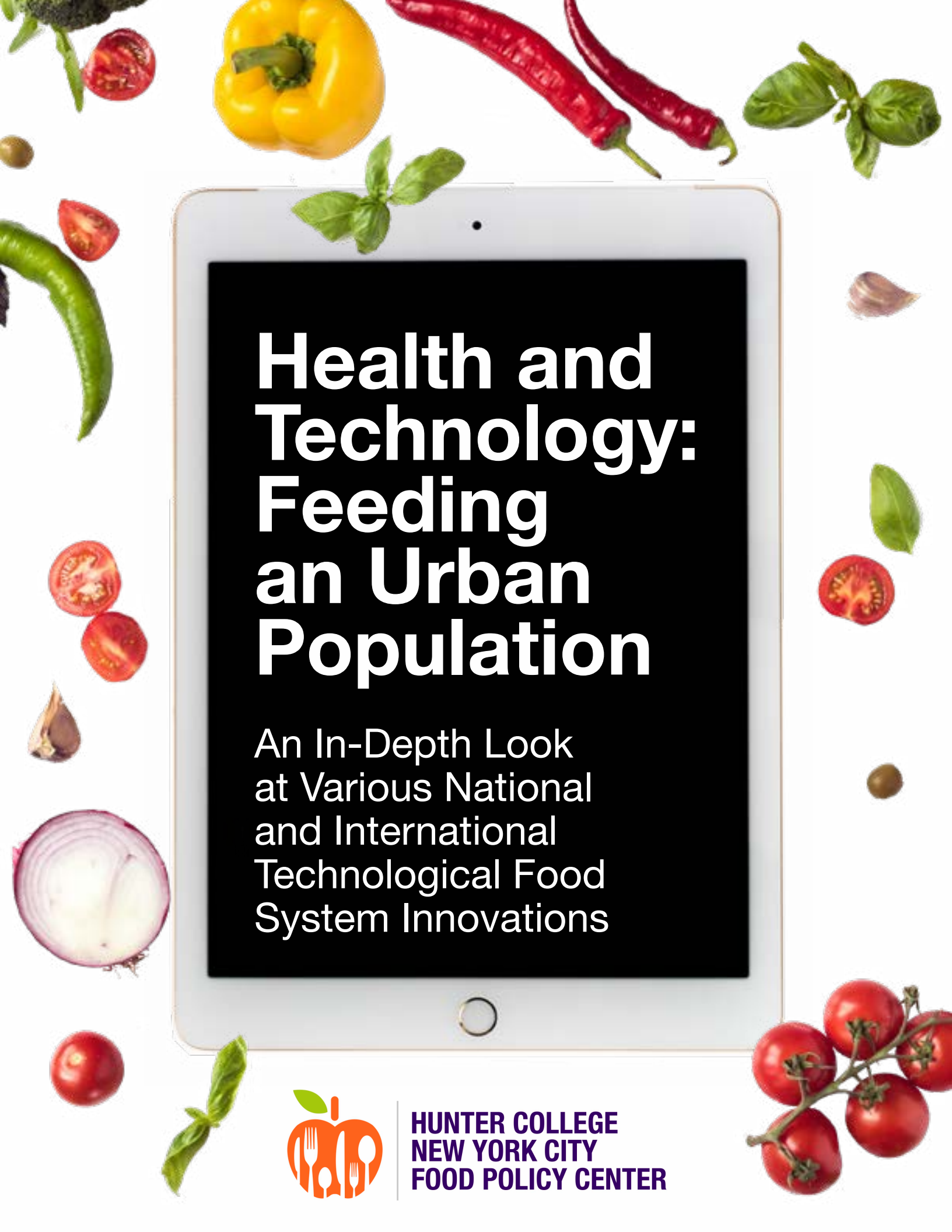


Health and Technology: Feeding an Urban Population

An In-Depth Look at Various National and International Technological Food System Innovations

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Suggested Citation:

Link A, Platkin C, Kwan A, Cather A, Lindstrom L. Health Tech & Feeding an Urban Population. Hunter College New York City Food Policy Center, Hunter College, 2018.

Available at: http://www.nycfoodpolicy.com/feedinganurbanpopulation

Table of Contents

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Credit: Aero Farms

About These Reports

About the Hunter College New York City Food Policy Center

The Hunter College New York City Food Policy Center develops intersectoral, innovative and evidence-based solutions to preventing diet-related diseases and promoting food security in New York City and other urban centers.

The Center works with policymakers, community organizations, advocates and the public to create healthier, more sustainable food environments and to use food to promote community and economic development. Through interdisciplinary research, policy analysis, evaluation and education, we leverage the expertise and passion of the students, faculty and staff of Hunter College. The Center aims to make New York City a model for smart, fair food policy.

Goals

The goal of this report is to inspire readers — including academics, researchers, community-based organizations, funders, social entrepreneurs, policymakers, government agencies and others involved in the food movement — to think about innovative, technological ways to overcome the challenges facing the food system, including food insecurity (i.e., hunger), access to healthy food, food waste, food safety and food-related chronic diseases. By describing the ways that technology has been used to find new solutions to long-standing food system problems and by identifying areas where technological development is lagging, the Hunter College New York City Food Policy Center hopes to also encourage those in the tech industry to partner with food system influencers to drive increased innovation in this important sector.

This report focuses on the food supply chain and is the second in a series of five reports the Center will release over the next six months. The first report on Food Insecurity is available here. Subsequent topics include: Food Waste; Food Safety; and Nutrition and Diet-Related Chronic Diseases.

