (updated regularly)	Policy - Bylaw	Land use, spatial planning
City of Vancouver - Urban Agriculture Guidelines for the Public Realm	2009	Guidelines	Urban agriculture, design
Park Board Urban Agriculture Policy	2015	Policy	Food systems, agriculture
Vancouver Food Strategy	2013	Policy - Strategy	Food systems, food security
City of Vancouver Healthy City Strategy	2014	Policy - Strategy	Health, wellbeing, community
Urban Farm Guidelines	2016	Guidelines	Food systems, urban agriculture, sustainability, resilience

Table 1. Policies, documents and guidelines reviewed by title, year published, document type and themes
This summary table is not intended to provide systematic coverage of all documents and policy areas within the City of Vancouver, it is only intended to display the policies, guidelines and strategies reviewed within the areas of earthquake preparedness and food systems planning that are relevant to this research.

3.0 Findings

Generally, the findings revealed that Vancouver's earthquake risk is significant and that food security is a current vulnerability for the city. However, Vancouver has taken substantial steps to develop policy, programs and strategies to improve urban agriculture planning and integrate these areas within broader resilience strategies.

Four key themes emerged from the policy scan:

- Earthquake Preparedness
- Resilience & Sustainability
- Food Systems Planning
- Urban Agriculture

These themes are presented in greater detail below. Table 2 provides a summary of the key themes, including attention to key takeaways and considerations for resilience.

Key Theme	Policies and Documents Evaluated	Key Takeaways	Resilience
Earthquake Preparedness	*Earthquake Preparedness Strategy (2013)* *Resilient Vancouver (2019)*	**Resilient Vancouver (2019)** • 10% of Vancouver households already experience food insecurity, this issue would be compounded by a large earthquake – the city would only have enough fresh produce to last 72 hours if access to outside food systems is lost. **Earthquake Preparedness Strategy (2013)** • Three key categories for preparedness: 1) reducing risk of damage to buildings, 2) ensuring redundancy in critical services like power, transportation, water, communication and waste, and 3) volunteer and community initiatives.	• Some overlap with 'Resilience'. • Does not include considerations of urban agriculture. • Focus is mainly on short-term recovery – may reduce longer-term resilience in the event of a large, disruptive earthquake.
Resilience & Sustainability	*Resilient Vancouver (2019)* *Resilient Neighbourhood Program (2019)* *The Greenest City 2020 Action Plan (2015)*	**Resilient Vancouver (2019):** • Food security is identified as a chief concern. • Identifies that Vancouver's food security issues are further exacerbated by a decline in local food sources. **Resilient Neighbourhoods Program (2019):** • Recommends neighbourhoods evaluate the resilience of their food assets and meal providers (including urban agriculture) which are identified for their role in disaster recovery. **The Greenest City 2020 Action Plan (2015):** • Community gardens & urban agriculture are considered food assets – increasing their number is a high priority.	• High level of integration with other policy areas within Resilient Vancouver. • Exacerbation of food security issues may affect city's most vulnerable—decreasing Vancouver's overall resilience to earthquake impacts.
Food Systems Planning	*Healthy City Strategy (2014)* *Vancouver Food Strategy (2013)*	**Healthy City Strategy (2014)** • Target is to increase citywide and neighbourhood food assets by a minimum of 50% by 2020. **Vancouver Food Strategy (2013)** • Food security is an important policy and planning concern for the City of Vancouver - Food systems are treated as part of a broader set of priorities that can address issues of food security, social inclusion and neighbourhood health. • The food strategy highlights the desire to update existing and develop new land use policies, zoning and other regulatory tools to bolster the creation of urban agriculture.	• Vancouver Food Strategy does not include explicit consideration for food security following an earthquake or disaster. • Extensive food systems planning indicate resilience-thinking– may ultimately increase capacity to respond to disruptive events.
Urban Agriculture	*Vancouver's Zoning & Development Bylaw – 3575 (2020)*	**Vancouver Zoning & Development Bylaw – 3575 (2020)** • 'Urban farms' (a type of urban agriculture) - Class A Urban Farms are a conditional use in all residential zones and Class B Urban Farms are conditional in all commercial and heritage zones. Class B Urban Farms are a permitted use in most light/medium intensity industrial zones.	• Food security and resilience are prominent features, but an explicit link between disaster planning and urban agriculture is missing in these policies and documents.

