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THE POTENTIAL ROLE OF VERTICAL AGRICULTURE IN BUILDING SUSTAINABLE AND RESILIENT COMMUNITY FOOD SYSTEMS

Outcomes from a Stakeholder Focus Group



AUTHORS

Addis Benyam
Post-doctoral Researcher
Food and Agriculture Institute
University of the Fraser Valley

Robert Newell
Associate Director
Food and Agriculture Institute
University of the Fraser Valley

Alex Glaros
Researcher
Food and Agriculture Institute
University of the Fraser Valley

COLLABORATING ORGANIZATIONS

Food and Agriculture Institute
University of the Fraser Valley

i-Open Technologies Group

QuantoTech Solutions Ltd.

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Executive Summary

Vertical farming is a promising technology-driven approach to agriculture, which could contribute to food system sustainability and resilience. Vertical farming involves growing crops using LED lights, circulating nutrient solutions, and stackable production units, and it generally requires fewer resources than conventional farming. Production occurs in controlled, indoor environments, and as such, there is no requirement for pesticides or herbicides. In addition, crops are protected from many of the impacts of climate change, such as fires and floods. Vertical agriculture can contribute to urban agriculture capacity, providing fresh, local, and healthy produce year-round. Yet, there are many scenarios and approaches for how vertical agriculture techniques can be implemented, and these different scenarios/approaches may or may not contribute to local environmental, economic, social, and food security objectives. This research project engages communities to discuss and assess scenarios for integrating vertical agriculture into local food systems in British Columbia (with a particular focus on Lower Mainland communities).

This report presents the summary of the first activity of our research, where we facilitated a taste test exercise and online focus group with government, NGOs, community organizations, and industry stakeholders associated with food systems in the Fraser Valley (particularly Mission, Abbotsford, and Chilliwack). The focus group occurred in February 2022, and prior to the session, participants were asked to try vertically-farmed lettuce to get a sense of the characteristics and quality of the products. In addition, participants were given links to an informational webpage and interactive food miles map for comparing vertically-farmed and conventionally-farmed lettuce. In the focus group, participants were asked for their feedback regarding the clarity and efficacy of the web information/tools. Discussion then ensued about the products and various considerations for integrating vertical agriculture into local and regional food systems in the Fraser Valley.

Focus group participants noted that vertical farming can contribute to local food security, increase supply chain efficiencies, and make relationships between customers and food producers more transparent. Furthermore, they discussed how vertical farming holds much promise in the context of severe weather events that severely disrupted supply chains in the Lower Mainland region the past year. Participants highlighted the importance of engaging in clear, accessible, and transparent communication strategies with local communities to increase the acceptance of vertical farming and minimize potential tensions with other forms of agriculture. Recommended communication and engagement strategies include:

- simplifying language and providing analogies in vertical agriculture communication tools,
- clarifying if and how vertical farming might complement or compete with other forms of agriculture,
- approaching organizations with significant community capital such as food banks, schools and hospitals, and
- highlighting the nutritional properties of vertically farmed produce.

Participants stressed the importance of 'knowing your audience', and developing communication tools and materials accordingly. Other comments highlighted the importance of recognizing that some demographic groups may be less open or willing to engage with these technologies. Future work to develop community strategies is required, focusing on what aspects of vertical farming should be emphasized or de-emphasized, and how these communication strategies might differ between stakeholder groups (e.g., food security organizations versus government agencies). These communication strategies, and the feedback obtained from employing such strategies, can support the development of vertical farming in ways that achieve locally determined food system sustainability and resilience outcomes.

Acknowledgements

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1. Background

Over the past decades, the intensive farming practices of conventional agriculture used to meet growing global food demand have exerted significant stresses on ecosystems and the environment. Simultaneously, our current food and agriculture systems are highly vulnerable to environmental and socioeconomic disturbances, which became evident during the COVID-19 pandemic. COVID-19 revealed numerous social, environmental, and economic vulnerabilities in our food systems that are susceptible to a variety of hazards shocks including climate change (Newell & Dale, 2020; Searchinger et al., 2018). Climate change and increasing extreme weather events are beginning to occur at frequencies which outpace our capacity to recover from the shocks, making the implementation of effective adaptation strategies a necessity. In November 2021, a record-breaking extreme precipitation event in British Columbia resulted in a state of emergency following a devastating flood that destroyed residential properties, farmlands, and livestock in the Fraser Valley region, a region regarded as the 'breadbasket' of the province. Food and commodity transportation routes were cut off and supply delivery to and from major cities and towns was heavily disrupted. Today, access to and availability of both local and imported food are still strained by growing inflation in the country and geopolitical conflicts driving surges in fossil fuel prices across the globe. Problems particular to food supply chains also emanate due in part to challenges in land availability or land use changes (BC Agriculture Council, 2020; Walsh et al., 2022), prolonging post-disaster recovery (Government of British Columbia, 2021). Such issues make the need to transition to innovative, resilient, and sustainable food systems imperative.

A potential, practical avenue for addressing some of the challenges experienced with our food systems issues is the adoption of technology-based indoor food production, also known as controlled environment agriculture (CEA). Among the CEA techniques, vertical agriculture presents promise as a viable way of developing urban agriculture capacity and improving food security (Goodman & Minner, 2019; Shamshiri et al., 2018). Vertically-farmed crops are cultivated indoors using stackable shelves, LED lights, and nutrients supplied to root systems via water, and the farming processes are run and coordinated using digital control systems (Halgamuge et al., 2021; Kozai et al., 2019). Vertical agriculture can contribute to environmental sustainability objectives due to the benefits it provides with respect to water conservation and low land use (Martin et al., 2019; Newell et al., 2021).

