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PLANNING CONSIDERATIONS FOR VERTICAL AGRICULTURE

University of the Fraser Valley
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The Food and Agriculture Institute at the University of the Fraser Valley is situated on the sacred lands of the Stó:lō peoples. The Stó:lō have an intrinsic relationship with S'ólh Tém:éxw (Our Sacred Land), and we express our gratitude and respect for the honour of living and working in this territory.

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EXECUTIVE SUMMARY

As an emerging approach to food production, there is a need to examine the implications that vertical agriculture holds for local food systems planning. Indoor, controlled environment growing is compatible with a variety of land uses, making it both an opportunity and source of tension for community food activists, organizations, and city planners. This study engages food systems stakeholders and local government to explore these opportunities and tensions. Building on a previous vertical agriculture site suitability and scenario mapping study, we conducted a workshop in December 2023 with twelve individuals with roles in the development and functioning of food systems in the Lower Mainland region of British Columbia. The main objective of this work was to better understand practical land use and planning considerations for this emerging approach to food production. Our key findings are as follows:

- Integrating vertical agriculture into agriculturally-zoned land may be the most feasible development approach for the industry in British Columbia.
- Despite the high cost of industrial land, integration of vertical growing within this zoning designation is also highly feasible, as vertical agriculture operations are most compatible with existing industrial land uses.
- A majority of participants favoured small-medium scales of production, located on mixed-use and/or residential or commercial land; however, flexible zoning is key to accommodate these possible land uses.
- There are opportunities to include vertical agriculture within business or educational parks, and such opportunities can contribute to circular economic development patterns.
- Additional site suitability considerations for vertical agriculture to include in the mapping and modeling work are underutilized spaces, especially on agricultural land.
- Proximity to available labour is an important consideration for community organizations seeking to implement vertical growing systems. Additionally, training supports offered by post-secondary institutions are needed to build a skilled labour pool, and incubator and accelerator programs can spur innovation and improve capacity for growing a local vertical agriculture industry.

BACKGROUND

Food systems planning is an emerging theoretical and applied field of research. Throughout the 20th century food was considered to be a wholly marketized and globalized commodity, under the sole purview of national and international economic and trade policy. In contrast, political, economic, and technological changes throughout the 21st century have made the local-regional production of food, at scale, both possible and efficient (Newman et al., 2023). Developing and evolving such local-regional systems requires increasing engagement of local, regional, and city government in food systems planning (Blay-Palmer, 2018; Dring et al., 2023).

Vertical agriculture, as an indoor, controlled environment approach to agricultural production, can theoretically happen anywhere. Many of the largest vertical agriculture companies operate in large-scale facilities or warehouses, located in urban or peri-urban areas on industrial or commercially-zoned land (e.g., QuantoTech, 2024; GoodLeaf, 2024). Other companies operate shipping container farms, which are situated on parking lots in mixed-use or commercially-zoned land (e.g., FreightFarms, 2024). Small grow tower units can be obtained by small-scale farmers or for personal use, with these units capable of operating across all land uses, including in residential backyards (TowerFarms, 2024).

The flexibility of vertical agriculture opens major opportunities for localizing food systems and creating short supply chains. However, it also creates tensions with local land use planning procedures and priorities, where high-volume agricultural production can now occur on residential, mixed-use, commercial, or industrially zoned lands. This means that vertical agriculture can conflict with conventional agricultural land use priorities *as well as* other land uses, including industrial, commercial, and residential. Understanding and unpacking the land use possibilities, opportunities, and tensions associated with vertical agriculture can support planners and vertical agriculture producers/practitioners identify possible suitable and/or feasible sites, as they seek to implement vertical agriculture in ways that optimize the benefits while addressing potential trade-offs.

METHODS

This study builds on a previous research effort, where we modeled possible food security/environmental impacts for diverse land use configurations of vertical agriculture (Glaros et al., 2023a). We defined three distinct priorities and possible land use scenarios for vertical agriculture growth across the Lower Mainland, British Columbia, including community development, mixed-use residential/commercial, and large-scale industrial vertical agriculture production.

