Impact of Subsidized Urban Farming on Food Shortage and Air Quality

By Patrick Tuttle, Blaija Djimbi, Kamil Krsyed

Writing for Engineering

Instructor: Thomas Barber

The City College of New York

Fall 2018

Table of Contents

Abstract

In terms of population and number of buildings, New York City is one of the most densely populated cities in the world. Additionally, there is a shortage of produce across the globe. A vast majority of the rooftops of the buildings are not utilized in any fashion. Our solution is to use the rooftops as locations for the growth of various crops and produce. Not only will the crops mitigate the food shortage in New York City, they will also improve air quality.

Introduction

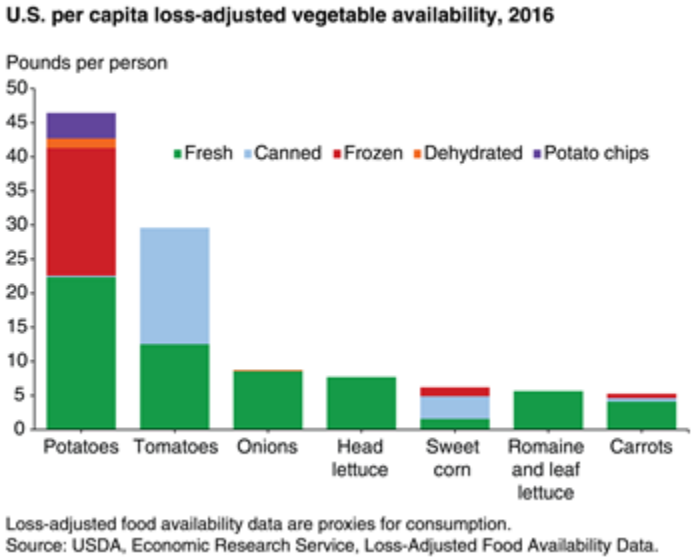
As of November 26, 2018, world population is over 7.6 billion and increases at an annual rate of 1.09 %, or roughly 76 million people per year [1]. As population continues to rise, the demand for food, housing, and population density increases while the available food, land, air quality and other resources decline. Additionally, more urbanization will result due to further population growth. According to a report done by the Food and Agriculture Organization (FAO) of the United Nations, by 2050, global population will exceed 9.1 billion, 70% (compared to 49% today) will be urban, which will greatly increase the demand for food [2]. For example, the FAO estimates that meat production will be increase by 200 million tons annually and crop demand will increase by 70% in the next thirty years [2].

In the United States in 2015, potatoes, tomatoes, onions, head lettuce, carrots, sweet corn, and romaine/leaf lettuce were the most consumed vegetables per capita [3]. Although a large percentage of vegetables are consumed annually in the United State, the USDA estimated nearly 70% of Americans do not consume the required daily amounts of vegetables [4]. In fact, a 2010 study in the American Journal of Preventive Medicine estimated vegetable supply in the U.S. would need to increase by 70% for every individual to meet the daily requirement [4].

In terms of population, New York City is the largest U.S. city and 9th largest city in the world [5]. NYC's five boroughs (Queens, Manhattan, Brooklyn, the Bronx, and Staten Island) is also home to over 1 million buildings [5]. New York state is in the Top 10 nationwide in producing cabbage, snap beans, cauliflower, squash, onions, sweet corn, pumpkin, and cucumbers [3] . Of the most consumed vegetables per capita in the U.S., New York is a major producer of only 2--onion and sweet corn; however, New York contains the U.S.'s largest city and is the 4th largest state [3]. This means that most vegetables consumed in New York City are imported. If measures are not taken to improve air quality, combat world hunger by increasing food supply, and if space, overall, is not utilized better, malnourishment will continue to rise, global temperatures will continue to rise, and population density could exceed its line of demarcation.

Urban farming utilizes pre-existing buildings or structures to grow crops. The building or structure must have a flat rooftop and able to support the excess weight of the fabricated farming structure and needed equipment. This project is a collaboration between the City of New York and a non-profit organization, OFOA (Organic Farmers of America). Owners of the qualified building(s) will receive an annual tax credit as payment. Urban farming will help increase the crop supply, air quality (NYC is the 10th worst in the U.S.[6]), and number of jobs in New York City. An estimated 40-50% of NYC buildings (400K-500K) are eligible for farming.

