



ECONOMIC FACT SHEET

OUTDOOR ROOFTOP FARMING

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 a research, training, innovation and action space that serves the community, making it possible for professionals, citizens, researchers, decision-makers and entrepreneurs to collaborate on the subjects 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.



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We also wish to thank the urban rooftop farms that have shared their economic data in order to allow us to create indicators for installation costs and revenues per square metre.



FOREWORD

This fact sheet was created in order to guide persons who wish to start an outdoor rooftop farm project as well as real estate developers and real estate managers who wish to host farm projects on their buildings' rooftops.

Based on business case analysis as well as on data collected from agriculture producers growing on rooftops in various production contexts, this fact sheet supplies basic information on the potential costs of installing and operating a rooftop farm. It is important to remember that they are indicators and that numerous difficult to plan factors can influence the final cost of a project and/or operation costs. Furthermore, over time, we observe that the installation cost diminishes and that revenues increase in rooftop farm projects. This fact sheet has been created using data collected in 2018 and 2019.

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 launch 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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OUTDOOR ROOFTOP FARMS

Urban agriculture is made up of numerous very diverse farming businesses. Although still marginal, the development of farms in urban environments is increasing and they are more and more present in the urban environment. In Quebec, in recent years, between 10 and 15 urban farming businesses have been launched each year.

In Vancouver, there are 13 urban farms for a total of 3.5 hectares ¹. In Brussels, there are 29² businesses while there are 35³ in Metropolitan Montréal. For all of Quebec, there are 50 urban farming businesses of which 14 are involved in rooftop production.

In recent years, rooftop farming production generates much enthusiasm among farmers wishing to produce in urban environments. Taking into account the large number of buildings able to host this kind of activity, rooftop production represents an enormous potential for development for urban agriculture. Despite the numerous challenges (bearing capacity, technical challenges, weather conditions), rooftop farms are being more and more examined by public authorities and real estate developers in order to address environmental issues such as biodiversity, management of organic matter, management of water, the fight against heat islands, etc.

With the announcement of 1.4 hectares of rooftop farm projects in Paris in 2020, and of 3 hectares in Quebec, we observe an increased popularity for the creation of urban rooftop farms for real estate developers and property managers. However, these varied projects still in development sometimes raise questions about the installation and operation costs of such farms. This fact sheet aims to answer these questions.

¹ Vancouver Urban Farming Society. (2017). Vancouver Urban Farming Census 2014 to 2016, 470. [Online] http://www.urbanfarmers.ca/wp-content/uploads/2016/12/FINAL_Vancouver_Urban_Farming_Census.pdf

² Bousten R., n » Maughan and M. Visser (2018) Évaluation de la production agricole primaire professionnelle en région de Bruxelles Capitale

³ Duchemin, E. and Vermette, J.- P. *Portrait de l'agriculture urbaine commerciale au Québec en 2018*. Carrefour de recherche et d'expertise et de transfert sur l'agriculture urbaine. [Online] : <http://cretau.ca/wp-content/uploads/2019/06/Portrait-AU-commerciale-2018-final.pdf>

THREE KINDS OF ROOF INSTALLATIONS

There are three kinds of roof installations that make it possible to develop urban agriculture.

INTENSIVE GREEN ROOFTOP URBAN FARMS

This type of roof is characterized by the presence of soil varying between 20 to 30 centimetres in depth. The farming activity of intensive green roofs can be done, either on all of the available surface for vegetable production, either on part of the roof on which slightly raised beds are formed, the remainder of the roof being covered by mulch.



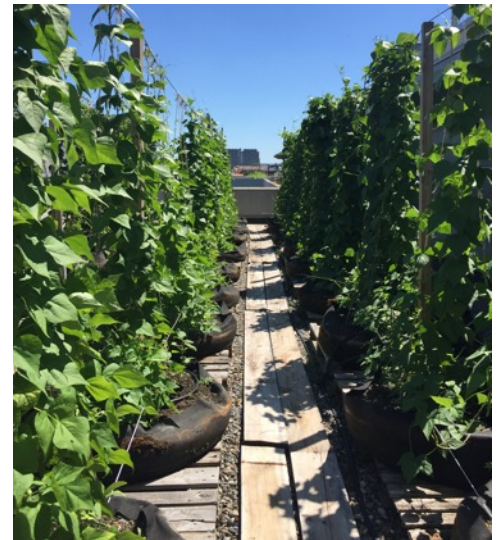
Ryerson Urban Farm, Toronto (Ontario, Canada)

ROOFTOP URBAN FARMS WITH CONTAINERS MADE OF GEOTEXTILE OR OTHER MATERIALS

This kind of roof hosts out of soil production, namely production in containers, mainly geotextile membrane bags of various sizes, filled with soil and watered with a drip system. The containers can also be made of plastic or with wooden structures, more rarely cement spaces within the building's structures. The production can also be made with hydroponic systems (Nutrient Film Technique [NFT], Ebb and flow) installed on all of the rooftop surface.



