Carrefour de recherche, d'expertise et de transfert en agriculture urbaine

CRETAU

ECONOMIC FACT SHEET

Vegetable production in a container farm

The CRETAU (Carrefour de recherche, d'expertise et de transfert en agriculture urbaine) is driven by AU/LAB (Laboratoire sur l'agriculture urbaine). AU/LAB is an organization focused on research, training, innovation, and action on the themes of urban agriculture and food. A not-for-profit organization, the laboratory is a national and international site for action and reflection on urban life and food. Based on a wealth of expertise and more than 10 years of experience, AU/LAB ensures that proposals, initiatives, and enterprises concerned with both production and processing as well as distribution and marketing of urban agriculture emerge. The laboratory acts in view of participating in the development of an urban food system, of sustainable urban planning, and of a circular economy within cities.

Carrefour de recherche, d'expertise et de transfert en agriculture urbaine

CRETAU

laboratoire agriculture urbaine

1401 Legendre Ouest, Bureau 305
Montréal, Québec
H4N 2R9
cretau.ca
au-lab.ca

WRITING AND RESEARCH

Adeline Cohen
Coordinator, Economic and ecosystem services
CRETAU
AU/LAB

MANAGEMENT

Éric Duchemin
Scientific Director
CRETAU
AU/LAB

REVISION

Mahmoud Ramadan, Agronomist
Counsellor in greenhouse and urban agriculture
Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Montérégie regional office

Abdenour Boukhalfa, Agronomist
Counsellor in greenhouse and urban agriculture
Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Montréal, Laval, and Lanaudière regional office

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297 Farm | CHURCHILLNORTHERN STUDIESCENTRE | Du Jour | ColdAcre FOOD SYSTEMS | DURHAM COLLEGE SUCCESS MATTERS

FOREWORD

This fact sheet was created to guide persons who wish to start producing vegetables with a container farm, as well as real estate developers and real estate managers who wish to host container farms on their land.

Based on the analysis of cases available in the literature as well as on data collected from producers growing vegetables in containers in various production contexts, this fact sheet supplies basic information on the potential costs of installing and operating a container farm. It is important to remember that they are indicators and that numerous difficult to plan variables can influence the final cost of a project and/or operation costs. This fact sheet has been created using data collected in 2019 and 2020.

This document is part of a series of economic fact sheets aiming to create an economic framework for the development and implementation of urban farms. This series is in addition to other work done by the CRETAU more specifically on the establishment of urban farming businesses, on the environmental services they offer (economic value for the city) as well as the economic impact of commercial urban agriculture.

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PRODUCTION OF VEGETABLES IN A CONTAINER

The production of vegetables in containers started to evolve in 2010. Numerous agricultural production or container designer enterprises were established starting in 2015 around the world. A report estimates that there were between 250 and 300 container farms in the world in 2017, while a 2019 article estimates this number to be 500.[1]

In Canada, the production of vegetables in containers is notably used by Indigenous communities and the education sector. In 2020, 7 First Nations communities and 4 post-secondary institutions have adopted this production method. There are a total of 21 enterprises producing vegetables in containers in 9 Canadian provinces and territories.

In Quebec, the evolution of container farms is still limited as they represent 10% of Canadian urban sites in 2020. The number of farms should, however, increase in the next year. Thus, 9 farms are about to start in Quebec, British Columbia, and Alberta.

In comparison with other indoor production systems, the production of food in a container has the advantage of giving flexibility in the choice of its location, giving the possibility of being located close to the customers, sometimes in remote locations or in places that are not favourable for agriculture. Their set up being possible over the course of a few months allows a container farm to be operational quite rapidly. Furthermore, the entry cost in the sector is relatively low compared to other indoor farm models.[1] The modular and turnkey aspects are especially appealing for entrepreneurs wishing to test the soil-less production system on a small scale before taking on a more substantial investment.

Despite these advantages, the sector faces skepticism because of the exaggerated production performance shared by some manufacturers, the lack of economic competitiveness compared to greenhouse production or indoor production in buildings,[2] as well as the model's lack of scaling capacity since to expand the farm, some of the equipment becomes redundant and less optimal.[1] In 2017, a survey of 150 farms emerging in the sector of controlled environment agriculture identified container farming as the most oversold technology in the indoor agricultural sector.[3]

[1] More details on the indoor farming sector are available in French
Cohen, A. and Duchemin, E. (2021). Portrait filière : états des lieux de la production maraîchage urbaine en intérieur au Québec, Canada et dans le monde. CRETAU (Carrefour de recherche, d'expertise et de transfert en agriculture urbaine) / AU/LAB (Laboratoire sur l'agriculture urbaine) 32 p.

[2] Tasgal, P. (2019). The economics of local vertical and greenhouse farming are getting competitive.

[3] Agrylist. (2017). State of indoor farming.

SIX MANUFACTURERS OF CONTAINER FARMS

We have identified about 30 enterprises that retrofit containers for agricultural use. These enterprises have, for the most part, chosen to concentrate their activity on the development of turnkey technologies designed to be sold to project owners having various legal structures, whether they be not-for-profit organizations, cooperatives, or private companies. These enterprises tend to carry out agricultural research and all propose to accompany their clients. Among the agricultural container manufacturers, at least 6 enterprises were operating in Canada in 2020.

La Boîte Maraîchère

La Boîte Maraîchère's 10-container complex in Laval, Quebec.