Because the Center's focus is New York City, these reports highlight challenges faced by urban food systems. However, the reports provide examples from a varied set of technological food system innovations nationally and internationally as well. Food system challenges specific to countries that are primarily rural are outside the scope of these reports.

The goal of this report is to inspire readers to think about innovative, technological ways to overcome the challenges facing our food system

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Methodology

This review was conducted by triangulating searches for food- and technology-related keywords across Google Scholar, Google and PubMed between July and November 2016. The research team met to discuss potential search terms and reach consensus. Of note, given the rapidly changing nature of the tech world, articles published in 2012 or later were prioritized, and in some cases, secondary sources, such as newspaper articles, were the only sources of available information about an app other than a product's website.

Search terms:

- Food system–related search terms included: *food; nutrition; food system; food policy; food insecurity; food security; food assistance; food bank; food pantry/pantries; EBT; SNAP; WIC; agriculture; urban agriculture; food desert; food hub; food logistics; farmers' market; grocery; food waste; food recovery; food safety; obesity; weight loss; meal planning; diet tracking; nutrition tracking; nutrition promotion; diabetes; etc.*
- Technology-related search terms included: *technology; mobile; application; internet; online; web; software; mHealth; big data; crowdsourcing; internet of things; sharing economy; social media; Facebook; Twitter; Instagram; YouTube; GIS; smartphone; text messaging; SMS; etc.*

For identified peer-reviewed literature:

- Research manuscripts were reviewed for relevant points including background and outcome data
- Reference lists were reviewed to identify additional sources
- Google Scholar's "cited by" feature was used to review citations from other peer reviewed journal articles or reviews.

For identified apps, websites and other forms of technology:

Apps and websites were evaluated to identify key features and review basic usability; whenever possible, team members downloaded and tested the apps

- Google searches for product names helped identify related articles and available outcomes
- Google Scholar searches for product names helped identify any research on a particular app or other technology's feasibility or efficacy
- App store reviews and comments were briefly evaluated
- In some categories, there were numerous apps, many of which were similar; those apps deemed by the research team to have stand-out features, significant reach or a unique draw were highlighted

How to Navigate This Report

This report is intended for audiences with various levels of knowledge about the food system, in all its complexity. Background information about food system issues, controversies, programs and challenges is provided to give context to discussions about existing technologies and the need for future innovation; however, this basic information is likely not necessary for all readers. Please use headings to navigate the report, skipping Background, Research and Statistics sections as desired.

Readers may also use the following icons to jump to sections relevant to their interests:

TECH INNOVATION
Discusses innovative apps or other technology that addresses a food system challenge.

INNOVATION NEEDED
Presents a food system challenge where technological development has been lagging and that could benefit from new ideas and innovation.

LEARN FROM OTHER FIELDS
Highlights technology used by other industries that may be used as a model to address a food system challenge.

For readers unfamiliar with technology terms, phrases and concepts, please see Appendix 1 for definitions and explanations.

Note that the introductory content and food-technology glossary (Appendix 1) are repeated across each report, so those who have read other reports in this series may skip ahead to Part 2.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Technology as a Force for Change

The digital revolution over the past 25 years has transformed the way we communicate, learn, conduct business, purchase goods and obtain information.[1-5] Industrialization, urbanization, and market globalization have led to significant shifts in lifestyle, eating behavior, and food choices worldwide.

Trends in technological innovation have created an insatiable desire for high-tech solutions to daily problems. Modern technology, most of which can be classified as "digital," incorporates the use of software, web and mobile applications, plus devices and hardware that help users complete a task or solve a problem.

Technology can make processes and workflows more efficient in a variety of ways. It can streamline tedious or complex processes, including the collection of data, which can then be used to inform and automate decisions. Furthermore, the design and development of the internet and the creation of networks between individual computers allow billions of users to connect and share information.

Internet access (via a computer, smartphone, tablet, e-reader, etc.) provides an essential means of communicating, connecting, learning and, increasingly, performing day-to-day activities, such as banking, research, shopping and entertainment.

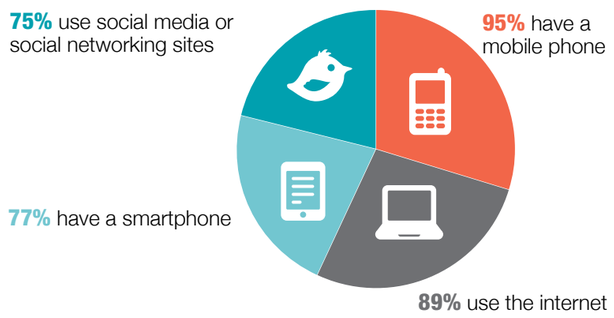
The ability to instantaneously look up information on any comprehensible topic has sparked what many deem an "information revolution."[6]

Current Stats: Mobile Phone, Smartphone, Internet and Social Media Use

Mobile technologies and the internet are becoming increasingly ubiquitous; in **2000**, an estimated **738 million people** used the internet. By **2017**, that number increased almost 5-fold: a total of **3.6 billion people used the internet globally** (2.6 billion of whom live in developing countries).[7]

In the United States, as of 2018:

Adults have high rates of mobile/smartphone ownership and technology usage:[8-10]



Minorities have high rates of smartphone ownership:

77% of Hispanic adults,
75% of non-Hispanic black adults, and
77% of non-Hispanic white adults own a smartphone[9]

Technology is expanding its reach in older populations as well.
Among adults older than 65:

67% use the internet **42%** own a smartphone[11,12]

However, these numbers vary significantly by household income bracket:

94% of seniors with household income of ≥$75,000 use the internet,
46% of seniors with household income of ≤$30,000 use the internet[12]

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

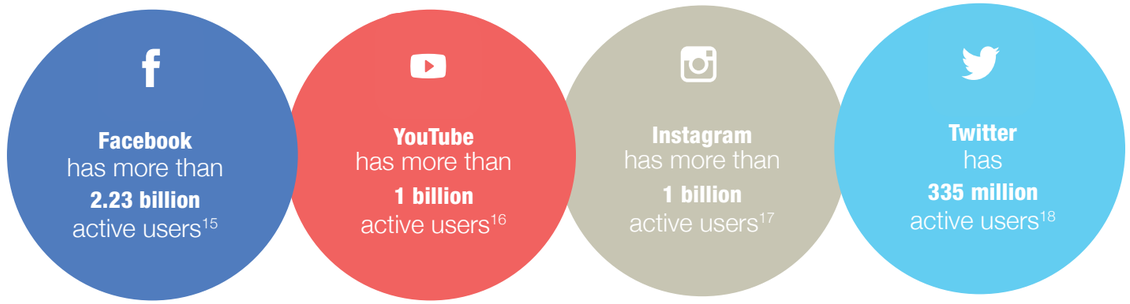
Of individuals who use the internet and smartphones:

72% and **52%**, respectively, have gone online or used their phones to seek health or medical information[11]

Globally, as of 2017

63% of the population use mobile phones[13] **48%** use the internet[7,14]

Social Media Use as of 2018



Smartphone Use in Under-Resourced Populations

With the decreasing prices of smartphones and pay-as-you-go data plans, an increasing number of individuals are using mobile technologies to connect to the internet. In fact, for many Americans, smartphones have become the least expensive way to access the internet.

One in five adults (20%) rely on smartphones as their primary means of accessing the internet and 7% have no alternative for going online, a group referred to as "smartphone-dependent" users by the Pew Research Center.[9]

31% of households earning less than **$30,000 per year** are smartphone-dependent, as are **35%** of Latinos and **24%** of African-Americans.

Of those who are smartphone-dependent:[11]

62% have used their smartphone to obtain information about a health condition
44% have searched for housing options
3% have looked up information about jobs (18% applied for jobs on their smartphone)
40% have used smartphones to look up government services
30% have taken an online class or accessed other educational content

The Lifeline Program:

Providing Phone and Internet Access for Low-Income Americans

As the use of the internet becomes increasingly commonplace, there has been a push by the Federal Communications Commission (FCC) to consider the internet as a public good and utility. **The Lifeline program, which was started in 1985, provides discounted telephone service to low-income households who qualify**.[19] Despite the fact that 84% of adults in the United States use the internet,[10] 20% do not have broadband access at home, and 40% of households earning less than $25,000 a year do not have an internet connection at home. Yet, 70% of schools assign homework that requires using the internet and the majority of jobs are posted online, with an increasing number accepting applications only through the internet.[20]

An FCC vote in March 2016 approved a broadband (internet connection) subsidy of $9.25/month for low-income households and, beginning in December 2016, for households with income at or below 135% of the federal poverty guidelines and/or who are eligible for other public benefit programs such as the Supplemental Nutrition Assistance Program (SNAP), Medicaid, and tribal and veterans benefits.[19]

Companies like Access Wireless, Safelink Wireless and Reachout Wireless provide free phones to those who qualify for the Lifeline program, and offer free plans with a designated amount of talk minutes and text messages per month. These providers do not generally give out *smart*phones, although users have the option to upgrade to a smartphone for a low price and use their free talk and text messaging plan on that smartphone in combination with the Lifeline subsidy, towards a plan with additional data.

Cities are also seeking new ways to extend internet access to more individuals. The LinkNYC program is an innovative initiative by New York City that installs free, fast public Wi-Fi kiosks in defunct telephone booths throughout the city. The kiosks also have charging ports and a tablet with maps and information about city services. These developments are important examples of ways to expand the reach of innovative digital technologies to solve problems experienced by the underserved.

GetCalFresh website

The Current State of Innovation and Technological Development within the Food System

The food system is composed of the entire infrastructure around feeding a population, including growing, processing, distributing, selling, preparing, consuming and disposing of foods. In the United States, the food system contributes nearly $1 trillion to the gross domestic product and food accounts for close to 13% of average household spending.[21]

Unfortunately, many sectors of the food system have been slow to innovate using technology. The history of the Electronic Benefit Transfer (EBT) card illuminates this slow evolution. A system for electronic funds transfer and early models of the debit card were invented in the mid-1960s;[22] yet, the EBT card was not piloted until 1984.[23] EBT cards were not widely adopted until the early 2000s, in response to a 2002 mandate for states to digitize their then long-antiquated paper "stamp"-based model.[23,24]

The food system is influenced by complex logistics, generally low profit margins and entrenched politics that may contribute to the slow pace of innovation. As disruptive technologies revolutionize other industries, the food system often lags behind.

That said, this report and upcoming reports include many examples that demonstrate creative solutions to complex food system issues, and also identify areas where new technological developments are needed.

PART 2.

FEEDING AN URBAN POPULATION:

TECHNOLOGY ACROSS THE FOOD CHAIN

As of 2014, 54% of the world's population was living in cities, and an estimated two-thirds will live in cities by 2050.[25] Furthermore, the global population is expected to grow by over two billion people by 2050.