Ferme Maraîchère, Centrale agricole, Montréal (Québec, Canada)



Institut Pasteur, Toulouse (France)



Ferme Maraîchère, Palais des Congrès de Montréal (Québec, Canada)

VERTICAL ROOFTOP URBAN FARMS

This type of roof is made up of vertical structures used for agricultural production. The models vary, there are structures that support felt membranes or hydroponic towers.



Ferme Maraîchère Verticale, Palais des Congrès de Montréal (Québec, Canada)

KEY PARAMETERS TO START A ROOFTOP FARM

With the experience of pioneers such as Brooklyn Grange that has been operating a farm since 2009, or of Ligne verte : Maraîcher and Topager, it is now possible to better delineate the challenges related to the implementation and viability of such projects.

SITE SELECTION

Finding a space is a challenge. The roof must be able to support the installations' weight and be easily accessible. It must be strategically located to facilitate sales activities and to greet visitors. It must also be possible to sign an agreement for a number of years (ideally for a minimum of 10 years) to use the space.

HYPER-LOCAL MARKETING

Marketing as well as the distribution of the fruits and vegetables must not be neglected at the development stage of the farm project. They would ideally need to be close to the production site in order to reduce work time for this activity as well as travelling time as much as possible. This aspect is vital for a project's viability. Close distribution will allow to rapidly sell the crops and will avoid the producer needing to build a costly storage infrastructure such as a cold room (on-site or on another site), which will avoid travel time, while keeping products chilled.

The types of marketing strategies observed are:

- 1) establishment of farms on the rooftops of supermarkets with sales in the store
- 2) establishment of farms on the rooftops of businesses with sales in baskets to the employees
- 3) sales to the surrounding community in baskets
- 4) sales to restaurants close to the production site
- 5) semi wholesale to specialized food businesses

An urban producer generally combines many of these marketing strategies.

A DIVERSIFIED ECONOMIC MODEL

A project can hardly be only based on the revenues generated by the production of fruits and vegetables. Diversifying agricultural revenues includes, among other things, having paid visits, holding special events, and on-site eating activities. These activities, such as the planning or accompaniment of projects carried out by the team, are an important part of a rooftop farm's economic model. Processing of products specifically marketed under a brand specific for the project is also observed. All of these activities can generate revenues higher or equal to that of agricultural production and their profit margins are sometimes much higher. However, they require a strategic place that allows for them to occur (access to a space, public access to the roof, visit-friendly layout, access to washrooms, etc.).

SKILLED AND VERSATILE HUMAN RESOURCES

The operation of a rooftop urban farm needs to produce high volumes on a small surface, with optimal work efficiency. This requires organization and knowledge. As a rooftop urban farm is based on a highly diversified production (which can also include the production of honey), on the link with the community as well as on activities that are neither horticultural nor agronomic, much versatility is needed within the human resources team.

CAPACITY TO NEGOTIATE

A rooftop urban farmer must be able to negotiate with various persons who collaborate in their project such as the building owner that they desire and the municipal body. Rooftop urban producers rarely own the buildings and the use of the roofs for farming activities involves many constraints or issues. Therefore, a lease for more than 5 or even 10 years is necessary, and it must include the following information that must be negotiated: who covers the installation costs and to whom do they belong to at the end of the lease if it is not renewed, who restores the roof, who is responsible for the transition if the producer decides to leave. Furthermore, there are legal questions on insurance, the lease, regulations, etc. that need to be dealt with or negotiated.

REGULATIONS AND PROGRAMS

Having good knowledge of the regulations, the various key people at the municipal level, the city's policies (social, environmental, commercial, etc.) and the potential support programs (often linked with the policies) are also key elements.

ESTABLISHMENT OF INFRASTRUCTURE

The development of an outdoor rooftop farm, whether it be in containers or of the intensive type, requires a large initial investment. This investment is generally the developer's responsibility or that of the building owner who is profiting from the project's benefits (obtaining an exemption for the building, increased membrane's life, better roof insulation, visibility, competitive advantage for recruitment, etc.).