La Boîte Maraîchère is a Quebec-based enterprise established in 2016 and installed in the Laval agricultural park since 2017. There, it developed a 10-container complex equipped for agricultural production. This first complex began by being used as a site for demonstrations and research. It is currently being upgraded in order to be solely devoted to commercial production, as the research and development component will be moved to another site. The enterprise has been awarded the first place in the food category of the enterprise creation chapter of Défi OSEntreprendre Laval.

The enterprise, through its *LBM Agtech* brand, also sells its model to entrepreneurs wishing to start up their container farm. Two urban sites are under development in Quebec, one in Charlevoix and the other in St-Roch-de-Richelieu. The enterprise is also developing mutualized sales to large-scale distribution banners with the partner farms.

Growcer

Schematic view of the Growcer container

Growcer is an Ottawa-based enterprise established in 2015. The enterprise designs and sells containers retrofitted for agricultural production, and especially for clients located in remote areas where fresh produce is difficult to access or not very affordable.

A first container was installed in 2017 at the *Churchill Northern Studies Centre*. Since 2017, containers have also been installed in Indigenous communities in Quebec, Ontario, Manitoba, Nunavut, British Columbia, and Yukon. In Churchill, for example, the price of a container-grown lettuce is $3.99 instead of $7. Other containers are also installed at the University of Ottawa and at Acadia University. In 2020, 24 containers of the brand were deployed in Canada.

Growcer offers 2 purchase options for its containers: cash or as a rent-to-own that ends with the purchase after 2 years. In 2019, the enterprise participated in the Dragon's Den show and refused a $250,000 investment offer in exchange for 30% of the enterprise's shares.[4] In 2020, the enterprise became profitable and has 17 employees, 4 of whom are focused on research and development. The enterprise is working on a new bigger model of container built with new materials.

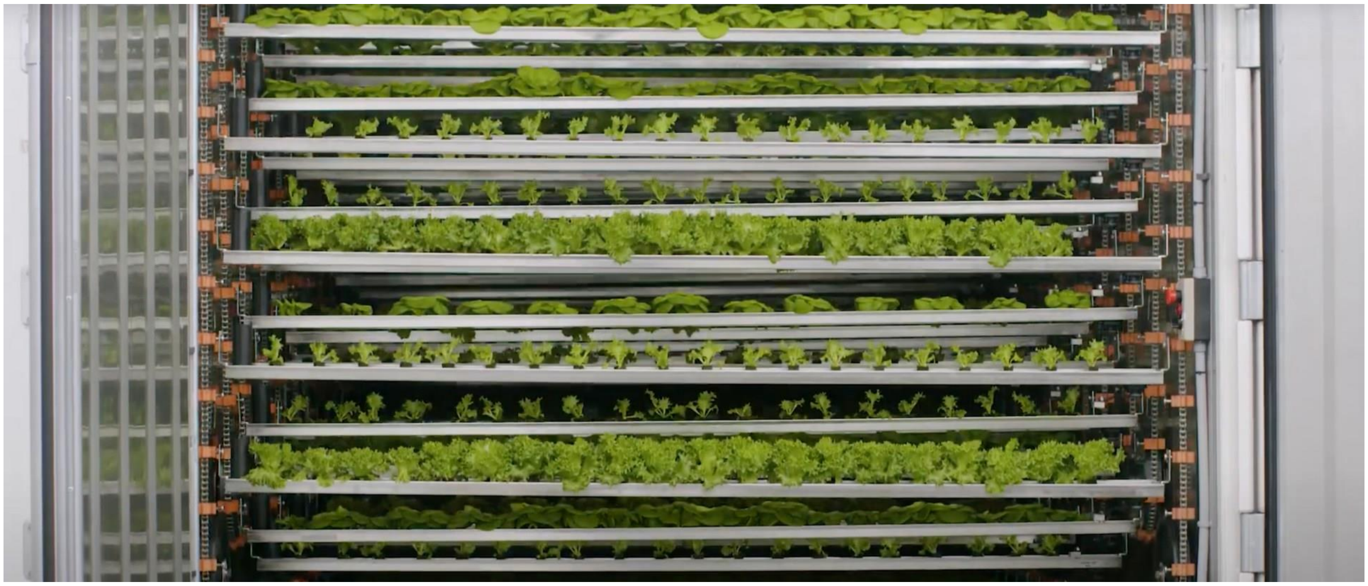
[4] Thibodeau, L. (2019). Ottawa startup The Growcer triumphs on Dragons' Den. Ottawa Business Journal. https://obj.ca/article/ottawa-startup-growcer-triumphs-dragons-den

CropBox

Schematic view of the CropBox container

ColdAcre is the Canadian distributor of *CropBox*, a container model designed by an American enterprise. The distributor is installed in Whitehorse (Yukon Territory) where 2 containers are focussed on food production. *ColdAcre* helps entrepreneurs located in remote areas to develop the design of off-the-grid farms, whether they are in containers or in buildings by using certain sources of renewable energy. The sale of containers and the consulting services represent a major part of the enterprise's revenues. In 2020, fewer than 5 *CropBox* containers were deployed in Canada.

CubicFarms


A CubicFarms container.

CubicFarms is a Canadian company established in 2015 that has developed a model of vertical farming technology designed for commercial scale production of leafy vegetables, herbs, microgreens, and nutritious animal feed. The containers or "machines" have undulating trays that move on a rotating circuit that brings the trays to and from LED lighting placed on the ceiling of the container.

The company's pilot site is composed of 12 containers installed in Pitt Meadow (British Columbia) since 2018. Customers include Swiss Leaf Farms in Busby (Alberta), as well as farms in Leamington (Ontario), Vineyard (Utah), and Calgary (Alberta). They have sales warehouses in North America and abroad for machine quantities ranging from 20 to 100 containers per farm.