This research project explores how vertical agriculture can be integrated into local food systems in communities in British Columbia (and beyond) in ways that support environmental, economic, and food security objectives. Specifically, it examines how developing and implementing vertical farming in multiple 'development scenarios'

can influence access to food, business viability, and environmental outcomes such as reduction in land use and greenhouse gas emissions. This research is done by integrating and analyzing data in a map-based platform called Agrilyze (www.agrilyze.ca), where different development scenarios (e.g., many small farms distributed through a city, a few large farms in industrial areas, etc.) will be mapped and analyzed. In addition, through focus groups and interviews, the research investigates the views and perspectives that consumers, food service providers, and other stakeholders hold regarding this farming method to gain insights into factors that influence awareness/acceptance of and access to vertical agriculture technologies and crops. This report discusses the outcomes of the project's first focus group.

2. Methods

The research is led by the Food and Agriculture Institute at the University of the Fraser Valley, and it is conducted in collaboration with two industry partners: QuantoTech Solutions and i-Open Technologies. QuantoTech Solutions operates a vertical demonstration farm on UFV's Chilliwack campus, and i-Open Technologies Group designed and developed the Agrilyze platform for storing, displaying, and analyzing food systems-related data. The research also engages a variety of community members, [local governments](#), non-governmental organizations, industry stakeholders, and food retailers in the Lower Mainland to reveal opportunities and challenges for broad-based adoption of vertical agriculture in building sustainable resilient food systems. The first research activity of this project consisted of a focus group of government and food systems stakeholders, who live and work in communities primarily in the west Fraser Valley region (Figure 1).



Figure 1. Study area for focus group discussion

2.1 Participant Recruitment

Prior to conducting the focus group, the researcher engaged in virtual meetings with food systems networks namely the Abbotsford FRESH and the Mission Food Security Coalition. Members of these networks were invited to the focus group discussion due to their professional and/or volunteer roles in food systems in the Fraser Valley region, including expertise/work in related fields such as community health, social services, and economic development. During the meetings, the researchers introduced the vertical agriculture project and the upcoming focus group.

Invitation letters were prepared, and with the assistance of the Abbotsford and Mission network groups, these were sent through the networks via e-mail to solicit expressions of interest. The invitation was also sent to community members and food systems professionals/stakeholders, with whom the Food and Agriculture Institute had previously engaged in other research efforts. A total of 16 participants ultimately attended the focus group (see Appendix A for institutional/organizational representation). A broad cross-section of community members from private, public, and community sectors took part in this study, representing a strong diversity of perspectives across the Fraser Valley region.

2.2 Taste Test Exercise

Prior to the focus group, participants were given a list of instructions to carry out an at-home exercise that involved taste-testing the vertically farmed lettuces. The lettuce heads were delivered to their addresses through the DirectFood.store food delivery service a few days before the focus group, and the participants were asked to jot down various attributes of the lettuce, both positive and negative observations and opinions related to freshness, taste, etc. These observations/opinions were later discussed in detail during the focus group (see Section 3). The exercise also involved participants scanning a QR code (or typing a URL into their Internet browser) attached to the package of the lettuce delivered to them (Figure 2). Upon scanning the code or typing the URL, they were taken to a webpage containing information on how vertically-farmed lettuce compares with conventional lettuce, as well as a map that displays the food miles of the lettuce that travelled to them.

The food miles map is an interactive tool that was initially displayed using Google Maps (Figure 3), but later built in the Agrilyze platform for the focus group session. The map displays census tracts of Mission, Abbotsford, and Chilliwack, and users can click on the place where their house is located to see roughly how many kilometres the lettuce travelled from the farm to reach them. Displayed above the map were approximate distances to areas in California, Arizona, and Mexico from where

lettuce is frequently imported. Visitors to the webpage can use the interactive map and look at the information on imported distances to compare food miles between the local, vertically-farm and imported, conventionally-farmed products.