Support programs for green roofs and environmental services are often interesting funding sources to set up facilities.

It is nevertheless important to have an investment of a few tens of thousands of dollars from the producer.

CASE STUDIES

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

BROOKLYN GRANGE



Brooklyn Navy Yard Farm, 1.5 acres (growing in soil and greenhouse)

Brooklyn Grange is a community-based private business located in New York. It is considered as a leader in rooftop farming.

Launched in 2010, Brooklyn Grange owns three urban farms located in Brooklyn and in Queens. In order to make the city of New York more sustainable, Brooklyn Grange aims to facilitate local and healthy food consumption through the creation of a short route to market, the reuse of organic matter and of rainwater while creating an inclusive ecosystem in the community.

Brooklyn Grange is not the owner of the surfaces that they grow, the enterprise has leases lasting 15 to 20 years.

Production

These three farms produce fruits, vegetables and microgreens on a surface of 23,000 m², for a total yearly yield of 36,000 kg. It also has three greenhouses, one of which is 450 m² for the production of microgreens and hydroponic production. In addition to their organic production of fruits and vegetables, Brooklyn Grange operates around forty beehives spread out on their roofs and throughout the city of New York. According to them, the most popular product is the production of microgreens that is done year-round as well as their spicy sauces made with products grown on their farms.

Distribution

Each of the Brooklyn Grange farms has different target customers. The Long Island and Sunset Park farms' products are found in various markets 1 or 2 times a week while the Navy Yard farm production is more reserved for restaurants and other food distributors.

Generally, besides the markets and the delivery of baskets (Community-supported agriculture [CSA]) to 60 members, the crops are distributed to 7 retail stores, 6 caterers, 2 distributors and 30 restaurant owners.

Furthermore, they have a transactional website allowing their customers to purchase processed products such as their famous spicy sauce as well as admittance tickets to their various activities (visits, workshops, yoga, lunches, etc.).

Brooklyn Grange sustains that there has been great enthusiasm for the urban agriculture sector during the last years and that the residents and workers are more and more looking for a connexion with nature and agriculture in an urban environment.

Table 1 The Brooklyn Grange urban farms

Farms	Roof surface (ha)	Cultivated surface (ha)	Year of establishment
Brooklyn Navy Yard Farm	0.6	0.40	2010
Long Island City Farm	0.4	0.32	2012
Sunset Park Farm	1.3	0.56	2019

Services

Brooklyn Grange also offers consultation, design, construction, and maintenance of installations and of the roofs. They organize guided tours of their sites and training sessions. They offer the service of organizing events and workshops as well as educational programs on various subjects related to nutrition.

Economic model

More than twenty employees work full time for the company as well as 60 seasonal and/or part-time employees.

Revenues are based on three main activities: agricultural production, events and design/construction services.

In recent years, the agricultural production revenues and those from events have been the same, however, the profit margin for events is much higher than that for agricultural production. The design and construction activities also have a larger profit margin than agricultural production, but their proportion is smaller than that of events. As for revenue generated by design and construction activities, they are as high as the combined revenue of the other two activities (agricultural production and events). However, according to the information that was obtained, the revenue from events is the one that should increase most rapidly in coming years with the addition of the transactional online site.

The enterprise claims that it reached its break-even point in the first year and it became profitable in 3 years with a continued increase in capital every year. Brooklyn Grange’s revenue has apparently tripled in the last 5 years.

The Long Island farm was funded with private investment capital, loans, fundraising and social financing through the Kickstarter.com platform. The Navy Yard and Sunset Park farms were funded by private capital investments and they have received a little less than US\$592,730 from the Department of Environmental Protection of the city of New York’s *Green Infrastructure Stormwater Management Grant Program*.

LA LIGNE VERTE : MARAÎCHER (IGA EXTRA - FAMILLE DUCHEMIN)



Jardin sur le toit du IGA Extra - Famille Duchemin

This rooftop farm is a La ligne verte : Toit vert project. La ligne verte : Toit vert is a Montréal private business that has given itself the mission of making all kinds of surfaces green to help its customers make their living environment more enjoyable and sustainable.

Created in 2009, La ligne verte : Toit vert designs, implements and operates various green roofs, landscaping, vegetal walls and urban agriculture projects. The enterprise also puts on various training sessions and workshops on the subject of urban agriculture. In 2017, La ligne verte, in collaboration with IGA extra Famille Duchemin located in Saint-Laurent borough launched the largest organic farm on the roof of a food retailer in Canada. A first in the country. Simultaneously, a second enterprise (La ligne verte : Maraîcher) stemming from the first was created for the maintenance of this vegetable roof and of others to come.