	City of Vancouver Urban Agriculture Guidelines for the Public Realm (2009) *Park Board Urban Agriculture Policy (2015)Urban Farm Guidelines (2016, amended 2019)*	• Development permits not required for non-profit urban agriculture on private land – a lengthier process is necessary for urban agriculture on city-owned land **City of Vancouver Urban Agriculture Guidelines for the Public Realm (2009)** • "The goals for encouraging urban agriculture are to reduce "distance to plate", encourage social interaction, and allow more locally grown food production." (pg. 1) **Park Board Urban Agriculture Policy (2015)** • "…recognizes urban agriculture as a valuable food-focused activity that can contribute to community development, environmental awareness and benefits, positive social interaction, learning, health, exercise, wellness, and access to fresh food." (pg. 1) **Urban Farm Guidelines (2016, amended 2019)** • **"**Urban farming will improve the resilience of Vancouver's food systems in accordance with the vision, principles and goals defined in the Vancouver Food Strategy and the Greenest City Action Plan which calls for an increase of urban farms to improve economic, social and environmental objectives." (pg. 1)	• Issue of access identified—community gardens have long waitlists; this may decrease the city's resilience in the event of an earthquake and exacerbate food insecurity.

Table 2. Summary of key themes, key takeaways and considerations for resilience

3.1 Earthquake Preparedness

From Vancouver's perspective, a major earthquake is inevitable (City of Vancouver, 2019a). Based on a modelled scenario of a 7.3 magnitude earthquake, Vancouver would experience an estimated $75 billion in direct economic loss and over half the city's residents would be displaced (City of Vancouver, 2019a). Damages would include the collapse of more than 150 buildings, and many areas of the city being unusable and inaccessible for months at a time (City of Vancouver, 2019a).

The modelled 7.3 magnitude earthquake scenario also revealed dire consequences for food security immediately following the event and during recovery. Regionally, many highways, rail lines, pipelines and digital networks have been constructed in flood plains and seismic zones and are vulnerable to disruptions, which would threaten Vancouver's food supply lines, likely exasperating food insecurity for residents (City of Vancouver, 2019a).

Vancouver's three high-level categories within the Earthquake Preparedness Strategy (reducing risk of damage to buildings; ensuring redundancy in critical services; and volunteer and community initiatives) do not explicitly mention food security or local food production. However, the strategy does consider how to ensure the resilience of critical services such as water, energy and transport which could support food supply lines following an earthquake (City of Vancouver, 2013b).

Further, the strategy establishes 25 Disaster Support Hubs to facilitate community support, which are designed to distribute food, water and supplies following an earthquake (City of Vancouver, 2013b). However, there does not seem to be consideration for how the Disaster Support Hubs could support food security during the potential weeks and months of recovery following a large earthquake. As well, any link between these hubs and food supply from locally produced sources, such as urban agriculture, is not mentioned.

3.2 Resilience & Sustainability

Vancouver has been internationally recognized for its approach to resilience, and in 2019, the city launched Resilient Vancouver, a multi-year strategy focused on building resilience to withstand and recover from shocks and stresses, including frequent earthquakes and food insecurity (Vancouver City Planning Commission, 2019). Many policy areas sit under this strategy, including food systems planning. Within the Resilient Neighbourhood Program which also sits under Resilient Vancouver, local food assets were consistently highlighted for their importance (City of Vancouver, 2019b). They are emphasized not only for encouraging food security, but also for their ability to facilitate social and cultural connections and their potential role in disaster recovery (City of Vancouver, 2019b).

Vancouver's sustainability strategy, The Greenest City 2020 Action Plan, is a policy that also sets the stage for resilient food system planning. The policy states a goal of increasing city-wide and neighbourhood food assets by a minimum of 50% over 2010 levels (City of Vancouver, 2015). Further, the plan emphasizes the strength of a local food system to contribute to human health and wellbeing (City of Vancouver, 2015).