Figure 2. Packaged Lettuces for Delivery to Participants

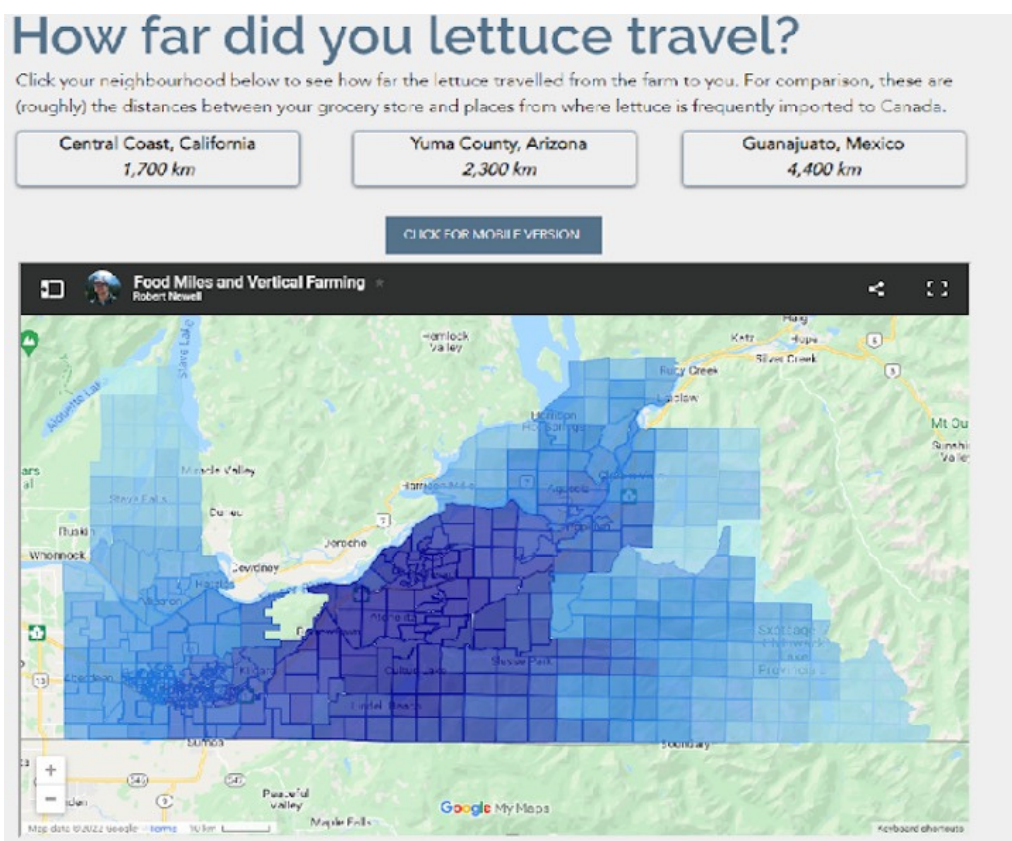


Figure 3. Interactive map of food miles for local, vertically-farmed lettuce

2.3 Research Framework

The research project employs a whole systems perspective. It examines the adoption of vertical agriculture as a potentially viable component of sustainable local food systems, and it conceptualizes its benefits and limitations as being part of complex and interconnected environmental, economic, social, and agricultural technology dynamics. Accordingly, the research examines vertical agriculture with respect to multiple aspects of food systems, as defined through environmental, economic, and social sustainability dimensions:

- **Environmental aspects** of vertical agriculture examined in this research relate to the resource efficiency potential of vertical agriculture, such as its role in building sustainable food systems, reducing greenhouse gas emissions with respect to the food miles, and sparing land compared to other food production systems such as traditional open field crop cultivation.
- **Economic aspects** of vertical agriculture examined in this research include economic viability and business potential in food supply chains, and the research considers how and where vertical farming might be implemented in urban areas, as well as the economic implications of these locations. In addition, consumer opinions/attitudes towards different attributes of the vertically-farmed lettuce (including the technology) are of interest, along with how much consumers will be willing (or not) to pay for vertically-farmed lettuce in comparison to conventional lettuce.
- **Social aspects** of vertical agriculture examined in this project include understanding the role vertical agriculture could play as a local food asset that contributes to food security, as well as how vertically-farmed products may (or may not) fit in local food culture. The project explores people's preferences and opinions around vertical farming as an agriculture method, which is linked to public awareness of the potential opportunities, challenges, and other considerations surrounding this farming method.

This list of sustainability criteria is non-exhaustive, and additional environmental, economic, and social considerations vertical farming emerged through the focus group. In addition, the framing outlined above applies to the full research project, and although all three sustainability dimensions were examined in the focus group, this initial session particularly focused on potential roles of vertical agriculture in the Fraser Valley and ways of engaging businesses and community members in this farming approach. To this end, questions used to guide the focus group discussion (Appendix B) were structured to stimulate discussion around vertical farming and (a)

food supply chains, (b) community food systems, (c) perspectives on products and technology, and (d) consumers.

2.4 Focus Group

The focus group ran for two hours on February 23rd, 2022, and it was conducted using Zoom to maintain physical distancing during the ongoing COVID-19 pandemic. Using an online format offered benefits, such as eliminating logistics and time-related limitations including but not limited to the costs to the researchers and participants, availability, finding meeting venues, etc. (Gray et al., 2020). In addition, the digital format enabled innovative ways for engagement, and in this case, focus group activities were facilitated using CoLabS (Figure 4), a web-based platform that facilitates collaborative discussion, brainstorming, and information sharing (Jost et al., 2021). Focus group participants were provided with the link to access a CoLabS on which they were able to see all the contents for the session, including the information they previously accessed via a QR code and Padlet-based 'digital working tables' for sharing thoughts and ideas.

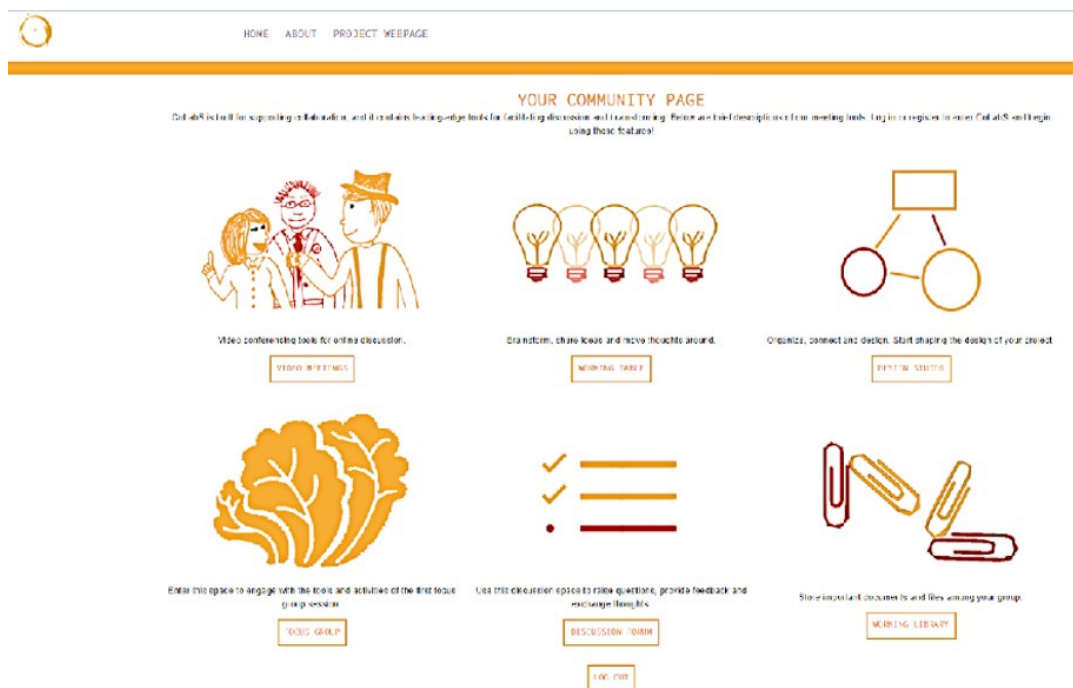


Figure 4. Screenshot of the CoLabS platform and tools

The focus group schedule is shown in Table 1. The session began with a presentation on the research project and the letter of consent for participating in the research, and participants were invited to ask questions. Then, a discussion was held about the at-home exercise specifically regarding the participants' impressions of the webpage and food miles map. As a part of this discussion, participants were asked to comment on the map-based tool, with respect to user-friendliness and the food miles information that it conveys.