Production

On its 2,200 m² growing surface, the farm produces more than thirty kinds of fruits and vegetables certified organic by Ecocert Canada. They also operate a dozen beehives placed on the roof that each produce close to 25 kg of honey each year. In order of financial importance, the production is: vegetables, honey, cut flowers and berries. In the spring of 2020, the farm grew to 450 m².

Distribution

Almost all of the production is sold in the IGA store until fall. A "Frais du toit" (Fresh from the roof) brand was created in order to identify the produce coming from the roof. A small part of the production is also distributed to area restaurants in order to sell surplus production.

The supermarket sustains that the produce from the roof is very well perceived by customers. They attract new customers because of their local aspect. The supermarket is surrounded by a building complex, the creation of the garden made the neighbourhood happy as it embellishes the neighbourhood for those who have a terrace with a view on the vegetable garden.



View of the IGA roof.

Services

La ligne verte : Maraîcher organizes events on the roof in order to diversify its sources of revenue and thus optimize its business model, an activity sector that should continue to develop and grow in the coming years. The farm also offers visits and suppers where the food mainly comes from the garden or local distributors.

Economic model

The team of workers is composed of 4 employees (3 seasonal employees and 1 full-time employee) and of some interns. The permanent employee is responsible for management, planning and event organization tasks. Volunteers sporadically help out during the season.

Two thirds (2/3) of revenues come from the sale of vegetables while the remainder comes from other sources (events, suppers, honey, flowers, etc.). Considering that the organization of events is an activity currently being developed, the revenues from the agricultural production are significantly higher than those related to these. However, the enterprise foresees that there is a high potential for revenues from events in the coming years.

In order to adapt the building's roof for farming production, the IGA made infrastructure investments of more than \$250,000. A grant from the Financière agricole du Québec's funding program that supports the next generation of farmers has made it possible for Ligne verte to purchase starting equipment and the annual wage subsidies cover part of the salaries of the seasonal workers. Ligne verte rents the space from the IGA at a very low cost (symbolic rent). They have a 10-year lease allowing them to grow almost 9 months per year.

In order to minimize the use of raw materials and to promote circular practises, the garden has acquired a rotary drum composter to convert the crop and farming residues.

JARDIN SUR LES TOITS DE L'OPÉRA BASTILLE



Jardin sur les toits de l'Opéra Bastille

This project is driven by Topager, an enterprise located in Paris that has the mission of grappling with urban environments' constraints in order to practise agroecology.

Launched in 2013, Topager does research, plans the design, implements and maintains urban edible vegetal projects and wild plants (for pollinators, among others). They also offer training and facilitating services on various subjects related to urban agriculture. In order to make the city of Paris -- and its roofs -- more sustainable, Topager's objective is to develop a social and circular economy around their project, whether it be through the recovery of urban waste, professional reintegration, education, etc. In 2019, Topager had 19 employees. This enterprise has implemented over 60 projects since it was launched.

In 2016, in response to ParisCulteurs' call for projects,⁴ Topager was the enterprise chosen to green the Opéra Bastille roofs. The "Opéra 4 saisons" combines ecological farming processes that promote biodiversity.

⁴ The ParisCulteurs program is a call of for proposals driven by Paris's town hall that makes it possible to develop the place of nature in the city, to help new farmers emerge, to create social links, jobs and to build awareness on eating well.

Production

The farm produces fruits (blackcurrants and other berries), vegetables (zucchini, patty pan squash, onions, etc.) edible flowers and microgreens on a surface of 1,200 m² on a roof with a total surface of 2,500 m². The farm grows between 6,000 kg and 8,000 kg of produce per year.

Crops grow directly in the soil and are divided on 4 terraces. Because of the tunnels used to extend the seasons and of the relatively mild weather conditions in Paris, Topager produces its fruits and vegetables year-round. Besides the rooftop production, Topager maintains 300 m² of hops growing on the walls of the Opéra that they process in order to produce 50 litres of beer per year, a production that Topager would like to increase in the coming years.

Table 2. The growth surface of the various sections of the garden on the Opéra Bastille.

Farm	Roof surface (m²)	Plant bed surface (m²)	Berry surface (m²)	Hops surface (m²)
Opéra Bastille	2,500	1,000	200	300

Topager has recently launched "Les Jardiniers de l'Opéra" an organization that will allow the Opéra employees and other persons to come and help them as volunteers on the project and/or participate in workshops. Beehives are positioned on some of the Opéra's terraces, but they are not operated by the Topager team, as they prefer to focus on wild pollinators and other auxiliary species in installations.