Vancouver has also made the strategic decision to include lower-level food system and resilience strategies such as the Vancouver Food Strategy and Resilient Neighbourhood Program within Vancouver's higher level resilience planning, indicating some level of integration between these areas. However, this connection does not seem to have been incorporated into Vancouver's earthquake preparedness strategy.

3.3 Food Systems Planning

In regards to food system-specific planning, Vancouver has been quite proactive; developing several policies to address issues of food insecurity and local food production. In 2013, the city developed the Vancouver Food Strategy, a high-level, yet detailed policy that treats food systems as part of a broader set of priorities. This sentiment is also integrated into the Healthy City Strategy, a high-level document developed in 2014 (City of Vancouver, 2014).

Indeed, Vancouver seems to take a holistic approach, with local food systems highlighted as being able to address social, physical and community issues (City of Vancouver, 2013a). The Vancouver Food Strategy commits to supporting and enabling all forms of urban agriculture, which it considers to encompass a broad range of uses (City of Vancouver, 2013a). This may allow for flexibility in the future and open the door to new innovations in local food production.

Perhaps most notably, the Vancouver Food Strategy commits to updating existing and developing new land use policies, zoning and regulations to increase urban agriculture throughout the city. This could help increase the amount of local food produced in Vancouver; which may ultimately aid recovery from an earthquake in the future.

While the Vancouver Food Strategy is comprehensive, it is unclear whether the region's seismic risk was considered during the strategy's development. The plan does seem to imply that local food production can aid in food security following a disaster, however there is no explicit link to the Earthquake Preparedness Strategy.

3.4 Urban Agriculture

While high-level policy is important for developing long-term strategy and a vision for the future, zoning, guidelines and regulations are most often the 'on-the-ground' measures that facilitate action. In this regard, Vancouver has made an effort to incorporate urban agriculture uses throughout the zoning and development bylaw in the form of 'urban farming', which involves growing fruits and vegetables for sale (City of Vancouver, 2013a). As such, urban farms are permitted or conditional uses across most commercial, residential and industrial zones (City of Vancouver, 2020).

Additionally, establishing urban agriculture uses on private land does not require a permit in Vancouver (City of Vancouver, 2021b) and the city also encourages residents to utilize boulevard space for growing fruits and vegetables (City of Vancouver, 2021a). These initiatives all contribute to the Vancouver Food Strategy's goal of increasing the number of food assets city-wide (City of Vancouver, 2013a). However, a 2021 report from the Vancouver Urban Farming Society found that the development process for certain classes of urban farms is lengthy and more costly than most farms can bear. This likely disincentivizes farmers from establishing or continuing to operate urban farms within the city and may reduce the amount of local food produced. The report recommends making urban farms permitted uses in all zones and eliminating the onerous development permit process (Vancouver Urban Farming Society, 2021, 2020).

Vancouver has also developed specific guidelines to support the success of current and new urban agriculture, including urban farms (City of Vancouver, 2019c). These guidelines include the size of garden plots, accessibility and co-location requirements and starter lists for plants and edible landscaping that are suitable to growing in the city's climate. In particular, the Park Board's Urban Agriculture Policy (2015) and City of Vancouver Urban Agriculture Guidelines for the Public Realm (2009) recognizes the important role played by community gardens and outlines how urban agriculture can help address food insecurity through local food production (Vancouver Board of Parks and Recreation, 2015).

As Vancouver recognizes the important role urban agriculture can have in disaster recovery, it seems a logical step to co-locate urban agriculture with the 25 Disaster Hubs from the Earthquake Preparedness Strategy so local produce can be easily distributed. However, it's unclear whether the 25 Disaster Hubs were deliberately located near urban agriculture uses.
Several hubs do seem to be located near community gardens; however, this is not consistent for all 25 locations, and may be coincidental as hubs are mainly located at community centres which also typically have gardens attached.