CubicFarms entered the stock market in November 2019, when its revenues for the year were $5.4M, including $5.2M in sales revenue. During the 1st quarter of 2020, Ospraie Ag Science invested $5.25M in CubicFarms (or 25% of the company's shares), and CubicFarms acquired HydroGreen, a livestock feed production system,[5] and sold a 100-container system to be installed in 2020 and 2022 in Surrey (British Columbia) for a value of $21.9M [6]. In February 2021, the company had secured investments to the tune of $54M.

[5] Information published on the company's website https://cubicfarms.com/
[6] Article Hortidaily.com (March 3, 2020) https://www.hortidaily.com/article/9195310/can-bc-100-machine-commercial-scale-vertical-farming-system-comes-to-surrey/

Freight Farms

A Freight Farms container operated by Durham College in Ontario, Photo credit: *Ryan Cullen (Durham College).*

Freight Farms is one of the first container manufacturers to appear on the market. The Boston-based enterprise was established in 2011 with the help of a community fundraiser on the Kickstarter site to develop their first prototype. Between 2013 and 2015, Freight Farms sold 118 *Leafy Green Machine* model containers.[7] A second generation of containers, *The Greenery*, was developed in 2019, and the company's latest model—*Greenery S*—was released in 2021. To this day, *Freight Farms* reports having sold 350 containers in 33 countries across 5 continents.[8] There are 2 companies commercially operating Freight Farms containers in Canada, one of which is located at *Durham College* in Ontario.

In addition to its container farm models, *Freight Farms* has developed a proprietary farming software called farmhand® and has a paid training offering, allowing company clients to acquire the horticultural and entrepreneurial skills necessary for their success. Services include on-site and on-line learning, as well as support to find funding, installation sites, and customers.

Freight Farms secured investments of US$26.4 million from 10 investors between 2013 and 2020. According to a 2017 report, between 60 and 80% of entrepreneurs using *Freight Farms* are profitable, and the return on investment is typically achieved within 3 years.[9]

[7] Newbean Capital. (2017). The promise and perils of container farming.
[8] Discussions with the enterprise in May 2021.
[9] Newbean Capital. (2017). The promise and perils of container farming.

Urban crop solutions

Model X. Credit: Urban Crop Solutions

Urban Crop Solutions is a Belgian enterprise established in 2014. It has sold containers worldwide and more specifically in Belgium, North America, Scandinavia, Singapore, and other South-East Asian countries. In 2020, the enterprise had 35 customers, some of which own several containers. Approximately 35% of the customers are research institutes such as the University of Liège or the University of Louvain. *Urban Crop Solutions* has carried out research projects from the outset and has opened a research centre in Waregem, close to Ghent in 2018. In this centre, one third of the research projects are carried out by the enterprise to develop climatic recipes for production that will be shared with its customers, one third of the research is subsidized by the Belgian government and the last third is managed by the enterprise's customers for the development of their own climatic recipes.

In 2020, *Urban Crop Solutions* has developed a new container model—*Model X*—based on the experience garnered from their first model. The new automated system of several containers is more productive and uses less energy per container. A container from this company is currently in operation in Quebec, less than 60 kilometres from Montréal in the Lanaudière region.

KEY PARAMETERS TO SET UP A CONTAINER FARM

Site preparation

Because of its low footprint and its soil-less production, a container farm can be installed on a site otherwise considered as unfit for farming, such as under-used parking lots, cemented, paved, or mineralized surfaces, brownfield sites, etc. The site must, however, be an even surface, with access to water and power, which often depend on a neighbouring building to allow for hook-up. It is preferable to find a location shielded from the sun to avoid frequent temperature changes that will influence the growing conditions and the energy needs. Even if the containers include insulation, temperature changes are more frequent than for production in a building. On top of these technical considerations, it is preferable that the container be located close to its market to reduce the cost~~s~~ of delivery, but also to build relationships between the farm and its potential customers.

Zoning and regulations

Although we often see maritime containers converted and temporarily installed in urban environments, a container retrofitted for agricultural production is different because it needs to be hooked up to water and power. Thus, a container farm is considered as a permanent installation, which is often prohibited by municipal regulations. Furthermore, it is essential to ensure that municipal zoning allows for agricultural production. Urban agriculture in containers is very recent, it is therefore quite possible that the municipal regulation is not adapted to such an activity and that agricultural use is not accepted in the zone where the farm would be located. It is therefore necessary to confirm this and take the necessary steps to comply. As well, the pioneers of this kind of agriculture have the double responsibility of implementing their project and of making the regulations evolve or of obtaining derogations, which can be costly in time and invested efforts.

Some municipalities such as L'Assomption which houses *Zone AgTech*, have carried out zoning changes upfront so that the installation of container farms is possible. A major issue is property taxes which are different when temporarily or permanently installing a container.

Example of the *Du Jour* company

For the *Du Jour* company, the administrative procedures with the city of Embrun in Ontario took more than a year. The container farm is classified as a "production greenhouse", while the installation site, a supermarket parking lot, is classified as a commercial zone, which does not allow greenhouse food production. The company needed to make a zoning change request to the municipality to get a zoning amendment that supports the installation of greenhouses on the site. A public consultation was held on this regulation amendment. Conditions were imposed for the company to be allowed to install a container: that there be no reduction in the number of parking spots, that it be located at least 3 metres from the main building (to comply with the Ontario building code) and that the container's look be improved.