Table 1. Vertical agriculture focus group schedule of activities

Activity	Description
Opening	Welcome and introduction to the sessions
Presentation	Background to vertical agriculture and the research
Research ethics	Consent forms and questions
Orientation	Demonstration of the CoLabS platform and focus group webpage
Web information	Feedback on the information webpage and food miles map
Breakout discussion	Vertical agriculture and the community
Breakout discussion	Vertical agriculture and the lettuce
Breakout discussion	Vertical agriculture and the consumer
Conclusion	Final thoughts and next steps for the project

Following the discussion on the webpage and interactive map, three 20-minute discussion sessions were conducted in Zoom breakout rooms, with eight participants assigned to each room. The focus group questions were categorized so that the three discussions respectively centred on the themes: “vertical farms and communities” (i.e., about local food systems), “vertical farms and lettuce” (i.e., about the product), and “vertical farms and consumers” (i.e., about community members who might access/eat the products). The first few minutes of each session began with participants using the CoLabS digital working tables to post comments related to the questions of the theme, and these comments and ideas were subsequently brought into a group discussion led by the researchers. Participants were encouraged to continue posting comments on the working table during the discussion.

3. Insights from the Focus Group

As noted earlier, the focus group activities and discussion questions were designed to examine vertical agriculture with respect to (a) food supply chains, (b) community food systems, (c) perspectives on the products and technology, and (d) consumers. Participant responses and insights from the discussion were thematically analyzed, and the results of the analysis are organized into the four categories listed above. Thematic analysis was applied to all the data (i.e., discussion on webpage and food miles map, breakout discussions, working table comments, and Zoom chat transcripts), and Table 2 gives a summary of the themes and their associations with focus group discussion questions and categories for the questions. The sections below discuss the outcomes of the thematic analysis, and this discussion is supported with illustrative quotes.

Table 2. Thematic analysis of focus group data

Category	Question	Theme
Interactive and Informational Tools	What are the differences between vertically-farmed lettuce and the conventional lettuce with which you are familiar?	Provide comprehensible contexts and analogy
	How far did the lettuce travel from the farm to you?	Employing practical techniques for public engagement
Community food systems	How (if all) do you think vertical farming can fit within your professional, volunteer, and/or day-to-day lives?	Working with public and third-sector institutions for community buy-in
	How aware/knowledgeable about vertical farming are your community members and local businesses?	Adapting communication for community acceptance
	What are attitudes and opinions regarding vertical farming practice?	Adapting vertical agriculture to local contexts
Perspectives on the product and technology	What did you (and think others would) find most appealing about the product, and how did it compare with conventional lettuce?	Appealing to preferences and expectations
	Do you think the use of technology and indoor farming would affect people's opinions about the product?	Adapting communication for community acceptance
Consumers	What (if anything) would lead to consumers, businesses, or food service/program organizations wanting to see vertically-farmed products in their local markets?	Employing value-driven propositions
	Do you think people in your community would be willing to spend more on vertically-farmed produce than conventional produce (why or why not)?	Employing value-driven propositions

3.1 The Role of Vertical Agriculture in Food Supply Chains

3.1.1 Comparison Between Vertical and Conventional Farming of Lettuce

Relevant theme: Provide comprehensible contexts and analogy

The participants noted that the map-based and numerical information on vertical and conventional comparisons to be beneficial; however, they suggested that the presentation needs to be simplified using language and analogies to which the 'average person' can relate and understand. Such comments referred to numbers on growing space and yield, as well as values provided in the map like population numbers. Participants recommended providing descriptions for what these numbers imply and why it was important to frame vertical/conventional comparisons around certain factors such as growing space/yield.

Participants recommended that an opening statement on the potential role of vertical agriculture on the webpage would better engage readers and clarify the purpose and context of the comparisons. Participants also identified further areas of comparison that would highlight the benefits of vertical farming over conventional farming (e.g., no pesticide use). This discussion was extended to include recommendations on providing explicit details about inputs used such as energy and water, as well as the costs of farming techniques and practices.

Participant Quote:

"...it's more about using me as a champion, right? I've already spent the money. Maybe I've already signed up for it. So then pick and package the information in a way that I can share with my group of dinner partners that night or something like that or explain it to my kids as to why we're having lettuce tonight."

Other comments included recommendations for examining and highlighting current farming practices occurring outside the Canadian context to stimulate broader understanding of vertical farming benefits and opportunities. For example, restaurants in some Asian countries operate vertical farming at the restaurants where they also cook and serve the produce to their customers. Sharing such examples could communicate real-world applications and comprehensible messages about the possibilities of vertical farming and its land sparing potential and food miles reduction benefits.

The participants also noted that boosting the local food system through increased supply chain efficiencies is imperative, and vertical agriculture can play a role in achieving this objective. However, when engaging the public about such an imperative/objective, public communications and efforts to raise awareness about vertical agriculture must take into consideration the perceptions and possible

reactions of conventional farmers and those with strong cultural attachments to conventional agriculture. Potential tensions can be minimized by clearly communicating the specific intentions for developing vertical farming, that is, making clear distinctions about whether it will change or simply supplement conventional farming. Also, it is important to provide reasons for its adoption, with such reasoning being grounded in (for instance) addressing food supply issues in highly-populated areas.