Figure 1: 2016 U.S. Per Capita Vegetable Consumption [3]



Plan of Work

Phase 1: Passing Legislation for Public Approval

The OFOA and New York State will draft a bill to be voted upon that will require eligible building owners to give access to their building for urban farming use. None of the costs associated with the project's foundation or maintenance will be the responsibility of the owner. In fact, building owner's utility costs will be subsidized by the city and each owner will receive a tax credit proportional to the size of their building.

Phase 2: Determination of Eligible Buildings

To determine which of the 1 million buildings in NYC are eligible, an independently contracted group of civil engineers will analyze building plans/blueprints and conduct various load-bearing studies. In addition to the load-bearing study, the engineers will determine the best method for roof access (the use of pre-existing stairways or fabricating access). Patrick, Blaija, and Kamil, along with the City of New York, will create and discuss contracts and access

stipulations with the building owners. The totality of determining eligible buildings will take 10 years; however, Queens will be the initial target area. During the construction period and urban farm implementation in Queens, the other out boroughs of Brooklyn, The Bronx, and Staten Island will be sequentially analyzed, and eligible buildings will be approved. Finally, Manhattan will be studied. The sequential study and implementation of the boroughs should streamline the process and minimize capital costs because the contracted engineering group and construction company will roll into the other borough upon completion of the previous borough.

Phase 3: Planning and Construction

In conjunction with the engineers analyzing the eligible buildings, a construction team will be formed, and training will commence. Two teams for construction will be formed, climate-controlled facility fabricators and unregulated farming fabricators, which will be discussed in more detail below. Additionally, expert farmers will help form a plan for planting, maintaining, and harvesting the respective crops. These farmers will function as consultants for the hired farmers. Urban farmers from Singapore, where urban farming has been performed for several years, will be consulted to help find and mitigate unforeseen issues.

4. Farming and Distribution

Although the scope of the project is large, the building density will be exploited and will minimize the worker requirement. Part of the planning will include an overestimation of the number of workers needed. The farmers will oversee multiple structures based on proximity of location. Data will be collected and analyzed to determine if future farming iterations require more, or fewer, workers for a given area. Additionally, air quality data will be collected and monitored to determine if the plants have a quantifiable positive effect on the local ecosystem.

Since this is a New York City funded project, New York City residence and buyers will be highly prioritized in terms of hiring and the sale of goods. All produce will be sold locally. If a surplus of goods arises, states in the most need of the produce will have priority to purchase them. All produce will be pesticide free and organically farmed.

Urban farming will consist of two farming classifications: 1. Climate controlled organic farming and 2. Unregulated, or natural organic farming.

1. Climate controlled

   A climate regulated housing unit, such as a greenhouse, is required for temperature and weather sensitive crops, such as fruits, seasonal vegetables, etc.

   2. Unregulated

   The crops that can grow in New York's natural elements will not require any housing or climate control. They will be open to the elements of nature; however, irrigation and drainage systems will be provided to ensure proper hydration.

Table 1: Data to Be Collected During Duration of Project

Air Quality	Year 2	Year 4	Year 6	Year 8	Year 10
PPM CO2					

Timeline

Implementation of urban rooftop gardens in the City of New York is a big scope project as there are approximately 1 million buildings in the city. It is estimated that completion of this project will take approximately 11 years.

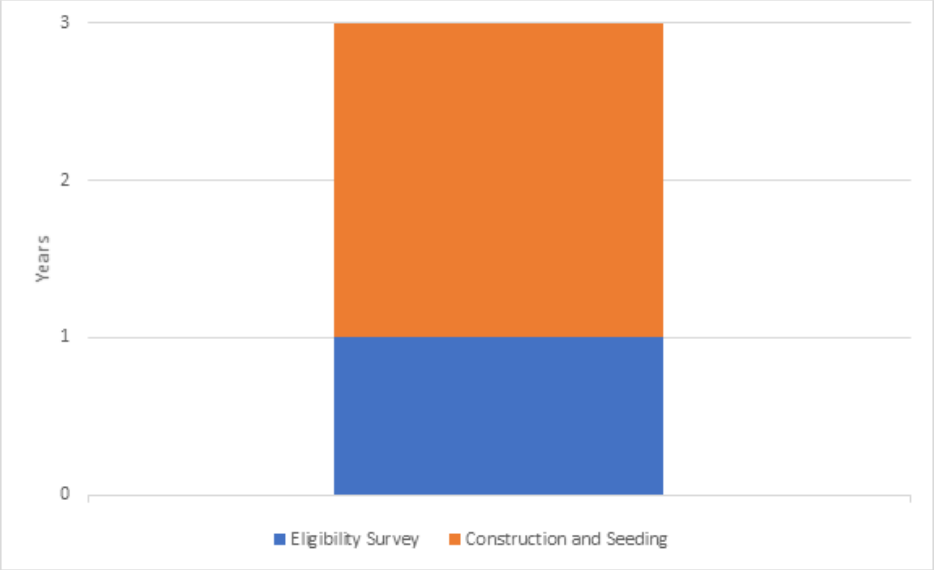
The most important phase of this project is the passing of legislation for public approval. Once the bill is approved, the sequential implementation of the process will commence.