Overall, the administrative steps, the installation, and the inspection took a year and a half, however, these steps made it possible to establish a basis that will make future installations in this city easier.

Choice of equipment

For turnkey container installations, the equipment choices are limited to the technologies developed by the manufacturers, however, additional customization must be considered, especially to adapt the container to the outside climate. Companies such as *ColdAcre* and *Rocket Greens* installed in Northern Canada have increased the insulation of their containers and added a chamber at the entrance to stop the cold air from entering into direct contact with the crops. This is one of the reasons why *Boîte Maraîchère* has developed a concept that includes many containers and not only one. This allows for an entrance and production workspaces. For *297 Farm VBA*, located in Aruba, the installation required the replacement of the dehumidifier by a model better adapted to the island's hot and humid conditions.

Choice of crops produced

Container farms can produce a wide variety of leafy greens, herbs, or microgreens. Trials are necessary, especially at the beginning, to identify the mix of varieties that can be grown with the same environmental parameters in order to answer the market's needs. It is not rare that these trials are carried out over one or two years to identify the most profitable production and marketing models, which is what *ColdAcre* has done. The container manufactuers often carry out agricultural and technological research that allows buyers to benefit from their knowledge and best practices.

CASE STUDIES

This section presents various cases, which, each in their own way gives information on the viability model of a container farm and illustrates the key parameters of a viable project.

ROCKET GREENS (Manitoba)

Photo credit: Churchill Northern Studies Centre

Rocket Greens is a project of the *Churchill Northern Studies Centre (CNSC)*, a not-for-profit organization in Northern Manitoba dedicated to ecological education which provides subsidized facilities, equipment, and accommodation for scientists carrying out research in the sub-arctic region. The organization has been operating for 40 years and became interested in starting a food security project after the community's access to rail was interrupted for 2 years because of a blizzard. The container was trucked from Seattle to Montréal and brought to Churchill by ship in 2017. It is one of the first container farms set up in Canada and it provides fresh produce to a community where produce is rarely sold at its peak of freshness.

Production

The standard-sized container is set up at the CNSC, on land owned by the organization. It is connected to the centre's power supply and has access to the building's back-up power system.

The organization reviewed several manufacturers' products and chose the Growcer brand because of their Canadian origin and of their experience operating in a Northern climate. The farm grows a variety of leafy greens including Boston lettuce, leaf lettuce, spinach, curly kale, bok choy, tatsoi, kale, mustard greens, arugula and 8 varieties of herbs. Because of its remote geographic location, seeds, fertilizers, and other growing supplies are ordered once a year and are stored in a room inside the CNSC building.

Distribution

The produce is distributed directly to 50 households in the community through a Community Supported Agriculture (CSA) program. Members subscribe for weekly boxes one month at a time. The standard "Launch Box" includes a rotation of 6 leafy greens and one bunch of herbs each week, while the "Mini Launch Box" includes a rotation of 3 leafy greens and one bunch of herbs. Customers pick up their boxes at the centre and return the empty box the following week. In addition to the CSA program, *Rocket*

Greens provides regular orders to 2 grocery stores, the hospital cafeteria, the CNSC cafeteria and flexible orders to restaurants.[10]

Economic model

The CNSC dedicates part of the sustainability manager's time to the project. Other staff and interns also occasionally support the project, especially on the weekly harvest days.

The project received financial support from the *Churchill Regional Economic Development Fund*, to purchase and install the container, and subsequently to upgrade the container with newly designed *Growcer* equipment. In addition, the project received core funding from the *Northern Manitoba Food Culture and Community Collaborative*, as well as employment grants to hire interns to carry out scientific experiments, communications, and innovation at the CNSC, and to occasionally support the farm. *Rocket Greens* also benefits from in-kind contributions from other parts of the CNSC for administration, the use of a delivery vehicle, as well as access to water and power. Technical support is provided by the *Growcer*, in return for being a customer of the container's manufacturer.

It took about a year to get used to the equipment, to optimize production, and to develop a product mix of leafy greens and herbs that pleases customers. The farm is now running at capacity with stable orders from loyal customers. Produce is priced to be affordable for the community and decisions are made based on the not-for-profit's food security and educative mission. Management and the board of directors are satisfied with the project's outcomes.

[10] During 2020, the restaurants and CNSC cafeteria orders have ceased, and the produce was redistributed to the box program members.

DU JOUR (Ontario)

Photo credit: Guillaume Pasquier, Coop Embrun

Du Jour is a tripartite joint venture established in 2020. Its resources are shared between *Coop Embrun* and two individual partners. The project is part of an active approach to bring the agricultural cooperative to new markets and promote local products. It has strong agricultural knowledge, contrary to the current trend of agricultural container operators, who enter the market with little or no experience. The objective is to fully integrate farmers in this emerging sector by training the cooperative's members to hydroponic production as well as urban agriculture and its challenges. Furthermore, the joint venture perceived the opportunity to meet the customers' demand at the *Coop Embrun* supermarket. By supplying continuous local production throughout the year, *Du Jour* and *Coop Embrun* hope to encourage their customers to repeat local purchases.

Production

The production is made with a hydroponic container manufactured by a Canadian company and is installed in a parking area of the *Independent* supermarket in Embrun, a town close to Ottawa. After a call for proposals, the company selected this local container manufacturer (located in Ottawa), which offers continued technical follow-up to its clients with its five years of expertise and a strong collaborative approach for both the agricultural and technical aspects. *Du Jour* produces four kinds of lettuces, as well as spinach and herbs such as Genovese basil, giant Italian parsley, and common mint.