Urban environments present specific food system challenges inherent in feeding growing volumes of people in densely concentrated regions. Agriculture generally requires large parcels of open land and has been historically incompatible with the urban and suburban sprawl, population density and high land values associated with urban areas, requiring that food be transported into these environments from other areas. Urban food systems are challenged by several central issues: accessibility, affordability, adequacy and availability of food.[26] Many of the same factors that challenge urban food systems, such as population density and lack of space, have led to significant innovation by allowing for niche models to gain rapid success, like meal kits and vertical farming.

The food system at large, and urban food systems in particular, are further complicated by structural and systemic inequalities, including racism and economic injustice. The food justice and food sovereignty movements focus on the broad goals of increasing the amount of food available and improving access to healthy foods for *all* people, and technology-based solutions are generally limited in providing robust solutions to these multi-layered, multi-system problems. In-depth analyses of social, economic and political contributors to food injustices are outside the scope of this report; see the work of Cadieux, Slocum, Gotlieb, Reynolds, Cohen, and Alkon[27-32] for additional context on those topics.

This report describes some of the recent technological advances to address the challenges along the complex layers of the food system, from growing and producing food, to storing and transporting it, to selling food to consumers. Indeed, technological innovation has had an impact along each step of the food supply chain, with tremendous potential for further innovation.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

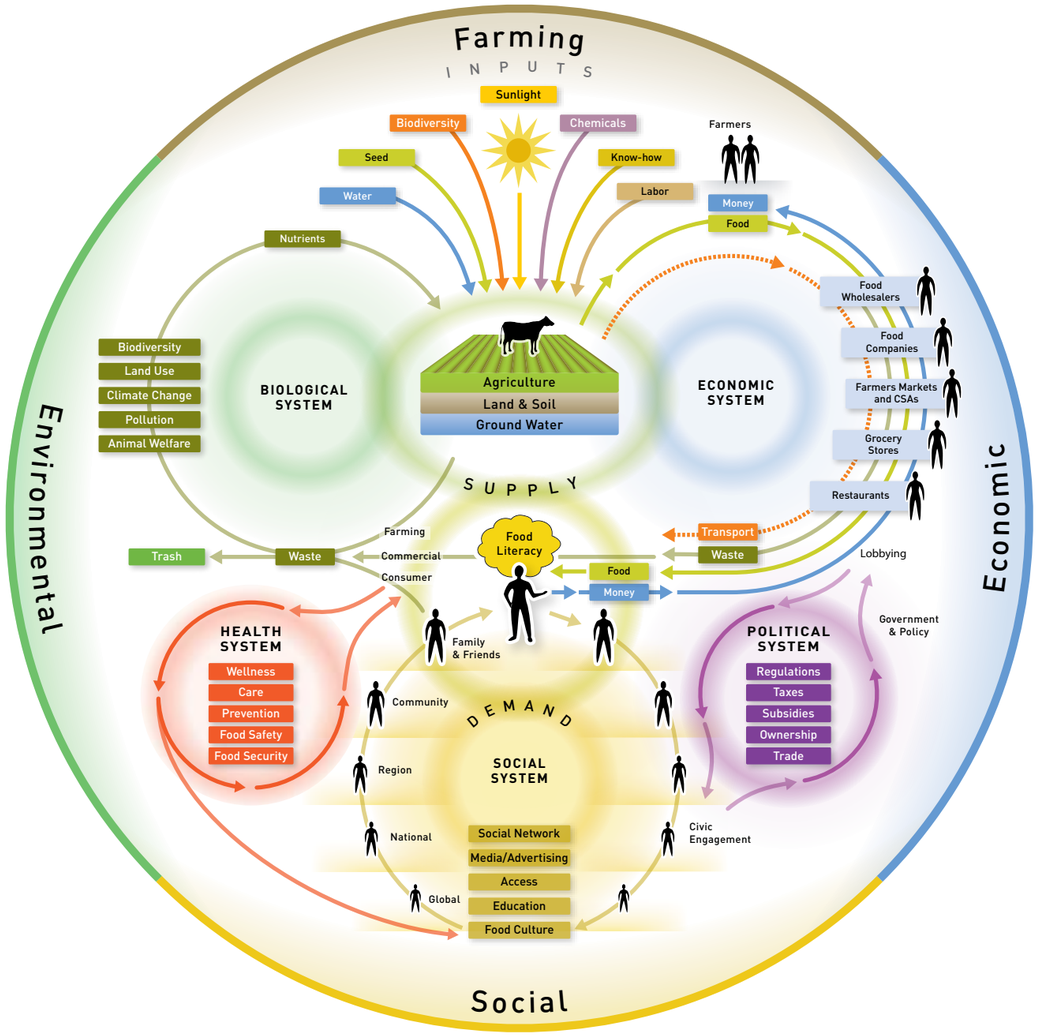
The report starts by highlighting one of the most challenging problems facing the urban food system and underserved populations—food deserts. This report explores how technology has been used to better understand the socioeconomic complexities that give rise to food deserts across urban food systems. Next, the report highlights innovations along each step of the food system, from agriculture to transportation and logistics to new retail models (See p. 18).