Participant Quote:

"... I can see there will be more willingness to accept vertical farming knowing that this is actually going to be a need. But if it's something that's communicated as taking over conventional farming, there will be a lot of pushbacks."

3.1.2 Food Miles through the Lens of Geospatial Representation

Relevant theme: Employing practical techniques for public engagement

The option of having an interactive tool to navigate and examine food miles was received well by the participants, but it was noted that the tool could be improved. Participant feedback for improving the tool included comments on how the food miles concept can be better represented if comparisons between the two food production methods focus more on resource usage/savings (such as fuel and/or fuel cost saved and avoided food waste), instead of simply stating the kilometres the lettuce travel to reach grocery stores or consumers. It was expressed that such a communication strategy could be employed to engage consumers on climate change issues and how vertical agriculture could contribute to related environmental and social objectives. Such messaging could increase appreciation for the products, and also why it may make sense to pay a little extra money for vertically-farmed crops (i.e., given its benefits and the data/numbers to support the existence of these benefits).

Participant Quote:

"...we talk about carbon, we talk about GHGs and fuel. And I also think in terms of context, this is probably one of the more compelling value propositions if I think about the younger generation that's coming up, I think climate change is definitely on their minds."

Participants identified ways of improving the food miles map to increase its clarity and salience as a communication and educational tool for representing meaningful and understandable information. Participants commented that it would make more sense to focus the map on only densely populated locations instead of remote areas where vertical farming development would be less likely. Other recommendations included simplifying the map layers and mapping spaces larger than census tracts to make the map more navigable and readable.

3.2 Fitting Vertical Agriculture in Communities

3.2.1 Vertical Farming in Professional, Volunteering and/or Day-to-day Life Scenarios

Relevant theme: Working with public and third-sector institutions for community buy-in

Many of the participants emphasized that meeting local food security needs could be considered to be the most critical driving force for effectively introducing vertical agriculture to communities as a desirable food production method. It was indicated that an availability of vertically-farmed crops would help narrow the gap between increasing demand for locally-produced, nutritious food and the limited supply, especially in terms of feeding those that need it the most. Many participants suggested that existing community outreach programs that are run by food banks and religious institutions could be key players through which vertically-farmed crops could be supplied and/or distributed. This approach could generate community buy-in, making vertical agriculture appealing to the public and increasing the potential for effectively integrating it into local food systems.

The discussion around the potential vertical agriculture has for supporting food programs and services was expanded upon, with participants explaining the difficulty the food banks (and related initiatives) face around accessing and serving their clients with locally grown fresh vegetables (i.e., these being rare products in the donations they receive). If vertically-farmed crops were to become easily accessible to food banks, it would support a considerable portion of their food hamper program that they run for local communities. It was suggested that setting up a hydroponic system and growing crops out of the food banks could be a viable way to fill the gap between fresh food supply and actual needs.

Participant Quotes:

"...in the off season, there is no one providing lettuce. We run a nutritional coupon program, and we give people who have food security issues in the City of Mission, the opportunity to come and buy fresh, locally grown vegetables. So, it would be really fantastic to link that kind of program for food insecure people to get lettuce to everybody throughout the year."

"...creation of community gardens in more areas around communities for easy access would benefit more community members."

Participants emphasized the importance of developing a business model that strategically targets food supply gaps. Such an approach includes targeting public

institutions, such as hospitals and schools, to be the customers/recipients of vertically-farmed crops. Access to vertically-farmed products would provide convenience and (ideally) less-costly logistics for these institutions, supporting their desires to source local and reliable produce.

It was noted that vertical farming may increase on agricultural lands as awareness of the benefits of this farming production method become more understood. Participants discussed how farmers and communities may take advantage of the regulations around the Agricultural Land Reserve (ALR), which allows the development of vertical farms on lands that were previously limited to conventional/traditional agricultural practices. It was noted that this presents new opportunities when considering the questions about where to fit vertical agriculture within the food production arena. However, participants also raised concerns about how these land use changes may invite investment opportunities and fierce competition from buyers in other jurisdictions or countries, potentially creating challenges for local food producers (especially small scale) trying to enter or remain in the market.

Participant Quotes:

"...at the present time, our website sales are a small portion, but we are looking to increase that substantially because that is the highest margin for us right now. Our main focus went on day-to-day sales is grocery stores, restaurants. And then a little bit on the domestic side, the end consumer side. So, what we do is we have a whole let's go find new restaurants, we go and meet with the chefs or the owners and talk to the grocery store produce managers, that type of thing to go and recruit new customers when we need them."

"...it would be good to encourage this form of agriculture OFF the ALR and instead on "waste" land that has no agricultural potential."

"...what we do is try to create space for innovation to come from businesses right? We're not the ones who come up with the idea, it's them. And then what we have as an opportunity to do is to make sure that there's the safety, the rules, and regulations around that, but also to amplify when there's challenges. And if that challenge is lack of space or, let's say, a provincial guideline that doesn't fit the way the industry is changing, then we can help to amplify those voices."

3.2.2 Awareness and Knowledge about Vertical Farming

Relevant theme: Adapting communication for community acceptance

Participant comments varied with respect to the awareness and attitudes local community members and businesses may have about vertical agriculture. Some

noted that their community members likely have no knowledge about this farming method, and others mentioned that people consider it to be something that is not available to them nor relevant to their local context. Participants felt that most community members would be receptive, curious, and even excited at the prospect of developing local vertical agriculture capacity; however, they also noted that this sentiment would not necessarily be shared by all, particularly the conventional farming community.