Distribution

The entire production is currently sold in the cooperative's supermarket. The enterprise chooses its varieties according to demand, which varies with the seasons. The marketing message is currently focused on local agriculture and on food safety that the hydroponic system offers close to the point of sale. In the future, the enterprise wishes to involve customers in the choice of varieties produced and organize workshops to discover and build the public's awareness of hydroponic agriculture.

Photo credit: Guillaume Pasquier, Coop Embrun

Economic model

The joint venture profits from *Coop Embrun's* resources, such as the resources for the promotion and sales in the *Independent*, that belongs to the cooperative. Two persons supply the expertise gained through past experiences in interior agriculture and are responsible for operational management (production/harvest), for administrative and financial management, as well as commercial strategy.

The investment for the project's implementation was covered by *Coop Embrun* and covers the purchase and installation of the container as well as a part-time salary for 5 years. In return, the *Du Jour* enterprise's profits are shared between the joint venture's partners. *Coop Embrun* perceives *Du Jour* as a pilot project that will be able to grow in the future if it is successful. *Du Jour* anticipates a return on investment in 5 years.

COLDACRE (Yukon Territory)

Credit: Carl Burgess from ColdAcre

ColdAcre is an indoor vegetable farming business operating two containers and an indoor microgreen facility located in Whitehorse, Yukon. The enterprise was established in 2018 and is majority-owned by *Solvert*, a Northern Canadian company specialized in solar energy. *ColdAcre*'s mission is to improve quality of life, access to nutritional diversity, and food safety for the inhabitants of the Northern territories through the implementation of year-round agricultural production technologies. Indeed, locally grown food represents only about 1% of Yukon's total food consumption[11], as the inhabitants rely on the importation of food for their sustenance. *ColdAcre* is helping to fill some of the self-sufficiency gaps by growing a diversity of leafy greens and herbs year-round for the local market, by providing indoor farming system advice, and by selling production equipment. *ColdAcre* is the Canadian distributor of *CropBox*, an American brand for a turnkey system of containers for agricultural use and sells its own production technology. The enterprise also produces and distributes oyster mushrooms and microgreens.

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[11]Morin, P. (2020). Yukon charts course to increase local food production. *CBC News.* https://www.cbc.ca/news/canada/north/yukon-agriculture-policy-2020-1.5652209

Production

The containers are installed in a light industrial zone, on land owned by *Solace Inc.* and use a hydroponic system. The diversified production includes Genovese basil, Thai basil, lettuce, romaine, arugula, chard, kale, tatsoi, bok choy, and watercress. Thanks to modular hydroponic equipment, production can vary to meet demand, which changes according to seasons. In order to grow year-round, the containers are insulated to withstand outside temperatures of -50 °C while maintaining adequate internal temperatures. Each container also includes an "Arctic Entrance", additional space acting as an air break between the exterior and interior. This space is also used for harvesting and packaging activities.

Distribution

The needs of the Whitehorse population vary significantly in the summer and the winter due to the flow of residents and tourists. As a result, *ColdAcre* has adapted its production and distribution to change with seasons as well. In the winter, the enterprise focuses on serving local residents with a CSA program of diverse leafy greens, distributing tailored orders to restaurants and standard, recurring orders to supermarkets. In the summer, when tourism is active and local residents tend to grow their own produce, the enterprise focuses its distribution to restaurants and supermarkets. Across the 3 distribution channels, *ColdAcre* is able to serve 5 grocery stores, 10 restaurants and between 50 and 120 CSA members.

ColdAcre prides itself in being a zero-waste company and aiming to become carbon neutral. These values are not only important to the enterprise, but also for its customers, who are willing to pay for the use of rigid biodegradable packaging at an extra cost of 22 to 40 cents per unit.

Services

In addition to producing food, *ColdAcre* consults and sells indoor growing systems. The company is also involved in its community and hosted, before the COVID-19 pandemic, weekly tours of its facility.

Credit: Carl Burgess from ColdAcre

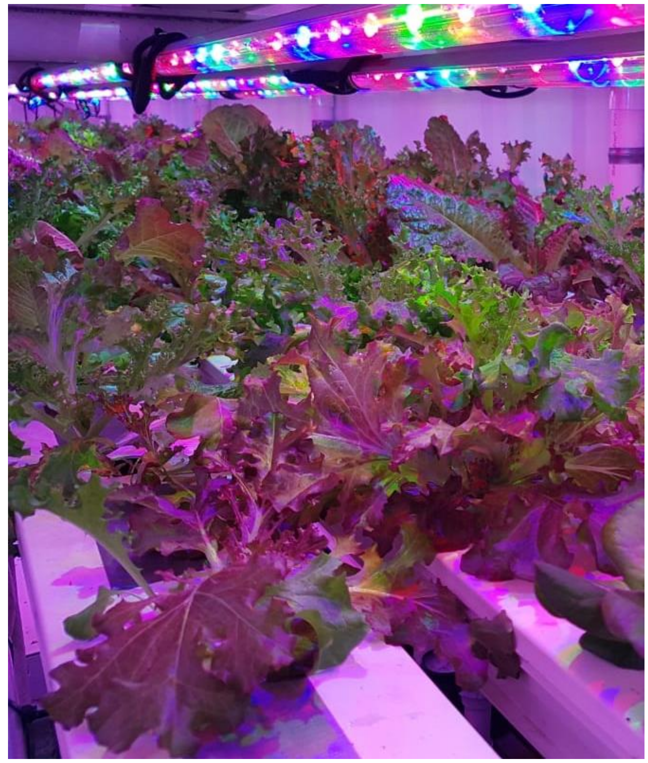
Economic model

ColdAcre employs 11 permanent staff. A large portion of their time is devoted to consulting and sales of indoor growing systems, to which all staff members contribute, while the rest of their time is devoted to food production, harvesting, and distribution. In addition, three students are employed full-time during the summer months.