Given the significant breadth and depth of these topics, the report focuses primarily on urban environments. However, as the rural, industrial agricultural system[a] remains urban environments' main source of food products, the report briefly explores some topics related to agricultural technologies, sustainable agriculture[b] and the concept of sustainable intensification[c] of food production, as well as supply chain logistics. Following the supply chain path, the report then describes innovations in food retail and new ways in which food is obtained by those living and working in urban environments. Notably, many of the newer food delivery models have grown to meet the needs of higher-income, urban populations and in their current iterations do not represent ways to increase access to healthy foods for underserved populations. However, these models offer new ways of thinking about the food chain and food access that can inspire innovative future solutions that meet the needs of a broader population.

a The term **"industrial agriculture"** is used in this report to describe the chemically intensive farming practices developed after World War II to supply the majority of the food in developed countries. Industrial agriculture typically employs monoculture, or the large-scale production of a single crop, and also encompasses the meat and dairy production industries and confined animal feeding operations[33].

b **Sustainable agriculture** is "the production of food, fiber, or other plant and animal products using farming techniques that protect the environment, public health, human communities, and animal welfare. This form of agriculture enables us to produce healthful food without compromising future generations' ability to do the same."[34]

c **Sustainable intensification** refers to new methods to grow more food on the same amount of land, while using less water, chemicals and energy, towards the goal of meeting the needs of a growing population with deplenishing resources.[35,36,37]



www.nourishlife.org

nourish
food + community

Food Deserts

Background

A food desert[d] is a neighborhood or community with limited access to affordable and nutritious foods.[38] An estimated 29.7 million Americans live within a food desert.[39] While this concept can be challenging to define (with changing definitions based on urban versus rural settings, access to various modes of transportation, etc.), reviews of the evidence suggest that, particularly in the United States, people living in low-income and underserved areas often have limited access to healthy foods,[40] and are at increased risk for obesity and diet-related chronic diseases.[40,41] People who live in food deserts generally spend a significant amount of time or effort getting to a grocery store or other retail option that has a variety of affordable, fresh and nutritious foods.

Food deserts exist in both urban and rural areas and have received a fair amount of attention over the past decade from academics and political leaders, such as former first lady Michelle Obama, thus sparking a range of interventions. Growing interest in the problem, however, has highlighted knowledge gaps in both the multifactorial contributors to food deserts and the best way to address them. A National Research Council workshop in 2009 concluded that improved methodologies for studying food deserts could better inform local policies, but noted the challenges of matching supply with demand, particularly given the strong price sensitivity among low-income households.[38] Food deserts are the result of complex interplays between social, economic and racial injustices, and there are no silver bullet solutions, however, technology can play a key role in understanding some of those complexities.

d The term “food desert” is used throughout this report as it is the most familiar descriptor for this concept and frequently used in academic literature. However, there is considerable controversy over this term, as a “desert” is a naturally occurring phenomenon. Rather, “food deserts” are the result of complex, and often intentional, economic, social and political factors.[42,43] Furthermore, the term desert connotes a complete dearth of available food sources, while the problems inherent in the concept of a “food desert” relate to the variety and types of food available for purchase.

Technology Helps to Identify Areas of Need

Mapping

Background

Mapping has long played an important role in urban planning and public health, beginning with John Snow's famous map, which traced a cholera outbreak to one particular water pump, and is one of the earliest known examples of the power that mapping data can have on understanding the relationship between social networks, environmental factors and human health.[44] Today, digital technologies enable new ways of collecting and storing rich datasets. Geographic Information Systems (GIS), for example, collect, store and analyze spatial or geographical data.

Digital GIS technologies that apply big data analytics to geospatial data have advanced through their commercial use by the oil/gas and mining industries, which use the technologies to find the right place to drill. Indeed, high-profit industries can drive technological innovations that have public health applications; GIS technologies have since been used to increase the speed and accuracy of infectious disease surveillance, for example.[45] With the increasing prevalence of GPS-enabled smartphones, newer mapping techniques can leverage data from individuals going about their daily lives. Social media applications also collect geographically tagged data that are tied to other photos or text-based commentary. Furthermore, digital technologies have enabled novel ways to analyze and present these types of complex data.

Mapping: Examples from Other Industries

Mapping projects like **OpenStreetMap** use the power of crowdsourcing to generate maps that are powered by local knowledge; anyone can create an account and make edits to the map, in a process similar to methods used by the crowdsourced online-encyclopedia website, Wikipedia.

Crowdsourcing and GIS methods have been used to map noise-pollution and other environmental problems in cities (e.g,. **Love Clean Streets** is a United Kingdom–based mapping app that lets users report graffiti, litter, potholes, etc.), as well as infectious disease outbreaks (e.g., **Outbreaks Near Me**).[46] The application of GIS methods to data mined from Twitter and other social media sources has been used to model influenza outbreaks,[47] and even depression.[48-50]

Mapping the Food Environment

GIS and new mapping technologies allow for much more robust measurement of the various components of the food system, from tracing supply chain routes to visualizing gaps in food security.[51-53] GIS mapping, in combination with other datasets, has been used to identify hotspots for hunger, food deserts and unhealthy food environments on city and state levels.[54,55,56]

The USDA developed a Food Access Research Atlas, which builds upon its 2011 "Food Desert Locator" model of supermarket access and income by including additional factors, such as an individual's access to a vehicle and other forms of transportation.[57] The more recent Food Environment Atlas compiles statistics on over 211 measures grouped into categories of food choices, health and well-being, and community characteristics.[58] The Food Environment Atlas mapping data are available to developers to include in apps or websites through an Application Programming Interface (API).[59]

Feeding America, the nationwide network of food banks, has undertaken an annual Map the Meal Gap project since 2010, using nationally representative survey data collected by the Census Bureau to estimate county-level rates of food insecurity.[60] Individual researchers have also used GIS, for example, to map the distance from New York City census block groups to the nearest food outlet, and then score each outlet based on the availability of healthy food items to calculate a food desert index.[61]These data help local food banks and other anti-hunger groups to better target resources to meet needs, and inform policymakers and researchers about food insecurity within particular communities.

