FoodMap NY

Leveraging Private-Sector Innovation and Investment for Food Security

FINAL PROJECT REPORT

Controlled Environment Agriculture

November 2024

NYU STERN Center for Sustainable Business

Mother Cabrini Health Foundation

Cornell SC Johnson College of Business
CENTER FOR SUSTAINABLE GLOBAL ENTERPRISE

Controlled Environment Agriculture

The Problem:
Food insecure populations in New York lack sufficient access to fresh fruits and vegetables.

New York's rural population has similar rates of food insecurity as urban populations at about 12% (NYHealth Foundation, 2022). Rural food-insecure individuals responded that affordability (79%) and transportation (54%) are the primary issues in accessibility (NYHealth Foundation, 2022). Beyond food-insecure individuals, 90% of the adult population in the U.S. does not get the recommended daily amount of fruits and vegetables with potential negative health outcomes. During the summer, household and community gardens and local farms can improve access. However, outdoor production is not possible year-round due to New York's cold climate. For example, a participant in the NYHealth 2022 survey stated: "There are limited stores in a rural area, so I have limited variety of leafy greens that are fresh, especially in the wintertime." Most leafy greens are produced in California and Arizona and can take 4-6 days to reach markets leading to a lower shelf-life (and greater food waste) than locally grown products.

GLASE
GREENHOUSE LIGHTING & SYSTEMS ENGINEERING

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The Proposed Solution

Controlled environment agriculture (CEA), growing crops in environments such as greenhouses or indoor vertical farms, allows for year-round growing of perishable fruits and vegetables and employs a local workforce. In CEA the plant growing environment can be optimized through heating and supplemental lighting. Hydroponic growing systems are typically used so the root-zone conditions can be optimized and water and fertilizer are recaptured and reused. Other advantages of CEA include much greater land use efficiency than field production, and the ability to grow without pesticides. However, difficulties with CEA include high up-front costs to set up facilities, high energy costs, technical expertise to operate sophisticated growing systems, and establishing distribution channels that are profitable.

Objective

Our objective is to model a pilot project for a public-private partnership CEA operation in upstate New York that addresses food insecurity and focuses on social impact while producing fresh products at near price-parity with out-of-state field produce.

Previous Research

Our previous work found that greenhouse operations that grow produce for local communities can address hidden hunger (from lack of fruits and vegetables); however, a primary issue is affordability (higher cost compared with field-grown produce). Previous research on the economic and environmental costs of greenhouse lettuce production in urban areas found that production in a one-acre greenhouse in an urban location leads to costs more than twice of imported field lettuce from California (including transportation costs) (Nicholson et al., 2020). Indoor vertical farms (no sunlight) in New York use about twice the energy of a greenhouse. Incorporating automated production and moving a greenhouse to a peri-urban area (<100 miles from major metropolitan areas) can decrease production costs to be only about 50% more than field production (Nicholson et al., 2023).

In major cities where land is scarce and expensive, local production in vertical farms may be used (at a two-fold higher production cost than field lettuce). However, rural/peri-urban environments allow for lower-cost production in greenhouses due to more affordable and available land and much lower capital costs than vertical farms. Vertical farms are an emerging sector and due to higher capital and research costs their products are mostly marketed at higher end supermarkets and restaurants. The vertical farm sector has also been plagued by several bankruptcies over the last few years. Thus, a greenhouse model was selected in our work with the goal of reaching price parity with out-of-state field production to truly address food security. In our project development, we focused on an economic model for a 10-acre greenhouse (economies of scale with larger size) in rural New York where there is greater access to affordable electricity, and both rural and urban markets can be serviced.

Stakeholder Engagement

Interviews with a wide range of stakeholders were conducted (Appendix A.). Stakeholder interviews identified that rural New York (centering on the North Country) could be an opportune location for a greenhouse business that has several site-specific advantages over urban/peri-urban production. A rural production location could improve local access to fresh produce, but also sell products to larger markets such as New York City; land is more available/affordable in rural New York; there are greater opportunities to take advantage of renewable energy (hydroelectric, solar); and rural communities can suffer from higher unemployment. Stakeholder interviews revealed that Jefferson County specifically could be a particularly good target location. Jefferson County hosts a U.S. Army Base, Fort Drum, and 9% of the population are veterans (compared to 3% statewide). In addition, Jefferson County is home to a recently closed (2021) correctional facility. Thus, the project could partner with local agencies such as Cornell Cooperative Extension in workforce training to provide jobs with social impact. Through interviews with non-profit food agencies, we determined that fresh and ready-to-eat vegetables would be the most likely foods to improve access and nutrition.