The main source of revenue comes from the consulting activity and sales of growing systems, allowing the company to pursue its desire of long-term expansion. Over time, *ColdAcre* has adjusted its product mix to match customer demand. It took the company about 3 months to adjust its offer to the market, which included growing the right mix of leafy greens and herbs, identifying the ideal packaging size along with the quantity of product per package and the price. To make the scale of operation work and to adapt the offer to demand, the farm had to build flexibility into its sales; what is not sold to restaurants and grocery stores is integrated into the CSA program, as these customers are more flexible. While the production and the distribution mix change with the seasons, on a yearly basis, each sales channel represents one third of the company's production revenue.

The farm is currently in an expansion phase. On top of the production of mushrooms and microgreens, the enterprise also wishes to cultivate vegetables traditionally, namely the production of root vegetables. In the long term, the enterprise plans that the production activity will contribute two thirds of the company's revenues.

297 FARM



297 Farm is a container farm located in Aruba, an island in the southern Caribbean Sea, 29 km north of Venezuela. The farm is part of *Antilla Energy VBA*, an alternative energy company established in 2014. *Antilla Energy VBA* is interested in applying the UN Sustainable Development Goals in the context of islands and saw indoor farming as an opportunity to provide food more sustainably given the island's resources. Its mission is to provide locally grown produce to Aruba's 110,000 residents and 1 million tourists per year, hence limiting expensive importations and improving product freshness.

Production

Over the past 3 years, *297 Farm* has experimented with various crops to meet the local market's demand. In 2020, the farm produces year-round a combination of butterhead lettuce, spring mix, and microgreens such as micro basil, radish greens, cilantro, and arugula. Their *CropBox* brand container is installed on rented land—a 320 m^2 plot on a larger property. Aruba's tropical climate tends to stay hot, day and night, which is not conducive to the commercial production of leafy greens, whether in greenhouses or outdoors. Container farming is an opportunity to provide ideal growing conditions for crops, to quickly set up an operation in order to test the market before planning a larger project.

Distribution

In 2020, *297 Farm* is running at full capacity and can sell all of its produce. During the first years of production, trials were carried out with direct-to-consumer sales. The enterprise is now focusing on selling packaged leafy greens to 6 supermarkets, a model proving to be less labour intensive. In the future, *297 Farm* wishes to focus more specifically on the tourist segment, a market more sensitive to product quality and variety.

Economic model

The farm employs one full-time production manager and 2 part-time staff dedicated to packaging, distribution, and sales. Farming represents roughly 12% of *Antilla Energy's* revenues. Other income is derived from the importation of edible oils for distribution to hotels, restaurants, and supermarkets. The subsequent collection of used cooking oil is exported to produce biofuels.

Through the development process, *297 Farm* has worked collaboratively with *Antilla Energy* shareholders and benefited from *CropBox's* expertise which provides ongoing support to its customers. *Antilla Energy* provided the start-up investment. This initial investment covered the cost of the container, its shipping from North Carolina, the site preparation, and the upgrade of the container's dehumidifier to one better adapted to the island's hot and humid conditions.

The farm can command a high price for its produce, and despite expensive energy costs (Can$0.46/kWh), the farming activity generated a profit 8 months after the first year of production. After nearly 3 years of operation, *297 Farm* is actively planning its expansion and will grow its production surface 10-fold in 2021.

297 Farm is a founding member of *United Farmers Aruba*, whose collective voice engages government bodies to advocate for a range of initiatives including, greater access to land for farming, access to lower cost water and power, the development of Good Agricultural Practices (GAP) Certification and a review of the importation and profit tax structures.

COVID-19 has highlighted the insecurity of food supply chains on importation-dependant island nations. Consequently, *297 Farm* has entered into a partnership with the Government of Aruba during the pandemic to secure 15,000 m^2 of land to expand its farm. The new project will also include the production of vine crops.

ECONOMIC ANALYSIS

BASIS OF THE ECONOMIC STUDY

This economic study[12] of container farms is based on 4 farms for which we have obtained detailed installation and operation costs as well as the revenues from the production activities. The participating enterprises have supplied data for 2019 and 2020, and the 4 projects are comparable in terms of production methods. We have focused on enterprises producing leafy greens. They produce between 1 and 5 varieties during the year. However, one enterprise also produces microgreens.

This case analysis includes data revealed in the *NewBean Capital* report on 3 enterprises *(cases A, B, and C)* which use the *Freight Farms* technology (*Leafy Green Machine* model). This data stems from 2017 and considering the technological evolution that has occurred in the market over the last 5 years, they cannot be compared directly to the most recent cases.[13]

Although some of the farms from the study have 2 containers, all data is presented for each container unit and per m^2 of production.

Table 1. Characteristics of the cases used in this economic fact sheet.