Distribution

The Opéra roof crops are mainly distributed in weekly baskets to the Opéra employees and to some of the neighbourhood residents. Edible flowers as well as microgreens are sold to gourmet restaurants and retailers of the area. The beer brewed with the hops growing at the Opéra is distributed to some of Topager's customers.

Services

Topager also offers consultation, design, construction, and maintenance of the installation with numerous green roof projects. The enterprise is currently testing various complementary service models for the *Opéra 4 saisons* project, such as terrace visits and the running of workshops. This would allow the project to diversify its activities and reach a better financial balance.



Hops growing on the Opéra, credit: Giovanni Del Brenna

Economic model

There is an average of 1.5 paid employees and interns who work on the project on a yearly basis. During work peaks in busy seasons, the number of employees can increase.

Revenues mostly come from the sales of the agricultural production, mainly thanks to the baskets that are delivered to the Opéra employees. The sale of products with strong added value (edible flowers and microgreens) as well as the roof visits earn less than half of the revenue from the production for the baskets. The brewery income is at this time symbolic considering the small production. It is, however, an activity that they wish to explore and develop in the coming years. The enterprise thinks that it should reach a breakeven point by 2021, with the diversification of its revenues.

In order to adapt the roof and buy the necessary farm equipment, an amount of \$515,000 (€350,000) was invested, \$75,000 of which came from Topager.

FERME EXPERIMENTALE - LABORATOIRE SUR L'AGRICULTURE URBAINE DU PALAIS DES CONGRÈS DE MONTRÉAL



Laboratoire sur l'agriculture urbaine du Palais des congrès de Montréal,
Credit: Palais des congrès de Montréal

This project is led by AU/LAB (Laboratoire sur l'agriculture urbaine) and the CRETAU (Carrefour de recherche d'expertise et de transfert en agriculture urbaine) which is a project of AU/LAB. AU/LAB is a not-for-profit organization that has the mission of documenting and facilitating the development of urban agriculture and environmental services that can be offered to cities.

Created in 2011, the rooftop farm project of the Palais des congrès was taken over by AU/LAB and CRETAU in 2016 in order to become an experimental farm. This project encompasses a vegetable production area in bags and containers, an urban vineyard, a vertical production space on felt and a research space where the vegetable production is made in geotextile bags.

Production

The farm produces a large variety of vegetables (zucchinis, tomatoes, bell peppers, hot peppers, eggplants, etc.), fruits (ground cherries, strawberries, red currants, etc.) of edible flowers and of herbs (basilica, parsley, shiso/perilla, sage, etc.) from May to October on a total surface of about 2,000 m².

There are also two beehives on the site, but they are managed by an organization not involved in the vegetable growing project.

Distribution

The Palais des congrès de Montréal rooftop crops are mainly sold to a caterer who has exclusive rights on them. Part of the production is bought by the restaurant owners and some productions (herbs, edible flowers, herb tea herbs and strawberries) are commercialized under the “Récoltes de ville” brand.

Services

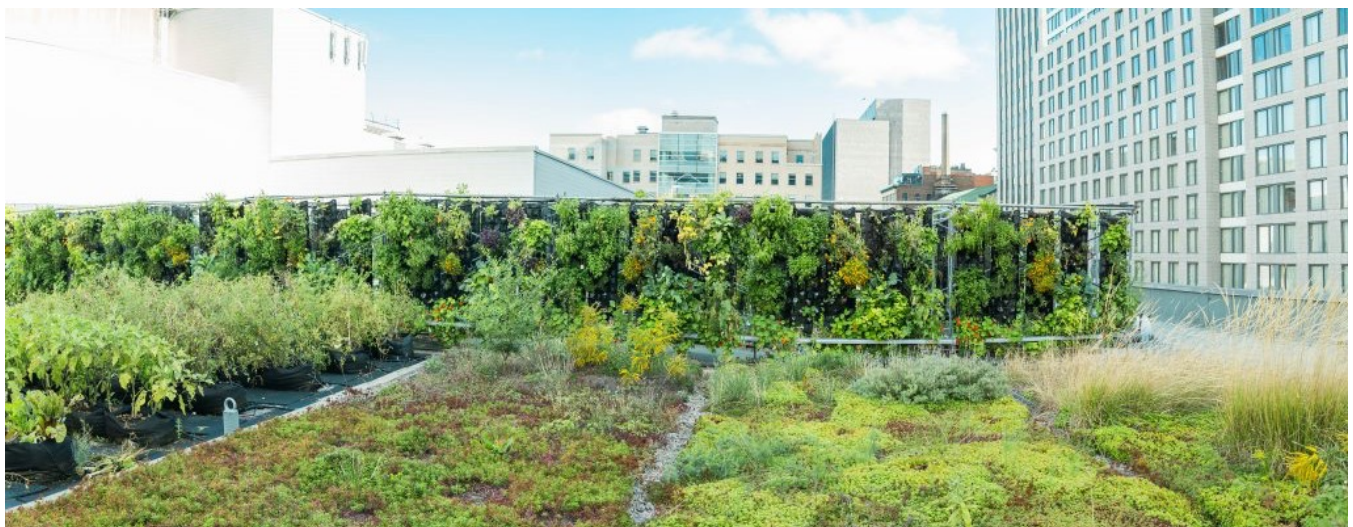
AU/LAB hosts congress participants from the Palais des congrès de Montréal who ask for a visit during the discussion between the congress organizers and the Palais. AU/LAB offers visits and sometimes organizes events on the roof in order to optimize its business model. Specialized training is also implemented and this kind of activity is likely to be developed and to grow in the coming years.