Potential Partners

Potential partners in the proposed project include:

- **Cornell Cooperative Extension** (workforce training)
- **Fort Drum** (institutional produce buying, workforce training)
- **Food Service Agencies** that provide assistance to the community (examples include: Food Sense, Salvation Army, Community Action Planning Council of Jefferson County, Watertown Urban Mission, Feed Our Vets)
- **Convalt Energy** (solar manufacturer and operator of a solar agrivoltaic farm in Jefferson County, possible owner/operator)
- **Confluent Energy** (developing AgTech park in Massena, NY; possible owner/operator if project executed in St. Lawrence County)
- **Havecon North America** (greenhouse design/build firm)
- **Green Automation** (suppliers of automated greenhouse production systems)

Project Parameters

Based on stakeholder input and previous research, our team decided to focus on a financial and distribution model for production of leafy greens in a greenhouse in a 10-acre large scale greenhouse in rural NY. Proposed parameters and background/justification are noted below.

PARAMETER	CHOICE	BACKGROUND/JUSTIFICATION
CEA Structure	Greenhouse	Year-round production, cheaper than indoor vertical farms, and aligned with regions with available land
Crop	Lettuce, ready to eat	3rd most consumed vegetable in the U.S. (behind potatoes and tomatoes), perishable crop (value in locally grown), consumer preference for ready to eat vegetables (no need to cook/process)
Size of production area	10 acres in greenhouse	Economies of scale with a larger size greenhouse lead to overall lower production costs
Degree of automation	Automated production, semi-automated packaging	Automation allows cheaper ongoing labor costs with a higher upfront cost, balancing low-cost vegetables with providing local jobs
Location of operation	Jefferson County, NY	Rural location with affordable land and energy, above average unemployment rates
Distribution model	Grocery brands valued by cost-conscious shoppers and food-service/institutions	Two types of products will be sold: 4 oz. clam-shells of ready-to-eat lettuce at a retail price of $2.99, and bulk 3-lb. bags of ready to eat less to food-service/institutions at a price of $5.99/bag.
Labor targets	Veterans and formerly incarcerated individuals	Working with a local non-profit to provide job training and recruitment for a majority of positions

Financial Impact Model

We conducted an economic analysis using a 10-acre greenhouse operation, assuming economies of scale. This assumption implies that larger operations can absorb costs more effectively and achieve higher profitability. By leveraging economies of scale, the fixed and variable costs per unit of output decrease as the scale of the operation increases, allowing for more efficient cost management and improved profitability for larger greenhouse operations.

We adapted the one-acre peri-urban greenhouse model from Nicholson et al. (2023), adjusting for site-specific costs in Jefferson County, NY, and scaled it to a 10-acre facility. Our analysis (Appendix E) integrates information about production,

processing, packaging, transportation, and other marketing costs and input for wholesale market delivery. Current structural and packaging cost estimates were obtained through discussions with Green Automation, suppliers of greenhouse production systems that have implemented many greenhouse projects in North America and worldwide. As part of our projection and intent to grow over time, we include the purchase of 40 acres of land in our model. This includes the 10-acre greenhouse area; 15 acres allocated for parking, packing, and bathroom areas and green space; and an additional 15 acres reserved for future expansion of the operation.

We have divided the analysis into several parameters to facilitate the understanding of the finance and economic analysis.

Production: We have assumed a gradual increase in production from 50% of potential output in year one to full output in year five, accounting for the learning curve required for workers to gain experience and skills and for sales outlets to be fully realized. Additionally, we have factored in a 2% yield loss during production. This approach reflects a realistic expectation of initial inefficiencies and natural production losses as the workforce becomes more proficient.

Table 1. Variable assumptions on output productivity.