	Direction of the production medium	**Irrigation**	**Sales method**
Case 1	Horizontal	Nutrient film technique (NFT)	Sales to grocery stores
Case 2	Horizontal	Nutrient film technique (NFT)	Direct sales in boxes, sales to grocery stores, sales to the HRI* sector
Case 3	Vertical	Drip irrigation	Direct sales at the farm, sales to the HRI sector (internal)
Case 4	Horizontal	Nutrient film technique (NFT)	Direct sales in boxes, sales to grocery stores, sales to the HRI* sector
Case A	Vertical	Drip irrigation	Direct sales
Case B	Vertical	Drip irrigation	Sales to grocery stores
Case C	Vertical	Drip irrigation	Sales to the HRI* sector

Legend: HRI: Hotels, restaurants and institutions

The collected data has allowed us to create projections for various kinds of farms and to calculate the costs, revenues and human resources needs per container.

[12] The farms participating in this study have asked for a certain level of confidentiality. Some information can therefore not be shared at the risk of revealing their identity. It is also important to note that there is no link between this section and the one that presents inspirational cases.
[13] Conversation with the enterprise, May 2021.

INSTALLATION OF A CONTAINER FARM

When zoning allows for the installation of a container to produce leafy greens, the installation is relatively simple, but requires many months for its set up and the start of production.

Investments in work time are required to find a site that meets market needs (vicinity to clients), production (access, external climate conditions), and if needed, to request regulatory changes from the municipality.

For the 4 studied cases, the cost of the containers varies between $108,000 and $220,000. This is comparable to our international research results where for 12 turnkey model manufacturers, the prices varied between $93,600 and $188,000.

The cost of transportation, site levelling and access to water and power services also need to be accounted for. In the studied cases, these costs vary between $8,250 and $40,000 per container. In Case 2, other investments related to the installation amounted to $90,000 per container. Installation costs for a standard 30 m^2 container are thus between $3,600 and $8,700 per m^2.

Table 2. Installation cost of container farms.

	Turnkey container ($)	**Transportation ($)**	**Site set up ($)**	**Other set up costs[a] ($)**	**Set up cost per container ($/cont.)**	**Set up cost per m^2 ($/$m^2$)**
Case 1	$183,000	$15,000	$10,000	n.a.	$208,000	$6,933
Case 2	$150,000	$7,500	$750	$90,000	$248,250	$8,275
Case 3	$107,700	n.a.	n.a.	n.a.	$107,700	$3,590
Case 4	$220,000	$30,000	$10,000	n.a.	$260,000	$8,667

Note: [a] Examples: market study, consulting services, etc.
Legend—n.a.: not available

REVENUES FROM VEGETABLE PRODUCTION

Many factors influence the revenues from production, including agricultural skills, the management of environmental variables, the varieties that are grown, the type of market chosen and the product sales prices.

In the studied cases, the difference between annual revenues per container is significant. It varies between $37,000 and $107,000 per container, or between $400 and $1,200 per m^2 of production surface.

Table 3. Production revenues of container farms.

	Capacity (number of plants per container per production cycle)	Plant density per m^2 at ground level	Number of production levels per container	Number of varieties harvested	Production per year per container (heads or units/cont.)	Annual production revenue per container ($/cont.)	Annual revenue per m^2 of production ($/m^2)	Shared production year
Case 1	2,500	83	4	3	21,867	$96,822	$1,086	a
				3	24,054	$106,504	$1,194	b
Case 2	2,500 3,000	83 - 100	4	2	25,610	$92,430	$957	a
Case 3	3,584	119	4	1	81[a]	$1,782[b]	$20[b]	a
				1	5,460	$36,920	$415	b (planned)
Case 4	1,800	60	4	5 +	n.a.	$41,553	$399	a
				5 +	n.a.	$47,407	$456	b
Case A	n.a.	n.a.	n.a.	3	n.a.	$88,792	$998	n.a.
Case B	n.a.	n.a.	n.a.	2	n.a.	$79,738	$896	n.a.
Case C	n.a.	n.a.	n.a.	1	n.a.	$49,401	$555	n.a.

Notes: [a] production in 1 kg units, [b] for this case, production is not at full capacity.
Legend—n.a.: not available

WORK TIME TO OPERATE A CONTAINER FARM

Labour costs represent the largest operating variable costs. Depending on the studied cases, they represent between 62% and 87% of variable costs.

Excluding the two outliers (Cases 2 and 3.a), labour represents between 1,300 and 2,500 hours per container per year, which represents between 25 and 50 hours per week, all year long.

Case 3 started with less than full capacity production, which accounts for the fewer number of hours, while for Case 2, research and development (R&D) activity could have influenced the higher number of hours.

In the cases where we have the number of work hours for two years at full production (Cases 1 and 4), the number of hours worked varies only slightly from one year to the next.

Table 4. Annual work time devoted to production and marketing per container

	Work time per year per container (% of work time)					**Annual work time per container**
	Seeding and germination	**Growth**	**Harvest, packaging, transportation**	**Commercialization and marketing**	**Administration and management**	
Case 1.a	240 (10%)	840 (35%)	840 (35%)	240 (10%)	240 (10%)	2,400
Case 1.b	250 (10%)	875 (35%)	875 (35%)	250 (10%)	250 (10%)	2,500
Case 2	600 (11%)	2,100 (39%)	1,800 (33%)	600 (11%)	300 (6%)	5,400
Case 3.a[a]	30 (5%)	108 (18%)	402 (67%)	36 (6%)	24 (4%)	600
Case 3.b[b]	91 (5%)	328 (18%)	1,219 (67%)	109 (6%)	73 (4%)	1,820
Case 4.a	52 (4%)	-	780 (60%)	13 (1%)	455 (35%)	1,300
Case 4.b	52 (4%)	-	780 (60%)	13 (1%)	455 (35%)	1,300
Case A	n.a.	n.a.	n.a.	n.a.	n.a.	1,320

Notes: [a] for this case, production is not at full capacity, [b] planned work hours

WATER AND POWER CONSUMPTION

For container production, the heating, ventilation, and air conditioning system is essential and includes various equipment such as a furnace, a humidifier/dehumidifier, CO_2 injector, ventilators, and a control software. The turnkey containers are often available with various levels of insulation (R10 to R40), however, the microclimate in the chosen site may change the heat flow between the interior and exterior, as well as the incoming air's properties.