Economic model

There is an average of 3 paid employees and interns who work on the various projects that are part of the Laboratoire sur l’agriculture urbaine du Palais des congrès de Montréal. During some periods of the year, volunteers contribute important help to the team.

The revenues are mainly linked to an annual agreement with the Palais des congrès caterer as well as events and training sessions. Carrying out of funded research greatly helps the project’s management and development.

Since 2011, the vast majority of material investments has been made by the Palais des congrès de Montréal. AU/LAB has invested in specific infrastructure such as the vertical production project set-up and the urban vineyard.



Vertical and container (on the left) production,
Credit: Palais des congrès de Montréal

ECONOMIC ANALYSIS

BASIS OF THE ECONOMIC STUDY

This economic study⁵ of outdoor rooftop farms is based on 5 cases for which we have obtained detailed set-up costs (in 4 cases) and operation costs as well as the revenues generated by the production part of the projects (in 4 cases). The 5 cases are comparable in terms of farming methods⁶.

Table 3. Characteristics of the cases used in this fact sheet.

	Roof installation type	Surface (m ²)	Marketing	Site
Case 1.	300-litre long bags, covering 0.72 m ²	1,000	No sales in 2019	Project implemented on an existing building
Case 2.	75-litre round bags, covering 0.2 m ²	510	Sale to restaurants	Project implemented on an existing building
Case 3.	30-litre bags	2,500	Sale of baskets and to restaurants	Project implemented on an existing building
Case 4.	Intensive green roof 1	2,200	Sale to stores (95%) and markets (5%)	Project implemented during building construction
Case 5.	Intensive green roof 2	2,500	Sale of baskets and to restaurants/stores	Project implemented on an existing building

The collected data has allowed us to create projections for different kinds of farms and to get the costs, revenues and human resources needs per m².

⁵ 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 not necessarily a link between this section and the one that presents inspirational cases.

⁶ We have narrowed this economic study to comparable cases, without vertical production installations, which could be the subject of another fact sheet.

IMPLEMENTATION OF A ROOFTOP FARM PROJECT

One of the important elements of outdoor rooftop farming is the installation set-up⁷.

In addition to the time necessary to find a roof that matches the production needs (accessibility, access to water, sunshine, load-bearing capacity, etc.) and the marketing strategy (proximity to points of sale or potential clients), numerous investments are to be planned for so that the roof can be productive.

For a rooftop farm of 2,000 m², the set-up investments vary between \$86,000 and \$410,000 depending on the cases studied.

The choice of an intensive green roof is clearly more expensive than a rooftop farm that uses geotextile bags. However, the first has many advantages such as the protection of the roof's membrane, the building's insulation, a longer useful life of the membrane (many decades) and the ease to grow certain varieties (especially in direct seeding) by using a seeder (mesclun, radish, white turnips, carrots, etc.). The use of geotextile bags, other than a lower cost, offers more flexibility (the roof can be dismantled and moved) and a rapid installation (without the need for specialists). However, this inevitably implies the purchase of new bags that have a useful life of about 10 years.

In a long-term vision, the installation of an intensive green roof is certainly a solution to be valued for a property developer or a building manager, especially during a building construction where the cost of the green roof can easily be internalized. Without counting that such a roof makes long-term savings on energy for heating and air conditioning possible.