This study gathered producers, planners, and stakeholders actively engaged in community food systems to discuss land use considerations for vertical agriculture. On December 4th, 2023, the research team led a workshop with twelve participants, who represented a broad cross-section of food system actors (Table 1). The workshop activities and discussion questions were designed to solicit a wide range of ideas, perceptions, knowledge, and expertise (1) to assess the viability of different possible land use patterns for vertical agriculture as per the scenarios mapping and modeling in the previous study, and (2) to identify additional considerations for the site placement of vertical farms and the development of a local vertical agriculture industry.

Table 1. Overview of research participants. Please note that all quotes are attributed to each sector group via sector codes, with numbers distinguishing between individual participants.

Sector	Number of Participants	Sector Code for Quotes
Academia	2	PA
City Government	2	PG
Community Organizations	4	PC
Producers/Farmers	2	PF
Community Food Activists	2	PFA

The workshop was conducted online using the Zoom platform, and took place over a period of 2 hours. We began the workshop by asking stakeholders about their general perspectives on vertical agriculture and what drew them to the workshop. We then presented a series of possible vertical agriculture industrial development patterns to ascertain general perceptions, considerations, and land use opportunities for this emerging approach to food production. The discussion centered around land use, zoning, and possible development forms of vertical growing technologies (e.g., as small-scale in-house grow units versus large-scale plant factories). We analyzed the research data to determine common themes identified across participants, and reflect on how vertical growing interfaces with existing food systems planning policies and procedures in the Lower Mainland, British Columbia.

RESULTS

The group discussions were analyzed thematically to identify the key concerns, opportunities, and considerations around building a vertical agriculture industry in the Lower Mainland. The analysis is organized into three categories: challenges and concerns, opportunities, and spatial considerations. Three challenges and concerns (i.e., agricultural land, industrial land, long-term land use), four opportunities (i.e., residential and commercial land, flexible zoning, agricultural or industrial parks, and circular economic development, small and medium-scale production), and two spatial considerations (i.e., underutilized and unconventional spaces, labour availability and proximity to training centres) themes emerged through the analysis. These results are discussed in further detail in the sections below.

Challenges and Concerns

1. Agricultural Land

Most participants highlighted the placement of vertical agriculture facilities on agriculturally-zoned land as a key concern. On one hand, participants were skeptical of placing additional food growing infrastructure on prime agricultural land reserve (ALR) land:

> *"And I should say I am, I am definitely not in favor of doing this kind of growing on agricultural ALR land, but I'd like to see good soil planted with products that have to be farmed outside." (PA)*

Multiple reasons exist for this concern. Participants thought that such an approach would result in the loss of a valuable ecological and agricultural resource, that is, fertile land. One participant compared the practice of developing vertical agriculture on the ALR with the proliferation of the greenhouse industry, and another participant warned of the future challenges that would be experienced when converting and developing land for vertical agriculture:

> *"It's already difficult when you see some of the best farmland in the country covered by a greenhouse. I just don't see that an answer for vertical farming is in agricultural land (PG1)."*

> *"The idea of putting vertical farming on ALR land just seems to be shooting ourselves in the foot (PC1)."*

On the other hand, in British Columbia, developing vertical farms on agriculturally-zoned land may be the most straightforward method of building a local vertical agriculture industry, given recent changes to the ALR that are permissive of vertical agriculture. As one city planner noted, permitting for vertical growing on this land would be straightforward and may be the most viable avenue for building a local industry due the fact that most land of the land in the region is agriculturally zoned:

> *"So I think that we just have to figure out how to put [vertical agriculture] on agricultural land. Seventy five percent of our land base is in agriculture (PG2)."*

2. Industrial Land

Many workshop participants agreed that there would be many challenges to implementing vertical agriculture on industrial land. While industrially-zoned land can support vertical agriculture with respect to space and facilities, it is potentially cost-prohibitive. As described by one city planner, industrial land is in short supply in the region:

> *"I think one of the challenges, you've talked about putting on industrial land...less than 3% of our land base is industrial. I think the current vacancy rate is less than 1%. And it's going for, you know, north of 7 million an acre. So it's not available, and I don't think the economics work...(PG2)."*