VARIABLE		VARIABLE	
Weeks per year	52	Ounce per kilogram	35.274
Production area (ft^2 under greenhouse cover)	435,600	Ounce per clamshell	4
Space use efficiency	90%	Pound per kilogram	2.20462
Net production area (90% space use) ft^2	392,040	Pound per bags (lbs)	3
Net production area (90% space use) ft^2	36,422	Production in y1	50%
Kg production per year	4,006,392	Production in y2	75%
Months per year factor	12	Production in y3	90%
Annual production (kg)	4,006,392	Production in y4	95%
Dead percentage	0.02	Production in y5	100%
Market price for retail stores (4 oz)	$2.99	Percentage sold to retail	0.7
Market price for food service (3 lbs)	$6.00	Percentage sold to food service	0.3
Yield (fully operational) (kg/m^2)	110		

Delivery: We have assumed that half of the produce will be sold locally (within 150 miles) and half delivered to the New York City metro area. Our delivery plan includes making deliveries approximately 3-11 times per week, utilizing six trucks and employing six drivers. This capacity will gradually increase in alignment with the anticipated growth in production. This delivery strategy aims to ensure timely distribution and effectively meet the demand in both local and distant markets.

Table 2. Variable assumptions on output productivity.

	YEAR 1	YEAR 2
NYC		
Pallets per week to NYC	260	559
Trucks per week to NYC	10	21
Deliveries per week to NYC	3	5
Miles per week to NYC	6,322	13,581
Gallons of gasoline per week to NYC	903	1,940
LOCAL		
Pallets per week to local	260	559
Trucks per week to local	10	21
Deliveries per week to local	5	11
Miles per week to local	3,001	6,447
Gallons of diesel per week local	429	921
TOTAL		
Price of diesel fuel ($/gal.)	4.63	5.41
Transportation costs per week	6,161	15,483
Transportation costs per year	$320,393	$805,159

Packaging: To achieve the main goal of the project—reducing food insecurity, making produce more accessible, and ensuring economic profitability—we assumed two types of products that would be sold. A significant portion of the produce will be packaged in 4-ounce clamshells, which will be sold to price-conscious retail stores, while the remaining produce will be packaged in 3-pound bags, intended for food service/institutional distribution. This strategy aims to maximize market reach and address different consumer needs, thereby enhancing both accessibility and profitability.

Table 1 displays the amount of produce (in kg) that will be packaged in 4 oz clamshells for retail stores and in 3 lb bags for food service. In Year 1, we plan a 70-30 split between clamshells and bags, respectively. This ratio will gradually shift (0.5 intervals) to a 90-10 split by Year 5. The purpose of this split is to ensure economic profitability, improve the well-being of the community, and make fresh food more accessible.

Table 3. Breakdown of retail vs. food service sales and associated packaging costs. Model assumes 70% of sales are retail in Year 1 which ramps down to 10% in Year 5. (Overall production ramps up from 50% in Y1 to 100% in Year 5).

	YEAR 1	YEAR 5
RETAIL		
Total amount of clamshells for sale to retail (4oz)	12,118,315	31,161,382
Total amount of boxes for sale to retail	1,514,789	3,895,172
Packaging cost for retail products	$3,839,991	$9,874,263
FOOD SERVICE		
Total product for sale to food service (kg)	588,939	392,626
Total amount of bags for food service (3lbs)	432,796	288,530
Packaging costs of bags for food service	$80,067	$53,378
Total packaging costs	$3,920,058	$9,927,641.22

Labor: As part of the overall goal of the project to support the community, we plan to hire production labor from veterans and individuals from underserved groups. This approach aims to provide employment opportunities and contribute to the social and economic well-being of these groups, further enhancing the project's positive impact.

As part of the project's goal, 47 jobs will be created for production, packing, processing, and delivering. Table 4 displays the total number of jobs and their respective functions.

In addition to the 47 jobs created for production, packing, processing, and delivering, another ten positions will be opened for key management and administrative roles. Table 4 displays the total number of jobs, including these additional positions and their functions. The other ten positions are at the administrative level, including pack haul manager, head grower, head of sales, head of maintenance, head of shipping/receiving, sales manager, administrative assistant, executive, and outside services.

Table 4.
Number of jobs created.