It is important to note that the creation of green roofs gives environmental benefits to the city and makes it possible to have positive impacts on living environments.

⁷ The construction planning of the green roof was not taken into consideration here, as we have considered that it was often the property developer or manager's responsibility. In the 4 analyzed cases, all of the costs were assumed by the building owners and not the vegetable growers. Furthermore, this cost is very variable depending on the projects, the roof characteristics, etc. One must generally consider that this amount would be about 6% of the project. We have also not taken into account any roof adaptation costs for the same reason. If the roof is not ready to receive a project, it simply cannot be adapted without major investments.

Table 4. Installation cost of rooftop farms

	Equipment	Roof surface		Cost (\$/m ²)
		1,000 m ²	2,000 m ²	
Case 1				
	Long Bed bags (0.74 m ²)	\$20,000	\$40,000	
	Irrigation (equipment)	\$3,000	\$6,000	
	Installation time (bags)	\$3,000	\$6,000	
	Installation time (irrigation)	\$700	\$1,400	
	Engineer to evaluate the structure	\$3,000	\$3,000	
	Access to water	\$500	\$500	
	Soil	\$14,000	\$28,000	
	Crane truck	\$750	\$1,000	
	Access to electricity	\$500	\$500	
	Total	\$45,450	\$86,400	\$45.5/m ²
Case 2				
	Round bags (20 gallons - 0.2 m ²)	\$40,000	\$80,000	
	Irrigation (equipment)	\$4,000	\$7,000	
	Installation time (bags)	\$3,000	\$6,000	
	Installation time (irrigation)	\$700	\$1,400	
	Engineer	\$3,000	\$3,000	
	Access to water	\$500	\$500	
	Soil	\$14,000	\$28,000	
	Crane truck	\$750	\$1,000	
	Access to electricity	\$500	\$500	
	Total	\$66,450	\$127,400	\$66.4/m ²
Case 3				
	Intensive green roof (23 cm)	\$108,000	\$216,000	\$108/m ²
Case 4				
	Intensive green roof (20 cm)	\$204,000	\$408,000	\$205/m ²
HYPOTHETICAL CASES- BASED ON STANDARD ESTIMATES FOR THE SET-UP OF INTENSIVE GREEN ROOFS				
	Intensive green roof (soil depth 23 cm)	\$130,000	\$260,000	\$130/m ²
	Intensive green roof (soil depth 30 cm)	\$180,000	\$360,000	\$180/m ²

REVENUE FROM A ROOFTOP FARM'S PRODUCTION OF VEGETABLES

Many elements will influence the revenue earned from the production of vegetables, including agronomic and horticultural skills, the type of production and detailed knowledge of the space constraints.

Revenue per m² starts at \$11.5 and goes to over \$25. In the collected samples, the case with the highest ratio earns a large part of its revenues from the production of mesclun.

Table 5. Revenue from the production of vegetables of a rooftop urban farm and work intensity for the operation.

Rooftop farms			
Revenues		Can\$	\$/m²
CASE 1 - CASE 3	Roof - bags	5,980 to 30,000	11.5 to 15.1
CASE 4 - CASE 5	Intensive green roof	33,800 to 60,000	13.5 to 27.3
Work time		Total hours	Hours/m²
CASE 1 - CASE 3	Roof - bags	728 to 2,000	0.8 to 2.9
CASE 4 - CASE 5	Intensive green roof	2,760 to 4,800	1.2 to 1.9
Biointensive farming in urban soil¹			
Revenues (Can\$)		1,800	\$1.5/m ²
Work time (total number of hours)		24,600	20.5 hours/m ²
Biointensive farming in rural soil²			
Revenues (Can\$)		100,000	\$10.0/m ²
Work time (total number of hours)			0.75 hours/m ²

Legend: ¹ Dayez et al. (2018), Le maraîchage agroécologique professionnel, sur petites surfaces en zones (péri-) urbaines, 108p., [online] : URL : http://www.cocreate.brussels/IMG/pdf/recueil_version_ecran.pdf

² Anne Le Mat, 2017, Analyse technico-économique en maraîchage biologique diversifié, Résultats et perspectives de l'analyse de groupe, CETAB+, [online] : URL

https://www.cetab.org/system/files/publications/cetab_2017_analyse_technicoeconomique_maraichage_annele_mat_stremi.pdf

WORK TIME TO OPERATE A ROOFTOP FARM

The work intensity necessary to operate a rooftop farm is also a key to success. In the analyzed cases, there are big differences. Two of the analyzed cases have a ratio of close to or slightly over 2, meaning that the amount of work time is higher by m² of culture. The first case can be explained by a small project (< 550 m²) with employees in professional integration (subsidized salary) and where the number of work hours is too high in relation to the tasks to be carried out. The second case illustrates an enterprise in its first year of existence working to build a business brand and a reputation (i.e. develop its market). When we have data for 2 years, we observe that they double. This difference can be explained by a human resources choice, compensated by professional integration wage subsidies.