It will take 11 years for the 5 boroughs of the City of New York to complete the construction. After discussing the process with our contracted group of civil engineers, we concluded that the teams will complete their survey for determination of eligible buildings in a single borough in 1 year. Construction will begin immediately after the completion of survey. In the meantime, teams of civil engineers will commence their survey and studies for next borough. Construction of the structure needed for farming, and seeding will take almost 2 years for 1 borough to complete.

Table 2. Timeline for completion of Urban Gardens

	Jan 2018 to Jan 2019	Feb 2019 to Feb 2021	Mar 2021 to Mar 2023	Apr 2023 to Apr 2025	May 2025 to May 2027	Jun 2027 to Jun 2029
Eligibility Determination	Queens	Brooklyn & Bronx	Staten Island & Manhattan			
Construction of structures and seeding		Queens	Brooklyn	The Bronx	Staten Island	Manhattan

Figure 2. Duration of work in each borough of the City of New York



Budget

Costs associated with rooftop garden are very high and represent around 20% to 30% more than to install a traditional roof, which is calculated per square foot. Among the biggest challenges associated with installing a subsidized garden to an urban garden are the costs related to the installation and maintenance, which are around $10 per square foot for a simple garden and $25 per square foot for an intensive garden.

Installation

The installation of a green rooftop or subsidized garden is mostly accomplished following many steps which are crucial and quite expensive.

1.Waterproofing:

Waterproofing is necessary for a roof that has leaks in it or to prevent leaking. A roof sealant creates a waterproof barrier that keeps out rain and melting snow. The actual price of a roof sealant depends on the structure of the roof, the product used, the local economy and the complexity of the installation. In New York City, one gallon of sealant might cost $15 to $30 per gallon and covers an area of 100 to 150 square feet. For 1,500 square feet roof, a material cost of $250 to $300 is required and the average costs for the installation of a sealant is between $1,000 to $2,500 [7]. The salary of engineers responsible for the installation of the system goes up to $ 26,276 per year.

2. Insulation layer:

Used to protect the building from moisture and temperature fluctuation. The average cost per square foot is between $0.64 and $1.19. For example, a 500 square foot area, your estimate will vary between $145 to $200, if you do it yourself. For a professional job, add between $150 to $300 for labor, and you are looking at around $300 to $500 for 6 hours of work [8]. An insulation worker is paid averagely $14.95 per hour and work at least 50 hours a week [7].

3. Drainage layer:

It evacuates the excess water or any other liquid into a drainage system. To install a drainage and protection layer on green rooftop, an amount between 20 to 30 dollars per meter square will be needed[9]. Therefore, the average cost of installing a drainage layer along a building rooftop is highly dependent to the dimensions of that rooftop--width and length. Also, the size of a rooftop building is often the sum of multiple apartments size. In 2010,the average size of an apartment floor in the United States is 2,392 square feet

[10] and 700 square foot or less size in New York [9]. Based on [9], for a rooftop of a size of 10 apartments which equals to 7,000 square foot, the average costs to install a drainage layer would have cost around $245,000. Each employee works at 45 hours a week and earns between $58,398 to 76,812.

4. Geotextile layer:

It creates a separation between oil and drainage layer. The average price for a prefabricated geotextile layer lies between $7.50 to $10.00 per meter square [10]. Using our estimated average of an apartment size in [9] and a rooftop with an area of 7,000 square foot, it requires around $6,503.215 to install a conventional geotextile layer. It important to notice that the cost of installing a geotextile could skyrocket based on the quality and/or nature of the geotextile layer.