Participant Quotes:

"...my sense is that nobody in my community has any awareness whatsoever about vertical agriculture. I think they would be VERY receptive and excited if the information were framed in the right way. I'm only talking about "regular people"--not actual farmers, who will certainly be more conflicted."

"...It's something that has popped up in news or social media platforms over the years as something done 'elsewhere' but doesn't seem relevant to our context. On the other side, most conversations with the average consumer I've witnessed are positive or curious. Although I have heard negative sentiments from small scale farmers around vertical farm as they wish the attention was more focused on supporting them and conventional farming practices."

"...in my professional life--I would love to incorporate a component on vertical agriculture in my "Dig for Your Rights!" educational program, which uses picture books about farming to help children understand and get involved in their local food system."

Participants noted that people often inquire about where the produce they buy or receive comes from and how local farmers that produce the crops are supported; they explained that similar questions will likely be raised when vertically-farmed crops are introduced in the markets. It was underscored that community-oriented strategies are essential when communicating information about vertically-farmed crops, especially regarding whether this farming technique will be accessible/beneficial to food-insecure groups. Participants also noted that comparable nutrition is a key component of the message, explaining that consumers will be curious if vertically-farmed crops are nutritionally beneficial compared with (for example) organic crops of the same kind. Providing explicit information and raising consumers awareness around such aspects of the crop was indicated to be essential, even before the products become available in the market.

3.2.3 Attitudes and Opinions towards Vertical Farming Practices

Relevant theme: Adapting vertical agriculture to local contexts

One of the participants discussed a small-scale vertical farm they were operating in

their house's basement, and they were able to market some of the products. It was expressed that these types of small-scale operations could be key driving factors to build local capacities that may allow interested community members to participate in their local food systems. Participants noted that such operations could occur in residential buildings and community spaces, but larger spaces will likely be necessary for those who would like to scale up.

Participant Quote:

"...I am currently outgrowing the space that I am using, and this is in a house. I'm using the basement. This is how I've always grown up until now. So, I am looking for some sort of commercial space to move into to continue growing. And I am finding that there is an awful shortage of suitable commercial space for these kinds of activities. I would like to see that the various organizations that produce this commercial space we're talking about big warehouse-type spaces, big open rooms, or concrete buildings, easy to keep clean this type of thing. I would like to see an increase in that type of thing that facilitates this kind of growing operation."

Participants discussed how issues that compromise and constrain food production and distribution and present local supply chain problems have highlighted a potential role for vertical agriculture. A salient example raised was extreme weather conditions and/or natural disasters that disrupt food supply chains. These circumstances spotlight the prospects of vertical agriculture as an alternative food production and provisioning system to local communities within a region.

Participant Quote:

"...people might be more open to it especially in the wake of the flooding -- need for diversified food supply."

It was recognized that for places like the Fraser Valley, where agriculture is an integral part of community identity, vertical agriculture may be welcomed as an alternative food production method, as it has the potential to increase the resilience of food production systems. This discussion included comments on community interactions, with participants stressing that it is essential to engage in consumer- and local-oriented approaches that build relationships and trust between the growers and consumers. Participants reflected on the inherent lack of transparency and relationships between consumers and producers that are typical in industrial-scale food production, noting that local vertical agriculture could avoid this problematic disconnect.

Participant Quotes:

"...I think what I see is that there is so much potential for vertical agriculture to become a

solution to many different food security problems and hopefully to involve segments of the population who have become disconnected from agriculture.”

“...vertical farming awareness - little knowledge, promotion and use in the community however the idea is growing, and the conversation is stronger.”

“...if they are aware of less transport/carbon cost plus no pesticide and less land/water use, they are interested to learn more.”

Some comments were shared concerning potential consumer hesitancy toward vertical agriculture due to the perceived ‘naturalness’ (or lack thereof) of vertically-farmed crops that are cultivated in enclosed environments. An approach suggested to address this potential issue was to engage local schools about providing lessons or guest presentations on innovative agriculture. Suggestions included bringing demonstration vertical farms to schools for lessons and activities, and participants noted that the ‘technology’ component could be an interesting aspect of these lessons/activities because of how younger generations are more attracted and attuned to newer technologies. Such activities could potentially spark curiosity to learn about vertical farming and how to engage in the practices.

Participants expressed that there are challenges surrounding access to and retention of skilled labour in vertical farms, particularly in operations that rely on manual labour. This is the case for start-ups that are not fully automated, and strategies and approaches for connecting these fledging operations with labour are necessary for them to be a part of local food systems. Also noted, it is important to consider the service intensity required by vertical farms, and how this may differ depending on their compatibility with different types of spaces and environments.

3.3 Evaluating the Attributes of Vertically-Farmed Crops and the Production Technology

3.3.1 Crop Features and Comparability with Conventionally-farmed Lettuce *Relevant theme: Appealing to preferences and expectations*

There were several features the participants pointed out as appealing about the vertically-farmed lettuce they sampled; these include freshness, colour (i.e., very green), taste/flavour, crispiness, aroma, and sweetness compared to a store-bought lettuce. It was emphasized that taste and freshness could be key features for encouraging repeat purchases. Participants also reported a relatively longer shelf life than other lettuce, as they had kept the lettuce for a few (two to four) days after delivery and/or before consumption. They indicated that the persistent freshness could be due to the lettuce roots being attached, and were curious if the lettuce

would grow back if the root part was planted post-consumption. They also appreciated the home-delivery of the lettuce, and this convenience was also considered to be a positive draw to the product.

Participants appreciated the compostable and paper-bag packaging as an acceptable waste product; however, there was a mention that it was too much packaging for a head of lettuce. While a reasonable concern, this product is currently being delivered direct and locally only, and the packaging may be reduced when serving consumers at larger scales in the future.