LABOR FTE	TOTAL FTES
Sowing line	2
Horticultural side	4
Maintenance	4
Packing line	28
Sanitation	3
Truck drivers	6

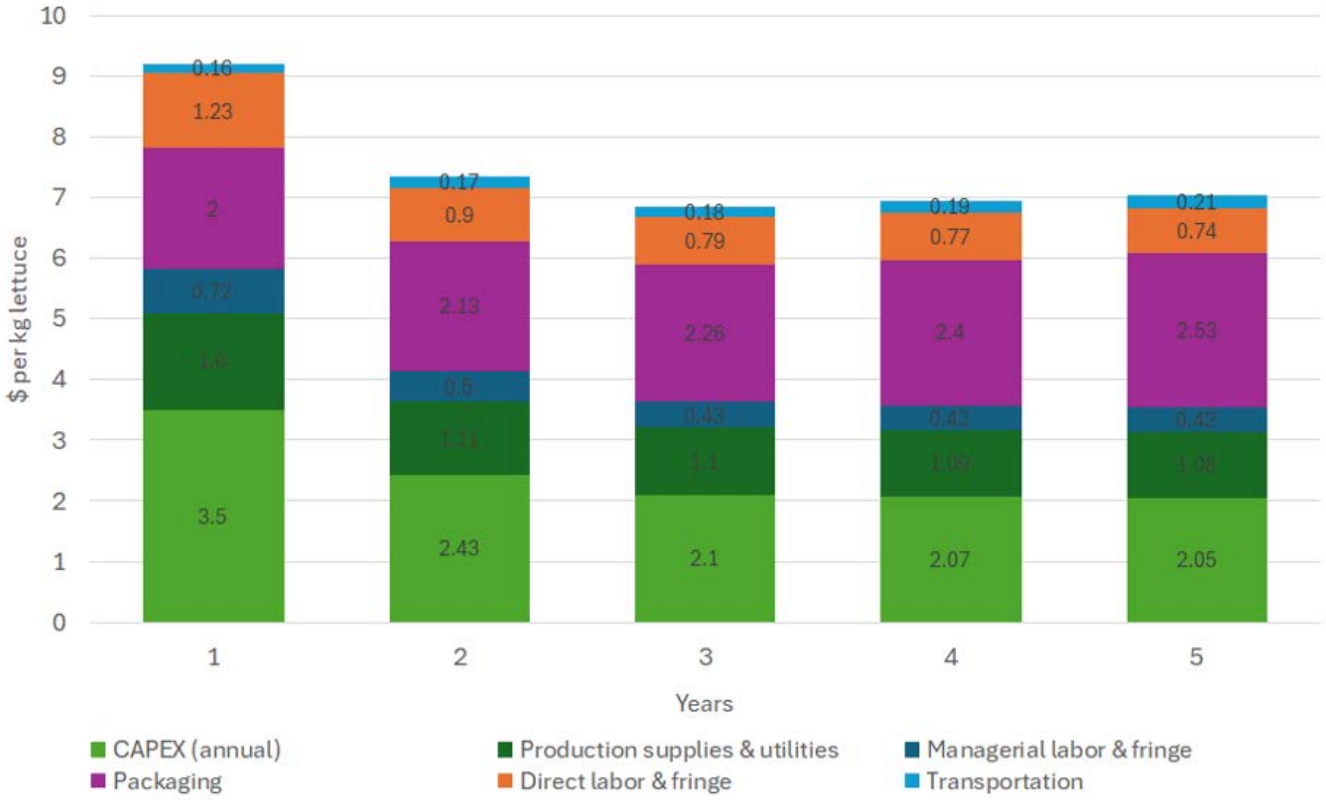
Finance: The structure and equipment costs for production amount to $61 million. The land value is $182,400, and the cost of building parking, packing, bathrooms, and other non-production areas is $6 million. The total initial investment value (CAPEX) is approximately $70 million. Production labor costs are about $3 million, and managerial labor costs are $1.4 million, with total annual production costs of $3 million. The average operating expenses (OPEX) amount to $18 million.

Revenues from clamshells are projected to be about $22 million in the first year, and revenues from 3-pound bags are expected to be about $2.5 million. However, as workers gain more experience and productivity and sales increase, both OPEX and revenues are anticipated to rise. By year five, OPEX is expected to approximate $28 million, with overall revenues projected to reach approximately $65 million. The financial indicators are as follows: NPV is $105 million, IRR is 24%, and the payback time is 5.04 years.

Table 5. Total costs and finance indicators for year 1 and 5.