Despite the prevalence of urban agriculture uses within Vancouver, there is an issue of access due to long waitlists. Availability of land and land tenure for urban agriculture, particularly for urban farming, also poses a challenge for establishing these local food assets (Vancouver Urban Farming Society, 2020). This may ultimately reduce the ability of urban agriculture to address issues of food security following an earthquake.

4.0 Discussion

The risk of food insecurity following an earthquake in Vancouver is prevalent, and the city has made an effort to increase the amount of urban agriculture through policy and zoning tools. However, the lack of integration with the Earthquake Preparedness Strategy could decrease the effectiveness of the city's urban agriculture efforts during earthquake recovery.

Further, the issue of access to community gardens and other urban agriculture uses as well as scarcity of land for urban farming may exasperate these challenges and calls into question the level of food justice within Vancouver's food system planning framework (Horst et al., 2017). However, Vancouver has also considered the holistic benefits of local food production through urban agriculture, which has multi-level benefits for people recovering from an earthquake.

The following sections discuss Vancouver's approach to building resilience through urban agriculture and the lack of integration of urban agriculture within earthquake planning. The discussion concludes with specific interventions, and provides insight for decision-makers in Vancouver and other communities in earthquake-prone areas, to improve resilience to earthquakes and other disasters through urban agriculture.

4.1 Vancouver's approach to building resilience through urban agriculture

Urban agriculture can help build ecological and social capacity against major collapses in urban food supplies (Barthel, Parker & Ernstson, 2015). Vancouver has incorporated this benefit and taken many important steps towards increasing resilience through local food production—namely encouraging the proliferation of urban agriculture uses and removing roadblocks to the creation of new urban farm parcels in the zoning bylaw. More urban agriculture throughout the city increases redundancy in the food system which could help improve food security when food supply lines are disrupted during an earthquake (Moench, 2014).

As well, the integration of food systems planning into other policy areas is a factor that scholarship has deemed to be important for building a resilient food system (e.g., Biehl et al., 2018), and Vancouver's higher-level policy (Vancouver Food Strategy) that governs local food production is well-integrated with economic and social considerations. In addition to building resilience, this can also create opportunities for efficiencies and synergies.

There are several areas that can contribute to greater resilience that warrant further discussion. The following sub-section explores resilience through a lens of access and food justice, considering accessibility as a key component of building resilience (French et al., 2019). Urban agriculture also has the ability to build social capital, which can increase capacity to respond and recover from disturbances (Moench, 2014).

4.1.1 Issues of accessibility & food justice

Scholars agree that disasters and food security are inherently interconnected. Food shortages following earthquakes is a pervasive problem that leads to loss of agency, malnutrition, illness and death, particularly for those who already struggle with access to food (e.g., Tirivangasi, 2018; Biehl et al., 2018; Forrester et al., 2017; Brown, 2015; Tsuboyama-Kasaoka & Purba, 2014). While urban agriculture has been shown to have many benefits for food security, some urban agriculture projects may actually perpetuate existing inequalities (i.e., benefitting already privileged communities), increase marginalization and may even contribute to the displacement of disadvantaged groups (Horst et al., 2017).

Lack of access to community gardens due to long waitlists was identified as an issue in Vancouver—a problem that may spread to other urban agriculture uses as well. Indeed, long waitlists and exclusionary practices may deepen inequalities in a society by benefitting better resourced organizations and the property-owning class (Horst et al., 2017). They can also have a detrimental

effect on food security for people hoping to access urban agriculture following an earthquake (Tsuboyama-Kasaoka & Purba, 2014).

Food access is considered an outcome of resilient food system activities; making it a vital consideration to ensure a resilient and just food system in Vancouver (Toth et al., 2016). Indeed, open-access urban agriculture has been shown to have positive benefits following an earthquake or other natural disaster (Chan, DuBois & Tidball, 2015) and should be an important consideration in earthquake and urban agriculture planning. Accessibility is a key consideration for building resilience—urban agriculture networks must be designed for accessibility to avoid congestion during an earthquake (French et al., 2019). Sardeshpande, Rupprecht & Russo (2021) even advocate for edible urban commons to increase access to fresh, healthy food as well as to increase resilience following food system disruptions.