Participant Quotes:

"...keeping water local - its nice that the lettuce, which is mostly water, hasn't been imported, and due to shelf life, may not be exported- keeping water in its region."

"...lettuce compelling aspects - How much less it travelled... better for environment. I am interested to learn about the nutritional difference from conventional lettuce."

"...all-round positive experience. It was delicious, no waste, loved the packaging, felt very virtuous about the small footprint, felt very healthy/confident/safe about safer product."

3.3.2 Opinions on In-door Production of Lettuce and the Technology

Relevant theme: Adapting communication for community acceptance

Participants suggested that the community acceptance of vertical agriculture might be supported due to vertical agriculture not seeming too 'unusual' or unfamiliar. It was suggested that food production in greenhouses has somewhat laid the foundation for comfort around indoor agriculture. The use of food production technologies in greenhouses has also been a long-standing practice, and the production of crops indoors is not an unfamiliar concept compared with newer or innovative food systems concepts/practices such as cellular agriculture (which the public might find more difficult to accept).

Participants commented that a key benefit of indoor agriculture is the protection it provides for farmers and farmlands from the impacts of weather-related catastrophes. Participants reiterated some of the benefits identified earlier in the discussion, and a major topic of conversation was the potential vertical farms can have in response to events that disrupt and disconnect communities from supply chains. Having vertical farming production systems in place would reduce the extra costs foodservice providers and consumers bear during times in which food transportation routes are compromised. Accordingly, public communications and education around vertical farming should include points around the vulnerabilities to exogenous shocks that are found in local food systems and economies.

Participant Quotes:

"...people who are interested in technology will pay attention, but the broader market may just look at cost, especially with inflation at current levels."

"...there are all sorts of aspects that people could understand better about this being a much safer product... it gives us amazing food security, especially on a household level, in terms of people being cut off or whatever the cost effectiveness that is incomparable with our current food system."

Participants raised concerns about perceived potential trade-offs due to a lack of familiarity with novel food technologies. In particular, consumers might question how technologically-driven food production systems differ from a traditional food production system (i.e., that they have been familiar with for ages) in terms of crop nutrition. The questions (and perhaps skepticism) could be more pronounced in communities that have formed cultural identities related to traditional agriculture and values around producing and consuming 'food from the earth' of local lands. Participants commented that it could be a challenging task to have the buy-in from these parts of the population; however, a decentralized approach to vertical agriculture could help reduce potential mistrust between local consumers and vertical agriculture farmers/operators.

Participant Quotes:

"...if I'm looking at two heads of lettuce and I'm conflicted about the value of one in terms of how it's grown, I'll probably buy the other one, even if it's worse in the sense that it has a larger environmental impact, for example, or it's imported not supporting the local economy."

"...there might be some distrust of like, is it nutritious? It's not from the Earth, is it cooked in a lab, which is kind of ironic because so much of our food is not really trustworthy. There are so many weird ingredients and stuff. So, you know, it's a bit of a conflict."

"... I would pay twice as much if it were really safe, good food, that was local. I do actually routinely. So, for me, it's not so much about the cost and for some people it won't be. But you have to get the feet over to the shelf before you can do anything else."

3.4 Consumers, Businesses, and their Perspectives on Vertically Farmed Crops

3.4.1 Vertically-farmed Crops in the Local Markets

Relevant theme: Employing value-driven propositions

Participants were asked about their thoughts on the opinions of consumers,

businesses, food service programs, or industries toward vertically-farmed crops and potentially increasing their availability in local markets. They noted that perspectives are likely varied among different segments of the population; for example, socioeconomic factors could influence views on vertical agriculture. Increasing awareness and acceptance of vertically-farmed products in the market will depend on factors such as who the target consumers are, the price of the products, and what is driving the implementation of local vertical agriculture (e.g., food security, economic development, etc.).

Different demographics and sectors potentially hold varying interests in vertical farming, which has implications for communications and engagement. For many, vertical agriculture will have appeal due to benefits such as no pesticide usage, local production, and low land and water consumption, but interests in the food production method can also be more differentiated and nuanced. For instance, for local grocery stores, the potential selling points could be the shorter crop growing cycle (i.e., compared with conventional field crops), allowing for faster sales turnaround times. For other groups, the technological aspects and urban agriculture opportunities could be the major points of interest.

Participant Quotes:

"...education for schools and food security would be an impactful way to bring this all together. Make modern agriculture a thing - Tendency of people from "the city" to view agriculture as old industry - it isn't, and I think this provides a window into modern agriculture."

"...connected to food production - some people feel uncomfortable in rural spaces, which is where much food production occurs, this has the opportunity to allow folks (restaurant owners, grocery stores etc.) to appreciate how their food is produced when it could literally be put on their back step."

"...I think that we need to look at what are the primary interests of the consumer and don't think it is as much about indoor growing as the benefits or value proposition... the why. Local, pesticide free, less land and water... and by the way it was grown indoors."

As noted earlier, participants cautioned that there are a number of factors that could lead to challenges for vertical farming to become popular as a local food production method. During such discussion, participants commented on the roles that food purchasing and growing play in social systems and how conventional approaches to agriculture and food retail hold favourable associations and attachments. Such comments were accompanied with examples of positive experiences in food retail spaces.

Participant Quote:

"...I often go to the farmer's market, and I have my favourite farmers there, so I have to stand in line to get to talk to him. And they always make a point of finding out how he and his mom are doing, how the farm is going. When I go to a normal grocery store, I use it as a form of exercise. I walk up and down. Every aisle doesn't even matter if I'm looking for something down that aisle. I just like walking around looking at things. So, I guess we're just at different stages of life. It's so it's my hobby and my way of exercising and social events."