	YEAR 1	YEAR 5
Structure and equipment costs for production	$69,696,000	
Cost for parking, packing, bath	$6,969,600	
Land cost	$182,400	
Growing equipment costs	$1,784,000	
Total annual costs	$18,134,043	$ 27,614,680
Revenue from 4oz. clamshells	$21,691,784	$65,253,393
Revenue from 3-lb. food-service bags	$2,596,775	$2,025,240
Cost per kg	$ 9.24	$ 7.03
Accumulated cash flow	-$69,622,597	$14,656,471
NPV =	$104,796,954	
IRR =	24%	
Payback period	5.04	

Figure 1. Production costs per kg of saleable lettuce. Model assumes: capital costs amortized over 20 years with 6% interest, annual inflation of 4% for all input costs, production ramps up over time from 50% in Y1 to 100% in Y5, and 50% of product sold locally (within 150 miles) and 50% sold to NYC metro area.



Potential Project Impact

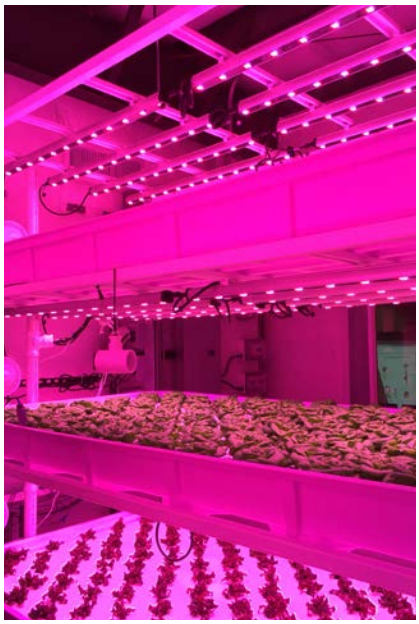
Ultimately, the 10-acre greenhouse, (constructed in a future phase) will grow ready to eat salad at price parity with field grown (retail price: $2.99 / 4 oz) and include institutional distribution models and thus support rural food security/ healthy diets in New York. When fully established the project will:

- Provide 400,000 New Yorkers annually with salad products that have a four- to six-day longer shelf life that low-income individuals and families across upstate New York regions currently find in their local value-focused grocery chains
- Reduce food waste substantially compared to products trucked from California
- Generate 57 year-round jobs with a goal of hiring a workforce that is >50% disadvantaged or marginalized community members (such as veterans and formerly incarcerated individuals)
- Long term, this project will result in a $70 million capital project implemented in a rural county with one of the highest unemployment rates in New York State

Market Opportunity

We conducted a market analysis to identify project-appropriate distribution models. The strategic focus of local greenhouse production is typically on leveraging key differentiators such as local sourcing, taste, freshness, and shelf-life of our produce. This approach not only sets us apart from larger, more industrial agricultural entities but also resonates with the growing consumer demand for health-conscious and environmentally sustainable food options.

We are poised to capture diverse market segments including local grocery chains, restaurants, and strategic institutions such as military bases, schools, and broader food-service. These segments offer robust avenues for long-term partnerships and community integration, enhancing our market footprint through direct relationships and localized supply chains. This model is designed to meet specific consumer demands while championing the benefits of local food systems—freshness, reduced carbon footprint, and support for the local economy.



Distribution Models

The project considers several distribution models to optimize market penetration and revenue:

1. **Private Label Supplier Model:** In this model, our greenhouse operations would grow and package leafy greens under another company's brand. This model is particularly beneficial for forming steady partnerships with grocery chains and specialty food stores that are keen on offering branded, locally sourced products. Key advantages include consistent demand and increased brand exposure through these partnerships, although it necessitates vigilant management of profit margins and strict adherence to quality standards set by our partners.

2. **Military Supply Contract Model:** By establishing a direct supply chain to nearby military installations, such as Fort Drum, this model leverages our proximity to secure a reliable revenue stream. The military's consistent demand for fresh, nutritious produce aligns with our capability to supply large volumes while meeting stringent quality criteria. Beyond financial stability, this model boosts our credibility and supports the local community by contributing to the health and wellness of military personnel.