While access remains an issue, Vancouver has considered a food justice lens in its food policy and planning. Indeed, the city has removed development road blocks for some urban agriculture uses in zoning and development, and prioritized urban agriculture in long-term planning (e.g., Greenest City 2020 Action Plan, Vancouver Food Strategy, Healthy City Strategy, and Resilient Vancouver). Addressing the development permit issue, ensuring available land and improving land tenure for urban farms can also help to increase local food production and improve food access. As more urban farms, orchards and community gardens are developed, accessibility may become less of a problem in the city.

Issues of access may also be addressed through rethinking how urban agriculture is governed. Community gardens and other forms of urban agriculture are often designed and managed by groups of neighbourhood residents to meet local needs and characterized by low investment and bottom-up governance structures (Fox-Kämper et al., 2018). A lack of medium and long-term political and administrative support can reduce the success of community gardens/urban agriculture (Wesener, Fox-Kämper, Sondermann, & Münderlein, 2020; Fox-Kämper et al., 2018). While a grassroots approach to urban agriculture may be more sustainable, urban agriculture governed by top-down structures may meet the needs of larger and more diverse populations and improve access for vulnerable populations (Fox-Kämper et al., 2018). In Vancouver, community gardens and food trees are governed mainly by private entities, the city and various government organizations. Further exploration into the potential political and administrative barriers for urban agriculture in Vancouver would be beneficial for a deeper understanding of how governance structures may support or hinder access.

4.1.2 Urban agriculture and building resilience through social capital

While the main focus of this research was on urban agriculture's potential to increase food security following an earthquake, the benefits of post-disaster agricultural activities are too beneficial to be overlooked. The World Health Organization stipulates that urban agriculture can play a role in disaster relief by supporting self-reliance and enhancing the capacities and self-esteem of an affected population, alongside reducing dependence on food aid (WHO, 2004). Increasing capacity is a vital consideration for building resilience, as it improves the ability to respond and mobilize resources as well as the ability to learn from past experiences, ideally enabling people to be better prepared for earthquakes in the future (Tyler and Moench, 2012).

Urban agriculture has the potential to build social capital and capacity through providing social and psychological benefits to survivors during longer-term recovery when conventional food distribution

systems are being repaired (Shimpo et al., 2019; Sioen et al., 2017; Camps-Calvet et al., 2015). Community gardens can provide positive stimuli to relieve and counteract long-term mental health impacts from negative and extremely stressful experiences that accompany earthquakes (e.g., Spittlehouse et al., 2014; Okvat & Zautra, 2013).

Many of these considerations are already present in Vancouver's policy, particularly the Healthy City Strategy (2014) and Vancouver Food Strategy (2013). The policies explicitly state the broader benefits of urban agriculture, and emphasize the need to protect and proliferate these uses to promote community and societal health. This could contribute to the city's overall resilience to future earthquakes.

Combining the social and communal benefits with the benefit of providing nutritious food could make urban agriculture a powerful tool in earthquake preparedness strategies. Yet, integration between these two realms does not feature prominently in Vancouver's policies. This gap will be discussed in the next section.

4.2 Integration between urban agriculture planning and earthquake preparedness

The disruption of food distribution resources following an earthquake is well documented; ensuring a resilient food system that is incorporated in disaster preparedness programs can be essential for effective recovery (Biehl et al., 2017; Brown, 2015; Masterson, 2020). Okvat and Zautra (2013), in their empirical review of the positive effects of contact with green space in disaster zones, contend that an extensive network of community gardens as part of a disaster preparation plan would have multi-level benefits (social, physical, community) and help bolster the resilience capacity of an urban centre.

Vancouver's Earthquake Preparedness Strategy places emphasis on protecting critical systems, which could help support food security following a disaster through providing water and energy sources for urban agriculture, as well as mending exterior food supply lines (e.g., Moench, 2014). Yet, the full potential of urban agriculture for earthquake recovery is not explicitly realized in the Strategy. While basic needs (food, power, shelter) are essential to address during earthquake recovery, being truly resilient involves also considering how a population may again thrive in the future. Thus, not only would urban agriculture be a beneficial addition to Vancouver's earthquake strategy due to the value it can provide for food security, it can also provide essential social support and emotional healing for survivors (e.g. Sioen et al., 2017; Okvat & Zautra, 2013). This helps build social capital and self-reliance and strengthens the capacity of the city to bounce forth in the future (Tyler & Moench, 2012; WHO, 2004).