ASSESSMENT OF THE ECONOMIC VIABILITY OF A ROOFTOP FARM

Currently, if an urban producer relies only on the production of fruits and vegetables for revenues, the viability of their rooftop farm is still very precarious. In the studied cases, only one producer would succeed according to our projections, to generate an annual profit only thanks to its agricultural production. This case (4) is the one that generates the most revenue per square metre (\$27.3/m²), with a high intensity of work (1.2h/m²). However as mentioned by the project leaders, the model is precarious and additional expenses (inputs, seeds, rent, loss of crops because of pests, etc.) can easily make it unprofitable in such a prospective.

For the other projects, none generates profits only through their agricultural production. However, this does not mean that the enterprises are not profitable as is shown by the Brooklyn Grange example, which are rooftop producers with diversified economic models. In the projects mentioned above, case 4 generated \$20,000 in additional revenues and case 5 generated \$3,000 from visits or country-style meals (see table 7). As for case 2, the revenues related to the site visits netted around \$1,500 annually and it earned around \$11,500 in support from the building manager.

This estimation shows that the urban producers must be more than farm operators. They also need to benefit from the opportunities that are brought on by the proximity of an important pool of people and must be actors of the city by developing a service offer.

THE KEYS OF SUCCESS FOR ROOFTOP PRODUCTION

A rooftop farm requires an economically valued production on a small surface. The 4 rooftop farms of this study, for which we have economic data, show that a minimum revenue of \$20/m² per year should be aimed for as production revenue in a business plan.

In the same manner, work intensity should be of about 1.5 h/m², or about 3,750 hours for a vegetable roof of 2,500 m². Some resources must be subsidized or some of the work must be carried out by volunteers; which is what is found in the majority of urban farms and small farms in suburban or rural areas. In order to have a low work intensity (the number of hours worked per m²), market access must be as simple as possible as it is generally a task requiring lots of time and human resources for transport and sales (e.g. being on-site at a booth).

In order to reach these two goals, a minimal surface is critical for the projects (we currently estimate it at 2,000 m² of growing surface) in order to avoid the need to travel between numerous sites. Furthermore, it is essential to create a steady team of vegetable growers/horticulturists and be able to structure/organize their tasks and their work schedule.

Finally, we note that it is difficult for a rooftop farm to develop a viable economic model based on the sole production of fruits and vegetables.

Table 7. Estimation of the viability of rooftop farms, based on the production of fruits and vegetables.

		Surface (m²)	Sales revenues from farm products (Can\$)	HR¹ operation costs (\$/year)	Small equipment cost (\$/year)²	Profit or deficit of vegetable production (\$/year)	Other declared revenue sources (\$/year)	Profit or deficit of project (\$/year)
Case 2 (2018)	Roof - bags	520	5,980	10,920	1,750	(6,690)	16,000	9,310
Case 2 (2019)	Roof - bags	520	7,850	22,965	1,750	(16,865)	15,000	(1,865)
Case 3	Roof - bags	2,500	30,000	30,000	8,000	(8,000)	Not calculated	--
Case 4	Intensive green roof	2,200	60,000	41,400	8,000	10,600	20,000	30,600
Case 5	Intensive green roof	2,500	33,800	72,000	6,500	(44,700)	(Being developed)	--
	Biointensive mfarm in urban soil ³	1,200	24,600	27,000		(2,400)	--	--

Legend: ¹This cost estimate for human resources is based on a \$15/h salary, ²This annual cost is an estimate and includes compost, seeds, stakes and other equipment. This estimate is attributed linearly commensurate with the growing surface, ³Dayez et al. (2018)

KEY ELEMENTS FOR ECONOMIC VIABILITY

Do not base the economic model solely on production. It is vital to diversify revenue sources with workshops, events, country-style meals, etc.

Cover part of the human resources needs through the involvement of volunteers or get support from government programs to financially support the jobs.

Get support through environmental service programs offered through the rooftop farm.

There is a need to target a strong value-added production and to consider the option of processing into niche products with strong branding.

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