3. **Retail Partnership Model:** Partnering with regional grocery stores and supermarkets allows us to place our products directly in front of consumers under our brand or the store's label. This model aids in managing surplus production and enhances brand visibility. While it offers access to established customer bases, it requires careful negotiation of placement and pricing to maintain favorable profit margins against potential retailer markups.

4. **Community Supported Agriculture (CSA) Model:** This model fosters a direct bond with the community by allowing consumers to subscribe to the harvest. Subscribers pay upfront for a season and receive regular deliveries of fresh produce, which ensures a stable cash flow and creates a loyal customer base. It also enables immediate feedback and continuous engagement with our consumer base, enhancing product offerings based on consumer preferences and feedback.

5. **Direct-to-Consumer Sales Model:** Establishing a direct sales channel through online platforms, farmers' markets, or a dedicated storefront allows us to interact directly with the end consumer. This model is advantageous for retaining higher profit margins, as it eliminates the middleman, and enhances brand recognition. Implementing this model involves setting up an efficient e-commerce system, participating in local markets, and potentially managing a physical retail location.

Based on our strategic evaluation of distribution models for our Controlled Environment Agriculture (CEA) initiative, we recommend prioritizing retail distribution to cost-conscious supermarkets as the primary channel. This approach leverages our local presence and commitment to freshness, aligning perfectly with consumer preferences for sustainable and locally-sourced food options. By partnering directly with regional grocery chains and supermarkets, we can ensure that our leafy greens are positioned prominently, reaching consumers effectively while enhancing brand visibility.

Simultaneously, we suggest a diversified approach by incorporating the Military Supply Contract Model, particularly with nearby Fort Drum, as a secondary source of revenue. This model promises stable demand and reinforces our community engagement by supporting local military personnel with fresh, nutritious produce. Moreover, it complements our retail efforts by providing a consistent revenue stream during market fluctuations, thus stabilizing our operations.

Further diversification can be achieved by engaging with local schools, institutions and community programs that provide food-access, which not only opens up new channels for our produce but also strengthens our community ties and supports local sustainability efforts. This holistic approach to distribution ensures our CEA project not only thrives commercially but also contributes positively to the community and environment.

Overall Recommendations and Next Steps

A 10-acre lettuce greenhouse in rural New York may be able to be profitable but also contribute to food-access in terms of retail products at price-parity with field competitors and food-service/institutional products at a very attractive $2/lb. for ready to eat salad. Greenhouse businesses are capital intensive and the largest barrier to moving forward is accessing capital at an affordable interest rate (6%). Based on the success and cautionary tales (Appendix B) it is important

for a potential owner/operator to be well-seasoned in greenhouse management and to avoid growing too large too quickly. Authentic relationships with community partners in job training and food access will also be important.

To bring the preliminary greenhouse project to fruition, recommended next steps include identifying community stakeholders committed to workforce development and social impact, engaging community partners for input on design, selecting an optimal location, securing a site, designing the production facility, refining the business model, executing offtake agreements with retailers/distributors serving food insecure customers, gathering feedback on design and model.

GLASE is seeking funding for a Phase 2 in project development. The project request will de-risk establishment of a year-round CEA operation in rural New York with proposed activities including:

- Identify a committed greenhouse operator through outreach within our network of regional greenhouse businesses (including three previously interviewed North Country greenhouse operators) and identify an entity with the interest and expertise to implement the project
- Work with Jefferson County stakeholders and non-profit organizations (including Cornell Cooperative Extension and Fort Drum) to form a workforce development plan and address food insecurity in terms of institutional access
- Partner with a specialized greenhouse design-build firm to complete a 60% Design Submittal (includes siting, 60% design drawings, permit submissions, and requests for vendor quotes
- Identify produce buyers that may commit to long-term affordable price contracts with institutions and retailers
- Refine a business model iteratively based on stakeholder feedback, community need, and buyer agreements
- Communicate project goals periodically with community stakeholders, media, and government
- Develop a community roadmap for construction which will be ready for execution by the committed greenhouse operator