While not yet common practice, insights can be found in the City of Baltimore's approach to integrating urban agriculture with disaster preparedness. Baltimore's Disaster Preparedness and Planning Project highlights implementation actions that include increasing land permanently secured for food production, including community gardens, market gardens and commercial urban agriculture, incentivizing increased agricultural product diversity in urban and regional food production and transitioning community and market gardens to commercial urban agriculture (City of Baltimore, 2018). Similar considerations could be incorporated in Vancouver's Earthquake Preparedness Strategy.

There are two areas in particular that may be suitable for a grassroots integration of urban agriculture in Vancouver's earthquake preparedness. Vancouver's Resilient Neighbourhoods Program and

the Community and Volunteers initiative under the Earthquake Preparedness Strategy both focus on what people can do at the neighbourhood level to prepare for earthquakes and improve resilience. As urban agriculture is largely managed at the neighbourhood level in Vancouver, both present an opportunity for a natural integration of urban agriculture into the city's resilience and earthquake management framework. It would also be beneficial to ensure pre-earthquake emergency plans are established across urban agriculture spaces (Masterson, 2020). Formal emergency planning procedures that include requirements for backup power and water sources and food transportation and distribution routes that include redundancy can ensure that urban agriculture is activated as an effective supplementary food source following an earthquake (Masterson, 2020; Wesener, 2020; Moench, 2014).

Further, urban agriculture could play an important role in improving the effectiveness of Vancouver's 25 Disaster Support Hubs. Co-locating future urban agriculture land uses with these hubs could help ensure the effective distribution of nutritious, fresh fruits and vegetables alongside emergency rations. Co-location also considers resilience aspects of distribution and grouping (French et al., 2019). Beneficial recovery spaces, such as community gardens, should be located in a way to create nodes with critical infrastructure, which can aid response following an earthquake (French et al., 2019).

5.0 Urban agriculture interventions to improve resilience in earthquake-prone regions

While this research focused on a single city, much can be learned from exploring Vancouver's approach to urban agriculture and earthquake planning. The following interventions and considerations are useful for planners, city officials and emergency management personnel in other earthquake-prone communities. However, it is essential to keep local context in mind when considering urban agriculture as a tool for improving earthquake and disaster recovery. Indeed, every community is different in how they can engage with urban agriculture in practice, and every community will experience an earthquake in a relatively unique way.

Consider urban agriculture in planning

A multitude of urban agriculture uses in a community adds redundancy to the food system and can improve food security and provide safe, supportive gathering spaces after a disaster (French et al., 2019; Moench, 2014; Okvat & Zautra, 2013). It's imperative that urban agriculture is consciously integrated into land use and zoning processes in order to sustain it (Azunre et al., 2019).

Sufficient land allocation for urban agriculture is another important consideration for planners. Vancouver is not alone in struggling with land tenure and allocating enough land for food production (Castillo et al., 2013). Indeed, in earthquake-prone Christchurch, funding and land tenure for the development of community gardens and other forms of urban agriculture are a persistent challenge (Wesener, 2020). Regional studies and urban agriculture plans could help identify underutilized land suitable for urban agriculture, taking into account proximity to underserved neighborhoods, water, quality of soil, and access to food markets and labor (Castillo et al., 2013).

The incorporation of urban agriculture as permitted uses throughout zoning bylaws can remove roadblocks for development and thus increase local food production. Considerations for simplifying the development permit process, or removing the need for development permits altogether for certain urban agriculture types could also help to increase the amount of food assets in a community. The spatial distribution of urban agriculture also largely determines which residents benefit from it (Smith, Meerow & Turner, 2021). Thus, consideration should be made for co-locating urban agriculture uses with emergency gathering points for food distribution following an earthquake, alongside considering

vulnerable neighbourhoods that already experience food insecurity and would benefit most from access to these uses (French et al., 2019).