Michael Hollister, a forward-thinking programmer, combined several datasets together, including the Capital Area Food Bank's service data, U.S. Census Bureau data, the USDA food desert map and Feeding America's Map the Meal Gap study, and analyzed those data with software that retailers use for marketing forecasts (Applied Predictive Technologies). The resulting Hunger Heat Map (see box p. 22) helps the Food Bank to identify areas that have a high proportion of people who need food aid and provides key information to inform decision making regarding resource allocation and potential partner organizations.

Using Mapping to Identify Areas of Hunger:

Capital Area Food Bank's Hunger Heat Map

What it does: Identifies communities in the Washington, DC metro area where food relief is needed.

How it works: Datasets from various sources are added to mapping programs to create visual depictions of where hunger is concentrated in communities. These maps, called heat maps, show where food aid is needed so that nonprofits can focus their efforts more effectively.

Why it's interesting: The technology converts datasets into a user-friendly format that allows nonprofits to better understand the communities they serve.

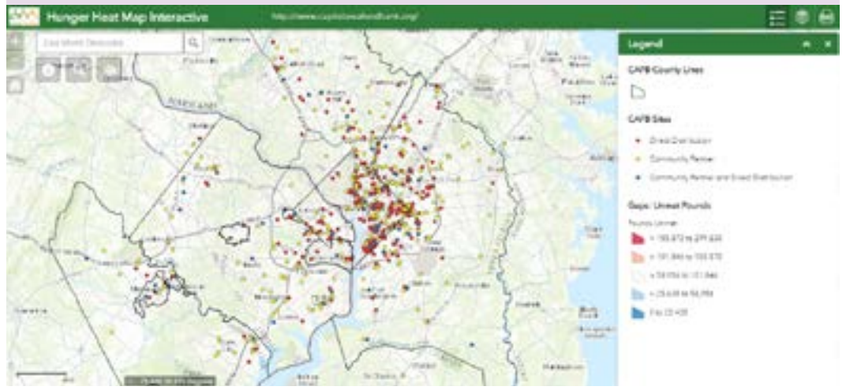
What can be learned from the technology: Visualizing abstract data can help create concrete solutions.

Created by: Capital Area Food Bank

Website: http://cafb.maps.arcgis.com/apps/MapJournal/index.html?appid=b4906ac11bf74cd781c5567124be9364

Cost: Free

Future of the app: The technology is currently being used in Washington, D.C., but has plans to expand nationally.



HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Mapping can also be used by individual consumers, for example, to find nearby farmers' markets or retailers that accept Supplemental Nutrition Assistance Program (SNAP) benefits (see Part 1, Health Tech & Food Insecurity).

Case Study:

Data-Mining Using Social Media

De Choudhury and colleagues used Instagram's API to examine three million posts that contained 588 food-related hashtags (which were predefined based on a prior study)[62] and geo-tags. The researchers then classified each location as a food desert or a non–food desert area and matched those locations on socioeconomic and demographic variables.[63]

The researchers found that the food-related posts in food deserts had 5-17% more references to high sugar, fat or cholesterol foods than those in non–food desert areas. Their resulting data model could predict, up to 80% of the time, whether a given food-related Instagram post was from a food desert or not, suggesting that these types of methodologies could be used as a supplement to national dietary intake surveys to assess general patterns in eating behavior that may vary by geography or culture.

The majority of research on food deserts indeed focuses on availability and access to healthy food rather than consumption patterns. There are certainly biases introduced by the public and social nature of these food-related posts, as people may not post pictures or tag locations for everything they eat. However, this novel data-mining approach offers vast and rich data streams that can be used to make inferences about daily eating behavior.

What the Research Shows:

GIS mapping data have shed considerable light onto the impact of the built environment and disparities on health outcomes.[64-66] These data can be used to test hypotheses, identify problems and create more targeted interventions.

One study in **New York City** found that areas with the lowest median household index and the highest proportion of black residents had the worst scores on the food desert index.[61]

Zhang's study in the **Hartford, Connecticut** area focused its efforts on identifying supermarkets that served areas otherwise void of healthy food retail options. The authors suggest that the knowledge gained from mapping could help speed up the delivery of mitigation efforts should a supermarket close, such as increasing the stock of produce in small corner stores, promoting farmers' markets and community gardens in the area, and generating investments to support new or existing stores.[54]

Another study in **Flint, Michigan** used GIS mapping in conjunction with knowledge from local experts to identify areas in which small-scale healthy food retail interventions (e.g., mobile markets and corner store investments) could have the greatest impact.[67] Sadler then worked with local community partners (produce cart operators, farmers' markets, nonprofit organizations and local/state government officials) to translate the findings into actionable interventions.

In other cases, GIS mapping data can bring new insights into long-held theories. Researchers in **Detroit** used GIS and survey data to learn that residents living in a food desert predominantly shopped for food staples at independent supermarkets outside of their neighborhoods, traveling an average of 3.6 miles. This was the case even for households without access to a vehicle.[68] The authors suggest that these data oppose the concept of building new supermarkets to serve food deserts and that allocating resources to travel could do more to improve the food environment of these areas of Detroit.