CONTROLLED ENVIRONMENT AGRICULTURE TEAM MEMBERS

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Stakeholders Interviewed

NAME	ORGANIZATION	DISCUSSION TOPICS
Hari Achuthan	Convalt Energy	Implementing community solar projects in Jefferson County, NY. Sourwine Farm project would like to include agrivoltaics (photovoltaic solar connected to field and greenhouse production)
Marty Broccoli	CCE Oneida County	Agriculture economic development, successful business models, produce distribution
Kaitlin Butler	Private investment / portfolio manager	Metrics investors look for in new business investments, engaging impact investors
Patrik Borenius, Eric Highfield	Green Automation	Manufacturer/installer of fully automated greenhouse leafy greens systems. Review of business plan, costs of production, packaging costs, and distribution.
Ryan Faville	Stewart's Shops	Stewart's local food pilots in Jefferson County, NY. Constraints and opportunities for including fresh produce in convenience stores, distribution models.
John Gaus	Agbotic	CEA producer (greenhouse, in-ground, certified organic), gaining market share by reaching cost parity with field production
Robert MacArthur	Confluent Energies	AgTech park/greenhouse development in Massena, NY where there is available hydroelectric energy, also use of anaerobic digesters to process food waste and generate energy for greenhouse
Michael Nuckols	CCE Jefferson County	Agriculture operations in NY's North Country, distribution models (retail, farmer's market), connections to non-profits in Jefferson County
Kim Trombly & Laura Trudell	CCE Franklin County	Laura oversees a community non-profit greenhouse project (Joint Council for Economic Activity, JCEO) that grows fresh produce for JCEO's food shelf. Both engage with non-profits that support food access. Discussion on consumer needs for ready-to-eat fruits and vegetables (without processing/cooking)
Justin Lukoff	Havecon North America	Greenhouse design, permitting, and construction firm, discussion on greenhouse construction timeline and costs
Tony Abbas	Prospiant	Greenhouse design, permitting, and construction firm, discussion on greenhouse construction timeline and costs

Note: CCE is Cornell Cooperative Extension, each county in New York has their own CCE association (or is part of a regional group of counties) they work on topics such as agricultural production, health & nutrition, and youth development

Success and Cautionary Stories

SUCCESSFUL CASE STUDIES

Company Overviews

Little Leaf Farms

Founded in 2010, Little Leaf Farms is a pioneer in controlled environment agriculture (CEA), operating state-of-the-art indoor vertical farms to grow leafy greens using hydroponic systems. The company is based in Massachusetts and has expanded its operations to Pennsylvania and North Carolina.

Gotham Greens

Established in 2009, Gotham Greens is a leading CEA company that grows and distributes fresh produce through its network of hydroponic greenhouse facilities across the United States. The company is headquartered in New York and has operations in several states, including California, Texas, and Georgia.

Market Opportunity and Growth

Both Little Leaf Farms and Gotham Greens have capitalized on the growing consumer demand for locally-grown, fresh, and sustainable produce. The CEA industry is projected to capture 10% or more of the fresh produce market by 2025, up from 2.7% currently for CEA-grown leafy greens.[1]

Little Leaf Farms accounted for 42% of all CEA lettuce produced in the U.S. as of December 2021, with over 50% growth in retail sales in the past year.3 Gotham Greens has registered 28% year-over-year growth, outpacing the 1% growth in the overall pre-packaged salads and lettuce category.[2]

Expansion Strategies

Little Leaf Farms

- Raised $90 million in funding in 2022 to support expansion plans.[1]
- Opened a new 10-acre facility in Pennsylvania, doubling production capacity.[1]
- Plans to operate at least 100 acres of indoor greenhouses by 2026.[1]
- Targeting 55% of the U.S. population with facilities on the East Coast and Midwest.[1]

Gotham Greens

- Raised $87 million in Series D funding in 2021 to fuel expansion.[2]
- Opened new hydroponic greenhouses in Texas, Georgia, and Colorado in 2022.[2]
- Expanded existing facilities in Chicago and Rhode Island.[2]
- Aims to increase store count and serve major retailers nationwide.[2]

Competitive Advantages

Little Leaf Farms

- Proven business model with a focus on sustainability and long-term viability.[1]
- Efficient growing process, reducing water usage and increasing productivity.[1]
- Ability to produce at a lower cost without sacrificing quality.[1]
- Longer shelf life and fresher products compared to field-grown produce.[1]

Gotham Greens

- Established brand with 10 years of experience in the CEA industry.[2]
- Localized supply chains and reduced transportation distances.[2]
- Sustainable growing practices using renewable energy and minimal water and land.[2]
- Diversified product portfolio including salad dressings and sauces.[2]

Challenges and Future Outlook

Both companies face challenges in managing high operating costs, particularly for energy and labor, while maintaining profitability and attracting investment. However, their focus on efficiency, sustainability, and meeting consumer demand for fresh, locally-grown produce positions them well for continued growth in the rapidly expanding CEA market.