Link urban agriculture with earthquake management

Urban agriculture has the potential to be a supplementary food source for communities in the aftermath of an earthquake, yet this consideration is not a part of many communities' disaster management frameworks (Biehl et al., 2018). Urban agriculture often functions as a 'silent system' that is activated following an earthquake (Wesener, 2020) and much of its potential may go unexplored if it is not highlighted in disaster planning. Considerations of food security and urban agriculture should therefore be integrated into preparedness plans and strategies to safeguard urban agriculture uses as valuable emergency resources. It could also be beneficial to strategically incorporate specific urban agriculture parcels into earthquake strategies, or mandate it in urban development permits. This could help ensure that the most vulnerable people can have access to the spaces to secure healthy food in the aftermath of an earthquake.

After an earthquake, transportation routes may be compromised and areas of a community may be blocked or inaccessible, which can have detrimental effects on food supply and distribution (Masterson, 2020). Urban agriculture can play an important role in supplying food for these areas through hyper localized food production. On the other hand, for areas that are inaccessible and don't have access to local urban agriculture, it is important to consider the logistics around the distribution of food from urban agriculture. For example, during the long recovery from the 2010/2011 earthquakes in Christchurch, New Zealand, community gardens contributed to the food supplies of people in need via charitable distribution networks and food bank drop-offs (Wesener, 2020). Consideration for how to leverage existing food distributors (e.g. food hubs, food banks, charitable networks) as well as considering backup networks can be beneficial for supporting local food supplies during a community's earthquake recovery.

Recognize the holistic benefits of urban agriculture for earthquake recovery

Urban agriculture has benefits beyond aiding food security, and they should not be overlooked when planning and creating policy for these uses. Consideration should be made for how urban agriculture carries broader benefits which can increase capacity for recovery and help improve the mental and physical health of survivors following an earthquake and re-establish a sense of normalcy, ultimately making a community more resilient to disruptions (Moench, 2014; Okvat & Zautra, 2013).

6.0 Conclusion

Earthquakes are notoriously difficult to plan for due to their unpredictable nature. The aftermath of an earthquake can be equally as devastating as the event itself, with food insecurity and malnutrition creating challenges for recovery. Urban agriculture offers a plethora of benefits for earthquake recovery, including local production of nutritious food, safe gathering spaces and emotional healing and support for survivors. Incorporating urban agriculture in earthquake preparedness thus has the potential to increase resilience by adding redundancy to the food system and increasing the capacity of an urban centre to respond to earthquakes while aiding recovery. Yet, despite the benefits, urban agriculture is underrepresented in earthquake management plans.

In the case of Vancouver, urban agriculture was found to be a strong contributor to local food production and resilience-building. Yet, there are still missing links when it comes to bolstering the city's preparedness for earthquakes. It's imperative that Vancouver, and other earthquake-prone regions understand the potential of urban agriculture for earthquake recovery and integrate the two

realms. Food justice, accessibility and land availability must also be considered in order to ensure barriers to urban agriculture are removed and people can access and receive the benefit of these spaces following an earthquake.

While this study explored the approach to urban agriculture and how it intersects with earthquake planning in a single city on Canada's Westcoast, the results are impactful for other earthquake-prone areas. This work expands on previous research into the potential of urban agriculture for disaster recovery; adding to the discussion through analyzing a particular case in order to understand how these two realms are integrated and related in a policy context. To be truly resilient, communities must consider new and innovative ways of approaching earthquake and disaster planning. Keeping beneficial policy areas separate from earthquake preparedness strategies can overlook their natural synergies and resilience-building power. Integration of urban agriculture within earthquake planning can improve earthquake recovery, and it can potentially save more lives and better prepare communities for uncertainty. Indeed, the unpredictability of earthquakes makes it all the more vital that communities leave no stone unturned, no opportunity wasted.

Declaration of competing interest

No financial interest or benefit has arisen from the direct applications of this research.

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