Similarly, Libman conducted a review of food policies in **New York City** over a seven-year time period in conjunction with collecting geographic and qualitative interview data.[69] While many of the policies focused on targeted, local interventions, such as adding a supermarket to a low-income area, they did not always address larger issues like high prices or the in-store environment and, further, may contribute to gentrification. Libman concludes that "geographically targeted policies should be a strategy, but not the only strategy for addressing food environment and health inequalities."[69]

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Technology-Enhanced Access to Healthy Food

Direct-to-Consumer Markets

Background

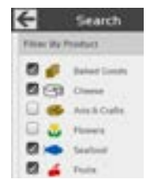
Models such as farmers' markets and community supported agriculture (CSA) subscriptions have enabled farms to sell their products directly to customers, which can result in higher profits for farmers and often better prices for consumers. According to the most recent USDA Census of Agriculture data, only 7% of farms in the United States engage in direct-to-consumer food sales, representing 0.3% of all farm sales.[70] However, demand is rapidly increasing for local food sales, having more than tripled between 1992 and 2012, with even greater growth in certain states such as California, Wisconsin, New York, Washington and Pennsylvania.[71]

Low-Tech Ways to Help Direct-to-Consumer Markets

Low- and no-tech solutions to improving healthy food availability within food deserts include bus stop farmers' markets and mobile farmers' markets (e.g., using trucks or RVs) that sell produce in food desert areas. Mobile technologies, apps and websites can be used to expand the reach of these types of markets by notifying users of a market's location and enabling alternative payment methods. Wireless payment systems that allow mobile markets to accept payments other than cash reduces burden for customers and permits the use of EBT cards. Further, the ability to accept mobile and credit card payments can help businesses increase sales, as people are generally willing to spend more with a credit card than cash.[72] The ability to transmit their location through apps also means that these markets can move around and reach people who do not have consistent access to healthy food.

Mobile Technology: Examples from the Field

Locating Farmers' Markets



- In New York City, a free text messaging service informs the user of the nearest farmers' market location and whether the market accepts EBT; users can text "SoGood" to 877-877.[73]
- Harvest to Hand is a free iOS and Android app that helps users find locally harvested food at farmers' markets, harvest festivals, pick-your-own farms and other venues. The app is operated by American National, which provides insurance to small farms and food businesses in the United States.
- Fresh Food Finder is a free app that provides information such as dates, times, locations, produce currently being sold and types of payment accepted at farmers' markets registered with the USDA (which numbered more than 8,600 as of March 2017).[74]
- Garden on the Go® in Indiana[75] was a farmers' market inside of a truck that operated year round and had weekly stops at various community locations. The program ran from 2011 to 2015 and used Twitter for real-time location updates, like many other food trucks do. This program was supported by grant from Indiana University Health, and unfortunately was not sustained after grant funding ended.

Mobile Payments

- Square is popular "cash register" point-of-sale, credit card–swiping hardware that plugs into a smartphone or tablet, allowing retailers to accept payments on the go, which is particularly helpful for small-batch food producers or vendors who sell at farmers' markets and pop-up venues.
- Mobile Market+ facilitates farmers' ability to accept mobile payments at farmers' markets, farm stands, and the like, including payments via EBT for WIC and SNAP programs, plus credit and debit cards.
- The First Data EBT solution provides merchants with an easy mechanism for accepting EBT payments that can leverage existing point-of-sale equipment and processes. First Data partners with industry vendors to integrate into third-party software packages. For example, if a merchant already accepts debit cards, First Data can link into that process, allowing the merchant to have one consolidated statement and funding stream.

What the Research Shows:

Direct-to-Consumer Markets
Relationship Between Farmers' Markets and SNAP Purchases

Strategies to promote the use of EBT at farmers' markets benefit both the farmers and low-income households in urban environments with limited access to fresh produce and other healthier food options. "SNAP represents the greatest untapped potential for farmers' markets in low-income communicates."[76] Providing wireless EBT terminals to farmers' market vendors has been shown to increase SNAP sales[77,78] as well as overall sales.[79] Between 2009 and 2012, the percentage of farmers' markets accepting EBT payments rose from 18% to 21%[80,81], while the amount of SNAP redemptions increased from $4.2 million to $21.1 million.[82]

Despite this growth, purchases at farmers' markets represented only less than 0.01% of SNAP program spending in 2010.[78,83] However, these data may be misleading, as they do not adjust for factors like the opening hours of farmers' markets in comparison to grocery stores, and the variety of food options available. One study found that providing individual wireless EBT terminals to farmers' market vendors (instead of having one for the whole market) increased SNAP sales by 38%.[78] Markets have varying success with SNAP; at the Mobile Oasis Farmers Market in North Carolina, a CSA-style delivery service and pop-up market that targets food deserts in North Carolina and accepts EBT, 15% of their 2015 sales were from SNAP.[24] At some greenmarkets in New York City, adding wireless EBT terminals and advertising in newspapers and on public transportation in multiple languages helped to double sales from SNAP, which can account for 70-80% of the total sales at markets in low-income neighborhoods.[84]

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

What the Research Shows (continued)

Impact on Prices

Direct-to-consumer markets allow farmers to skip the middleman, which can help keep prices down for consumers, however research comparing the prices of produce and other goods at farmers' markets to prices at grocery stores have mixed results. Consumers often perceive farmers' markets to be more expensive than large supermarkets and other retailers. Indeed, large agri-businesses and large chain grocery retailers benefit significantly from economies of scale, a concept that arises from the combined purchasing power and operational efficiencies that large enterprises hold.