5. Vegetation layer:

The vegetation layer helps to absorb rainwater, provide insulation, provide habitat for wildlife, increase the benevolence[11], lower urban air temperature and mitigate the heat island effect[12], etc. The installation of a properly designed vegetation layer can cost $180 to 240 per meter square which represents $10 to 23 per square foot, this includes soil, and root barriers. Also, the replacement of a green rooftop constitutes one third of the installation cost [13]. An intensive rooftop also known as rooftop garden is suitable for almost any variety of vegetables or plants. In the state of New York seed potatoes prices can reach up to $6.5 per 1 pound--based on the variety of the potatoes. On average 1 pound of potato seeds is needed to grow 10 feet of potatoes [14], therefore, it will require around $ 45,500 to plant potatoes on a 7,000 square foot building. Using the

same approach, planting tomatoes on 7,000 square foot rooftop can cost up to $140,000 and produce twice more than potatoes per 10 feet.

Extra expenses and maintenance costs

On average, engineers who install layers, draining system and all other compartments of a green rooftop perceive a salary which lies between $59,398 and $76,812 per year[15]--this salary could vary due the qualification of a worker, year of experience and so on. The maintenance of green rooftop costs around 0.75 cents per square mile which is close to $5,250 for a rooftop like the one given in [9]. Added to these costs mentioned above, the cost related to system of transportation, parking spot which add up to an amount between 335,000 and 464,000 [16]. This amount is reduced to a third for the replacement of green rooftop which normally happen every 30 to 50 years.

Qualifications

Dr. Patrick Tuttle received his Chemical Engineering Degree from The City College of New York and PhD from The Ohio State University in Urban Development. He currently serves as the President and CEO of the OFOA.

Kamil Syed received his Bachelor's in Construction Engineering from The City College of New York and master's from Columbia University. He currently serves as the COO of the OFOA

Blaija Djimbi received his Bachelor's in Mechanical Engineering from The City College of New York and master's from Columbia University. He currently serves as the CFO of the OFOA.

Reference List

1) Worldometers. http://www.worldometers.info/world-population/, last accessed 12/4/2018
2) How To Feed the World in 2050, FAO, http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf, last accessed 12/4/2018
3) Food Availability and Consumption, USDA, https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/food-availability-and-consumption/, last accessed 12/4/2018
4) T. McMillan, The U.S. Doesn't Have Enough Of The Vegetables We're Supposed to Eat, September 19, 2015, https://www.npr.org/sections/thesalt/2015/09/19/441494432/the-u-s-doesnt-have-enough-of-the-vegetables-were-supposed-to-eat, last accessed 12/4/2018
5) The World's Largest Cities and Urban Areas in 2020, City Mayors Statistics, http://www.citymayors.com/statistics/urban_2020_1.html, last accessed 12/4/2018.
6) Buildings, NYC Government, https://www1.nyc.gov/assets/sirr/downloads/pdf/Ch4_Buildings_FINAL_singles.pdf, last accessed 12/4/2018.
7) https://www.improvenet.com/r/costs-and-prices/membrane-roofing
8) https://www.costowl.com/home-improvement/roof-sealant-cost.html
9) https://www.improvenet.com/r/costs-and-prices/spray-foam-insulation-cost-estimator
10) https://www.platinumpropertiesnyc.com/blog/average-nyc-apartment-sqft-how-much-is-enough
11) https://www.tencategeo.us/media/f8b7f6ed-d355-4090-9c86-9af3b245ef24/VEylqg/TenCate%20Geosynthetics/Documents%20AMER/Industry%20Papers/2014-%20Cost%20Savings%20By%20Using%20Geosynthetics%20In%20The%20Construction%20of%20Civil%20Work%20Projects.pdf

12) "Benefits of Green Roofs". *www.greenroof.hrt.msu.edu*. Retrieved 2018-11-01.

13) Vandermeulen, Valerie; Verspecht, A.; Vermeire, B.; Van Huylenbroeck, G.; Gellynck, X. (November 30, 2011). "The use of economic valuation to create public support for green infrastructure investments in urban areas". *Landscape and Urban Planning*. **103** (2): 198–206. doi:10.1016/j.landurbplan.2011.07.010. Retrieved 28 February 2014.

14) Sproul, Julian; Wan, Man Pun; Mandel, Benjamin H.; Rosenfeld, Arthur H. (March 2014). "Economic comparison of white, green, and black flat roofs in the United States". *Energy and Buildings*. **71**: 20–27. doi:10.1016/j.enbuild.2013.11.058. Retrieved 27 February 2014.

15) https://www.homesteadingtoday.com/threads/cost-of-seed-potato.478960/

16) https://www1.salary.com/NY/New-York/Plumber-salary.html