The studied cases are installed in various climates and have various insulation levels. Case 1 stands out with a high power consumption, because of a high need for air conditioning as a result of the hot exterior climate. In other cases, consumption is between 36,000 kWh and 45,000 kWh per year.

Water consumption also varies from case to case between 2,400 L and 18,000 L per year. It depends on the irrigation system, the plants' evapotranspiration, and water renewal in the reservoirs. These cases do not consider the water consumed to clean the leafy vegetables. Not all the enterprises wash the leafy vegetables at harvest time. Case 1 has identified an additional 42,000 L consumption per year for this task.

Table 5. Annual water and power consumption per container.

	Water consumption (L/yr)	**Power consumption (kWh/yr)**
Case 1.a	18,000	57,600
Case 1.b	18,000	57,600
Case 2	2,400	36,000
Case 3.a[a]	8,213	27,125
Case 3.b	13,779	45,000
Case 4.a	11,000	n.a.
Case 4.b	11,000	n.a.
Case A	n.a.	45,540
Case B	n.a.	47,100
Case C	n.a.	45,480

Note [a] for this case, production is not at full capacity.

KEY ELEMENTS FOR ECONOMIC VIABILITY

In all the studied cases for this economic fact sheet, growing vegetables in a container appeared in larger structures such as those of a not-for-profit, an institution, a cooperative, or an enterprise involved in other activities. Depending on the case, the host organization can obtain the required funding for the initial investment and, in some cases, for part of the human resources, whether it be at the beginning of the process or on a regular basis.

The local market (that varies with the seasons), the competition, the varieties grown are all factors that influence the farms' economic sustainability. The installation location in the urban environment is important, especially because these business models are focused on short a marketing chain.

Setting up close to the sales locations makes it possible to reduce the costs associated with sales and transportation. In urban areas, the containers can take up underutilized spaces for which rental cost is lower. In particular, the studied cases have little or no rent to pay.

Finally, understanding the customers' needs allows to make the appropriate choices regarding the crops sold, their packaging, and their sales price.

Table 6. Assessment of the sustainability of container farms.

	Revenue from the sale of the production ($/year)	HR operation costs ($/year)[a]	Power costs ($/year)[b]	Other variable costs for the enterprise ($/year)[c]	Profit or deficit for the production ($/year)	Other fixed costs excluding depreciation ($/year)	Other declared revenue sources ($/year)	Project profit or deficit before depreciation ($/year)
Case 1.a	$96,822	$42,480	$5,700	$4,200	$44,442	$3,850	n.a.	$40,592
Case 1.b	$106,504	$44,250	$5,700	$6,500	$50,054	$3,850	n.a.	$46,204
Case 2	$92,430	$106,200	$3,600	$11,800	($29,170)	$9,350	$184,000	$145,480
Case 3.a	$1,782	$10,620	$2,713	$3,719	($15,270)	$0	$0	($15,270)
Case 3.b	$36,920	$32,214	$4,500	$12,858	($12,652)	$0	$0	($12,652)
Case 4.b	$41,553	$23,010	$400	$8,500	$9,643	$0	$35,000	$44,643
Case 4.c	$47,407	$23,010	$400	$8,500	$15,497	$0	$35,000	$50,497
Case A	$88,792	$26,050	$5,993	$9,440	$47,309	$2,368	n.a.	$44,941
Case B	$79,738	$26,050	$6,199	$9,677	$37,813	$9,473	n.a.	$28,340
Case C	$49,401	$14,210	$5,987	$4,658	$24,546	$0	n.a.	$24,546

Notes: [a] This cost estimate of human resources is based on an average hourly wage of $15/h + 18% in payroll taxes, [b] this estimate of the enterprise costs is based on a $0.10/kWh power cost. Preferential rates are available through the MAPAQ's financial assistance program to promote the development of greenhouses and controlled environment agriculture, [c] Models exclude the price of water which is free in Quebec.

ASSESSMENT OF THE ECONOMIC VIABILITY OF A CONTAINER FARM

By ignoring the outliers having production circumstances that vary from the sector's average characteristics, the variable operation costs are estimated at between $32,000 and $120,000 per year.

Starting with the economic model from the studied cases (Table 6), it is possible to profitably grow leafy greens in a container. In Cases 1 and 4, the production revenues create a profit that can be used to cover the necessary start-up investments, and this, right from the first or second year of operation.

It must be highlighted that for Cases 2 and 4, it is revenues other than those of production that make it possible to increase the enterprise's profitability, such as salary grants or revenues from the sale of equipment. Thus, for the studied cases, the return on investment of the profitable cases is about 7 years.

For Case 2, revenue not related to production makes it possible for the enterprise to be profitable. It is an enterprise that wishes to expand and that aims for profitability in the mid term. Case 3, in the launching stage, has not yet operated a container at full capacity for a full year. The project does not plan for a profitable production activity for its first year at full capacity.

However, it must be considered that a project can take 2 years before being mature and allowing for maximum production. Which means that a container producer must have funds or start-up support to cover the fixed costs for the first years.

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