Sources:

[1] https://www.foodnavigator-usa.com/Article/2022/03/29/Gotham-Greens-doubles-greenhouse-footprint-capturing-under-penetrated-market-opportunity-for-indoor-farming-companies#

[2] https://www.foodnavigator-usa.com/Article/2022/06/24/little-leaf-farms-captures-42-of-indoor-grown-leafy-greens-retail-sales

CAUTIONARY CASE STUDIES

Company Overviews

AppHarvest

Founded in 2017, AppHarvest was a pioneer in large-scale controlled environment agriculture (CEA), building massive high-tech greenhouses to grow tomatoes, leafy greens, and other produce. Based in Kentucky, the company raised over $200 million from investors and went public in 2021 with a valuation of over $1 billion.

AeroFarms

Established in 2004, AeroFarms was one of the earliest players in vertical farming, using aeroponics and LED lighting to grow leafy greens indoors without soil or sunlight. The New Jersey-based company raised over $230 million in venture funding and was valued at nearly $500 million in 2021.

Rapid Expansion and High Expectations

Both companies embarked on aggressive expansion plans, fueled by investor enthusiasm and the promise of disrupting traditional agriculture with sustainable, locally-grown produce.

- **AppHarvest** built some of the largest CEA facilities in the world, including a 60-acre greenhouse in Kentucky and a 15-acre facility in West Virginia.
- **AeroFarms** opened a state-of-the-art 138,000 square foot indoor vertical farm in Newark, NJ, and had plans for 25 additional farms by 2026.

Investors were captivated by the companies' bold projections, with AeroFarms forecasting revenue growth from $4 million in 2021 to $553 million by 2026.

Challenges and Setbacks

However, both companies faced significant challenges in scaling up their operations:

- **High Operating Costs:** The capital-intensive nature of CEA operations, coupled with high energy and labor costs, made it difficult to achieve profitability.
- **Technical Difficulties:** Maintaining optimal growing conditions and achieving consistent yields proved challenging, leading to crop losses and operational disruptions.
- **Supply Chain Issues:** Pandemic-related supply chain disruptions delayed construction and equipment delivery, impacting production timelines.
- **Management Inexperience:** Lawsuits alleged that AppHarvest's management team lacked experience in large-scale farming operations, leading to misrepresentations and operational missteps.
- **Capital Constraints:** As losses mounted, both companies struggled to raise additional funding, with investors growing skeptical of the vertical farming business model's viability.

The Downfall

In June 2023, AeroFarms filed for Chapter 11 bankruptcy protection, citing unsustainable debt levels and operational challenges. A month later, AppHarvest followed suit, announcing plans to sell its facilities to investors and effectively wind down operations.

Lessons Learned

The rise and fall of AppHarvest and AeroFarms highlight several key lessons for the vertical farming industry:

- **Realistic Projections:** Companies must set realistic growth and profitability targets, avoiding overly optimistic projections that erode investor confidence.
- **Cost Management:** Achieving cost efficiencies in energy, labor, and capital expenditures is crucial for long-term sustainability.
- **Experienced Leadership:** Successful CEA operations require experienced agricultural and operational leadership to navigate the unique challenges of controlled environment farming.
- **Scalability:** Companies should focus on achieving profitability at a smaller scale before embarking on aggressive expansion plans.
- **Risk Mitigation:** Diversifying product offerings, exploring niche markets, and implementing robust risk management strategies can help mitigate the inherent risks of CEA operations.

While AppHarvest and AeroFarms faced significant setbacks, their pioneering efforts have paved the way for a more mature and sustainable vertical farming industry, with new players and business models emerging to address the lessons learned from these cautionary tales.

Sources:

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APPENDIX C

Project Pitch-Deck Slides

view resource

APPENDIX D

CEA Market Analysis

view resource

APPENDIX E

Greenhouse Business Model Spreadsheet

view resource

Please contact Dr. Neil Mattson nsm47@cornell.edu for an editable version or questions