3.4.2 Willing to Spend More on Vertically-farmed Produce

Relevant theme: Employing value-driven propositions

Participants expressed that willingness-to-pay for vertically-farmed crops will depend on the consumer base targeted (e.g., boutique grocery stores or larger supermarkets). Given the costly technology behind vertical farming systems, some products might be sold at higher prices in smaller (boutique) stores, where a higher price margin is not as unacceptable as in a larger supermarket. Participants expressed that consumer and retailer appreciation of the benefits of vertically-farmed crops (i.e., those discussed above, such as food security and reduced environmental footprint) likely will increase willingness to spend more for products. It was noted that prices will change over time as production is brought to scale, allowing for competitive pricing.

Participant Quotes:

"... I would spend double if necessary (though I would prefer not to!) for the benefits—and so would many people that I know. However, it would also be fantastic to see produce offered to low income and food insecure members of the population at a fraction of the price, which I believe could be done if the infrastructure were mobilized widely in schools, institutions, homes, etc."

"...vertical farm products in local markets - Unique products available all year round at a consistent price for business. Difficult to run a food service business where your price fluctuates, and certain products are not available all the time."

"...doubt folks would pay more for the intrinsic value of vert ag - People pay more for marketing. But how the vertical agriculture is marketed could boost product value."

"...spend more? - I'm not sure I would spend more unless it was the only one available or was a better product than others available."

4. Implications and Conclusions

The focus group revealed compelling arguments for claiming that vertical agriculture could be viable and play a key role in local and regional food systems in the Fraser Valley, as well as provided ideas on how this could be actualized. Providing a comprehensible context and developing effective tools for comparing and understanding differences between vertical agriculture and conventional farming were identified as practical strategies for engaging community members about its potential benefits to local food systems. Also identified was a need to link vertical agriculture to existing gaps in the local food supply and demand. Pressing food security concerns can be used as compelling arguments and framed as opportunity-building cases for introducing innovative food production systems such as vertical farming. Such points are particularly relevant to disaster-prone regions and farmlands that are more likely to face climate-induced impacts in the near future.

Participants indicated that attitude toward vertical farming may largely depend on how effectively the benefits can be realized, and it was highlighted that sociodemographic factors, such as income and purchasing capacity, will influence people's interest and attraction to the products. In addition, it is important to consider more nuanced interests that go beyond food accessibility and affordability, and are distinctive to certain groups, such as technological interest. Relatedly, public engagement around vertical agriculture requires careful considerations as to how people might react to vertical agriculture on social and cultural levels, especially in terms of its competitive co-existence with small scale traditional, open field, or greenhouse producers that have been serving communities and economies for many decades.

Participants provided important insights and recommendations for the successful introduction and implementation of vertical farming in their communities. A frequently discussed item was the importance of identifying and communicating the value propositions for vertically-farmed crops. Participants emphasized the importance of articulating potential benefits that appeal to widely-held values, such as food security, resilience in the face of natural disaster, and reduced land use land sparing, and doing so prior to presenting the technological aspects, which could appeal to more niche groups. This said, participants also emphasized the importance of understanding the audience, recognizing that the technology could be an engaging feature to younger generations.

Although the focus group produced many important insights about public communications and engagement strategies for vertical agriculture, questions remain on the best ways to implement these insights. Such questions include

whether primarily presenting the benefits, and less so the technology, can serve as an effective communication strategy to shape views and perceptions about vertical agriculture and its potential roles in local food systems. In addition, it is important to consider how value propositions can be communicated to diverse groups, such as community organizations, food service providers, and government actors that hold particular interests in vertical agriculture (such as local economic development, agricultural innovation, etc.), which perhaps differ from the 'average consumer'.

In the current digital age, consumers and foodservice providers have access and are exposed to vast amounts of information on food markets, supply chains, production methods, etc. Such information, along with a diversity of lived experiences, influences perspectives on local food systems and what would be beneficial or problematic for these systems. It is therefore worthwhile to engage in future dialogues with community members and industry stakeholders to see if similar insights and perspectives are echoed, while also revealing different views and perspectives. Such future work will provide a more comprehensive understanding of the role vertical agriculture could play in local food systems, as well as the opportunities and challenges around increasing adoption and realizing its potential benefits.

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Appendices

Appendix A. *Organizations and Institutional Affiliations of Participants*

Organizations and Institutions
Abbotsford Fresh – Industry Development
Archway Community Services
Chilliwack Economic Partners Corporation
City of Abbotsford
City of Mission
Community Futures South Fraser
Emma’s Acres (Mission)
Fraser Health Authority
Fraser Valley Regional District
Mission Community Skills Centre Society
Mission Food Security Coalition
Nutriva Group
University of the Fraser Valley
Yarrow ECO Village

Appendices

Appendix B. Focus Group Discussion Questions

A. The Role of Vertical Agriculture in Food Supply Chains

1. What is the difference between vertically-farmed lettuce and the conventional lettuces that are more familiar to you?
2. How far did the lettuce travel from the farm to you?

B. Fitting Vertical Agriculture in Communities

1. How (if all) do you think vertical farming can fit within your professional, volunteer, and/or day-to-day lives?
2. How aware/knowledgeable about vertical farming are your community members and local businesses?
3. What are attitudes and opinions regarding vertical farming practice?

C. Evaluating the Attributes of Vertically-Farmed Crops and the Production Technology

1. When trying the vertically-farmed lettuce, what did you find most appealing about the product, and how did it compare with conventional lettuce?
2. What aspects of the lettuce do think people, such as other consumers and food providers, might like and not like?
3. Do you think the use of technology and indoor farming would affect people's opinions about the product?

D. Consumers and their Perspectives on Vertically-farmed Crops

1. What (if anything) would lead to consumers, businesses, or food service/program organizations wanting to see vertically-farmed products in their local markets?
2. Do you think people in your community would be willing to spend more on vertically-farmed produce than conventional produce (why or why not)?