This comment was echoed by another city planner, who described the challenges of competing with industrial land uses. When asked where vertical agriculture facilities should go, the planner explained:

> *"We're limited on industrial lands. So you as a farmer are now competing with other industrial companies for very small limited areas. It's a difficult question (PG1)".*

The same participant later noted that there was less financial incentive for cities to support vertical agriculture on industrial land. The reason for this is due to differences in agricultural versus industrial taxation levels, where industrial properties/operations are taxed at higher rates and thus result in more municipal revenue:

> *"How would this land use affect taxation? So BC Assessment allows for farmland in the agricultural land reserve to be taxed accordingly. So scenario, we now have a vertical farm in an industrial park. Is that building now taxed at a farm taxation rate?...Now as the city, we have a huge industrial site that is now being taxed at farm rate. Is that in our best interest? Or is it in our best interest to have that taxed at an industrial rate? So it's a question for your project, how is this going to affect the municipalities (PG1)."*

3. Long-term Land Use

A key consideration and long-term planning challenge for any built structure is its implications for future land-use planning and development. Ensuring that a vertical growing facility can be repurposed in ways that are still compatible with the current or future designated land uses (i.e. residential, commercial, industrial, or agricultural) is crucial for the acceptability of developing a vertical farm. Such long-term considerations may be easier for commercial or industrial land and buildings than residential or agricultural land uses. One participant explained:

> *"We have to look again at what happens in 5, 10, 15, 20 years time to that structure... using a permanent structure where it's already permitted, such as an industrial location or a commercial location, then it's an easy or solution that in 10 years time it can be referred to another use that's compatible with the land use (PG1)."*

Opportunities

1. Residential and Commercial Land

Several participants (n=5) indicated a desire for vertical growing to be implemented within mixed-use zones, including commercial and residential lands. These zones were attractive to workshop participants due to how they can accommodate smaller scales of production. In addition, these participants indicated that such a form of development would be much more acceptable than converting/developing farmland. For example, when asked why vertical growing would ideally not be implemented on agricultural lands, one participant noted the following:

> *"But especially when, you know, small-scale vertical farms could probably be put in residential areas rather easily (PC1)."*

Participants also explained that residential and commercial zones are advantageous in that they already are connected to municipal services that could support vertical agriculture. As explained by one participant, such connections allow for a less expensive and more seamless integration of the infrastructure required to support a vertical farm:

> *"Yeah, I can't stress enough the importance of the infrastructure that's already in place. So it doesn't help a farmer if we allow for zoning to allow it. And then they find out that they've got to invest half a million dollars in upgrading water mains, and sanitary sewers, and all that sort of stuff, roadways, you name it. So it's without really understanding the needs (PG1)."*

Enabling medium to large-scale vertical growing on commercial-residential land could be particularly important for supporting the objectives of community food organizations. Currently, some municipalities prohibit individuals and organizations from operating shipping container gardens or smaller-scale grow units in commercial or mixed-use land, which can prevent local vertical agriculture from realizing its potential with respect to food security and/or sustainability objectives. One participant commented:

> *"And another thing is, I think it was discussed in another group, but that vertical agriculture can't happen in commercial zones [in our city]... Which a lot of our social services, locations, or houses, are located...that would be preventative of us being able to do that (PC2)."*

2. Flexible Zoning

Vertical agriculture is adaptable to multiple land uses, and accordingly flexible zoning allowances would best support the growing of a local industry. As described by one research participant, grow structures could be integrated at a variety of scales and in diverse land use contexts:

> *"But what if we also looked at smaller scale vertical farming operations, you know, maybe on the basement floor, like where a suite would be, or in a shipping container on the backyard in the backyard...that approach, leasing out small footprints in people's back and front yards, could potentially work for vertical agriculture as well. So that's my concern is that people forget that there's lots of different ways to do this (PA)."*

Another participant compared the potential of flexible allowances for agricultural production on mixed-use land with oil pumpjacks on agricultural land in the prairies. The participant explained that vertical agriculture could be implemented in the same way that oil extraction infrastructure and operations can be established on leased land with non-industrial designated land use:

> *"Big Oil, nodding oil donkeys, on people's land in Alberta and Saskatchewan and Manitoba...they lease a tiny little piece of [agricultural] land. There's an opportunity here for small businesses and whatnot to do the same thing with commercial and residential land in our communities, right, being able to find somebody with a big enough residential space where they can support a small container farm or a container-sized farm, and then lease that space off of them (PC1)."*

3. Agricultural or Industrial Parks and Circular Economic Development

Most participants were highly interested in exploring the circular economy opportunities around vertical agriculture. Such opportunities include integrating vertical farms with mixed-use parks, business development zones, or a variety of mixed-use contexts in ways that enable multi-business partnerships and circular resource usage. This type of business development model could be particularly interesting for smaller-scale vertical farming operations. For example, one vertical farmer described the importance of their partnership with local chicken farmers to dispose of their post-harvest waste:

> *"So we have to throw away soil at the end of the harvesting process. And right now we are donating it to a local farm, who make their own compost after they let the chickens at these discards and the chickens love picking up the seeds and finishing off vegetable scraps, all this type of thing. But the disposal of this kind of thing becomes a problem at a large scale... And that is something that needs to be taken into consideration for the location of a vertical farm (PFA1)."*

4. Small and Medium-scale Production

Several participants highlighted their concerns with larger-scale systems of production that are associated with agricultural and industrial land uses. Flexible, small, and/or medium scale growing is highly adaptable in that it can be accommodated in a variety of land uses and building types. Such opportunities were described by one participant:

> *"But I think the other thing is there's a real danger in vertical farming just becoming the next big industrial farming strategy...and us not having the local economy boost that comes from having local farming and, and having local food (PC1)."*

Yet, smaller- and medium-scale vertical agriculture operations may result in tensions with local land-use regulations, as compared to larger-scale systems on industrial or agricultural land. This is an important consideration when considering the long-term land- and building-use implications of vertical agriculture development, as discussed previously.

An additional concern highlighted by participants regards the accessibility of vertical farming technology for the majority of producers, for when large capital is required to set up production facilities (i.e., such as with large-scale farms). This was explained by a participant as follows:

> *"I feel like often when we have these kinds of conversations, the unspoken assumption is that we're talking about the highest tech, largest scale commercial operations, which does lead me to similar concerns that some of the other participants have expressed (PA)."*

Spatial Considerations

1. Underutilized and Unconventional Spaces

Research participants highlighted that many possible locations for vertical farming exist across the region. Similar to previous research, participants noted the possibility of implementing this infrastructure in educational institutions, on parking lots, or in basements of apartment and condominium complexes. Additional possible land uses that were highlighted included underutilized land within the ALR, such as gravel pits:

> *"But I had someone suggest to me, what about the gravel pits that we have throughout the [area]...try and reclaim that land? Why not? Why not use it for greenhouses or vertical agriculture Instead (PF)?"*

2. Labour Availability and Proximity to Training Centres

Participants noted the importance of co-locating vertical farms with areas where an adequate skilled labour pool exists. One participant expressed interest in establishing a farm on the property where their community organization is located; however, they were concerned about the potential lack of available qualified personnel to manage the facility and maintain the equipment:

> *"Where I'm coming from in terms of thinking about capacity and the sustainability of the operation... if there's a way to have a layer that reflects that. Because I think in a lot of the communities that we would be looking at potentially putting an agriculture system in or community garden or a greenhouse, a real concern would be viability, to have capacity to operate going into the future (PC3)."*

Skilled labourers with knowledge and expertise in vertical growing are not commonplace, as universities and colleges are only beginning to develop training materials and programming to support the emerging sector. One participant described their concerns about the training of (or lack thereof) qualified personnel in universities throughout the province:

> *"And you know, one of the things that I'm actually concerned by is the complete lack of attention that most colleges and universities in British Columbia, at least British Columbia, are putting into vertical farming or closed environment agriculture (PC1)."*

Locating vertical agriculture facilities in close proximity to post-secondary institutions with vertical agriculture expertise could enable partnership strategies for ensuring an adequate skill labour pool exists to support a growing industry. Such partnerships could involve community organizations and academic institutions to connect new vertical farmers to jobs in the operation and maintenance of vertical growing facilities.

KEY FINDINGS AND CONCLUSIONS

This study engaged a range of local food systems stakeholders in the Lower Mainland region of British Columbia to elucidate key challenges, opportunities, and key considerations around land use and planning for vertical agriculture. Scholars are increasingly calling for researchers and practitioners to consider and explore the feasible and desirable pathways for agri-tech integration in society (see e.g., Glaros et al., 2023b). The participants in this study were optimistic about the potential of vertical agriculture to fit into a variety of land use scenarios in the study area. In particular, small- and medium-scale growing on commercial and/or residential or mixed-use land was identified as the most desirable possible land use development scenario.

Other opportunities for developing vertical agriculture that were identified by the study participants include integrating vertical agriculture into business or industrial parks. Such integration would involve land use regulations and spatial development patterns that incentivize circular economy activities. Other research similarly identifies opportunities for the integration of vertical agriculture into circular resource use pathways, with the goals of such integration being to minimize energy use and industrial waste (Gentry, 2019).

Participants also noted concerns surrounding the development of a vertical agriculture industry in the Lower Mainland. Despite permissible regulations in British Columbia, some participants were hesitant toward developing a local vertical agriculture industry by establishing vertical farms on agricultural land. While this may be the most feasible potential development pathway for the industry due to the regulatory environment, it was less desirable for some participants, given its potential to centralize growing and close access to industry participation from smaller scale growers.

This research also identified key considerations surrounding the suitability of sites and potential development patterns for vertical agriculture. Underutilized spaces such as parking lots and free spaces in public institutions such as schools were identified as potential growing spaces prior to this study, and this study expanded on these thoughts by adding that there is potential to include growing facilities on agriculturally-zoned land with gravel pits and other lower quality spaces.

Other key considerations for site suitability and selection include the proximity of a vertical agriculture operation to a skilled labour pool and post-secondary institutions. These considerations are particularly important for community development

approaches to vertical agriculture supported by community food organizations, as such often experience capacity limitations that would prevent them from developing in-house vertical farming knowledge and expertise. Academic, not-for-profit, and industry partnerships are crucial to pursue vertical agriculture development pathways with the potential to support local community food organizations to improve community access to food and fresh produce.

A related element of the partnership approach described above is the importance of developing business incubator and accelerator (BAI) capacity. These BAIs are designed to support start-ups for the purposes of promoting innovation. Building agritech BAI capacity can support the transitions to sustainable, resilient food systems, as BAI programs can define the criteria for which start-ups and early-stage businesses receive support (Newell et al, 2021). Clustering BAIs, post-secondary institutions, and food system non-for-profits together can provide a critical mass that supports the development of the industry.

Municipalities should consider flexible zoning arrangements to effectively accommodate vertical growing. Such zoning could result in more vertical farms appearing, given the increasing interest that community organizations, activists, and producers have in establishing small- and medium-scale grow units (as opposed to large-scale grow systems on agricultural or industrial land). With the proper zoning regulations, residential and commercial areas can accommodate such smaller-scale forms of vertical farming, and urban beekeeping and henkeeping allowances passed in recent years across many municipalities in Canada could inform ways of (or at least serve as precedent for) designing these regulations (see Berquist et al., 2012).

Additional consideration should be given to the scale at which potential land and building use decisions are made. Participants in this study identified that land-use constraints associated with industrial and residential lands could be a key driver of vertical farming primarily developing on agricultural land. Although participants expressed concern around developing farmland to accommodate vertical agriculture, future research could take a more granular exploration of land use and consider the possible land use implications of vertical farming on marginal agricultural land. Adopting such a multi-scalar lens when determining and assessing site suitability considerations could result in a more nuanced exploration of different scenarios for local vertical agriculture development in ways that illuminate a more holistic picture for food systems planning (Buchan et al., 2015).

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