Studies in North Carolina[85] and New Zealand[86] found cheaper prices for the same products at farmers' markets and other direct-to-consumer markets in comparison to grocery stores. In North Carolina, prices were on an average 18% cheaper. However, another study found that WIC recipients reported higher prices at farmers' markets compared to grocery stores; nonetheless 51% of participants still shopped at farmers' markets.[87]

Yet, increased access to direct-to-consumer markets can have impacts on the prices of existing food options in the area. One study found that the arrival of a farmers' market to a food desert helped to drive prices down at local food retailers by 12% in 3 years.[88]

Increasing Fruit and Vegetable Intake

Low socioeconomic status is frequently associated with higher rates of diet-related health issues like obesity, hypertension and diabetes.[89] Promoting the proliferation of direct-to-consumer markets through technology could play a role in nutritional health promotion as well. The addition of farm stands to low-income communities has been shown to increase nearby residents' fruit and vegetable intake.[90]

Specific interventions have sought to increase SNAP recipient purchases of fruits and vegetables at farmers' markets by providing monetary incentives.[91-93] New York City's Health Bucks program provides a $2 coupon for every $5 in EBT benefits spent at farmers' markets, thus increasing the purchasing power of SNAP benefits for fresh produce by 40%.[94,95] In the first ten years of the program (2005-2015), New Yorkers used Health Bucks to purchase over $2 million worth of fresh produce. The coupons are also used as an incentive for attending nutrition and health education events and programming by community-based organizations.[96] As monetary incentives to promote healthier food choices have been found to be "unambiguously effective,"[92,97] these sorts of program could easily be digitized to help extend their reach.

Online Grocery Delivery

Background

Digital technologies have opened up a wide range of food retailing practices that both offer new ways to obtain food and extend the reach of existing brick-and-mortar stores. Online grocery stores and ordering platforms have revolutionized the way that many households shop for groceries, allowing users to browse products and make purchases on a web page or mobile application and have the groceries delivered to their home. Other companies have sought to provide delivery service of produce and other farm products directly to consumers.

Online grocery stores and other food delivery services can bring food to households within a food desert.

Early industry leaders in online grocery retail include **PeaPod** and **Fresh Direct**.

PeaPod was the true pioneer in this realm, launching the first company to run their entire business through e-commerce in 1989, even before the internet was "born" in 1996. Peapod delivers to Chicagoland, Milwaukee, southeast Wisconsin, Indianapolis, Connecticut, Massachusetts, Rhode Island, Southern New Hampshire, New York, New Jersey, Maryland, Virginia, Washington, D.C., Philadelphia and other parts of Pennsylvania.

Credit: New York State's myBenefits.com website

Fresh Direct was founded in 1999 and is an online grocer for the New York City metropolitan area. Peapod's prices are generally lower across the board than Fresh Direct's, but Fresh Direct's pricing structure is reasonable in comparison to prices at NYC brick-and-mortar grocers.[98]

Additional web-based grocery delivery models are described in more detail on p. 70.

Online EBT Purchases: Food Retailers Deliver to SNAP Recipients

Due to regulations on EBT cards that require purchases to be made in person with a PIN number, online grocers do not regularly accept this form of payment and thus recipients of SNAP cannot use their benefits to shop at these stores. The exception has been Schwan's, a nationwide home food delivery service that accepts EBT payments upon delivery. Schwan's focuses on frozen foods and includes many "freezer meals" that are quick and easy to prepare.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

2014 Pilot Program

A pilot program of the 2014 Farm Bill granted waivers to several grocery websites, allowing them to accept EBT payments for online orders. FreshDirect ran one of these pilots in the Bronx, and waived the delivery fees, taxes and surcharges for orders (which had to be at least $30) but customers were required to accept the order in person and to swipe their EBT card and enter their PIN number.[99] This program was fraught with issues, including being poorly promoted and understood within the community.[100] The requirement that customers be home at the time of delivery to accept the order in person was problematic for individuals with busy schedules and limited availability; in contrast, customers paying with credit cards have the option for a neighbor or doorman to accept their order on their behalf, and in suburban areas, FreshDirect permits unattended deliveries. FreshDirect, which did not receive payment for missed orders because they were unable to charge the customer's EBT card, incurred a regular loss of revenue when EBT pilot customers were not present at the time of delivery.

2017-2018 Pilot Program

In January 2017, the USDA announced a new pilot program that allows SNAP recipients to purchase groceries online using their EBT cards. This pilot will address the primary technological issue, allowing customers to use their EBT cards online. New software developed by a company called Acculynk will enable customers to enter their PINs at website checkouts. For details on how this will work, see this article.

Seven retailers, including Amazon and FreshDirect, will be participating in the program. Initially, the program will be limited to seven states, including New York, and pilots will launch in 2018. The scope of the pilot is narrow because each state has its system for processing SNAP purchases, and participating states will have to change their current systems to accommodate online purchasing. If the pilot is successful, the USDA plans to expand the program to additional retailers and locations.

Case Study: Online Grocery Delivery

Crisp! was a web-based grocery delivery company that focused on low prices and fresh produce, with a specific aim to bring healthy food into food deserts.[101] Crisp! was started by Catholic Charities in Chicago and was partially funded by a grant from the USDA. While their initial model (in summer 2013) operated mobile food carts, this was not feasible during the winter and they switched to a delivery model in 2014. Crisp! had significant growth, with sales increasing 42% from 2014 to 2015,[101] but their model failed to be sustainable, perhaps due to the end of their grant funding or the numerous complexities of urban transportation logistics, and they are no longer in operation.

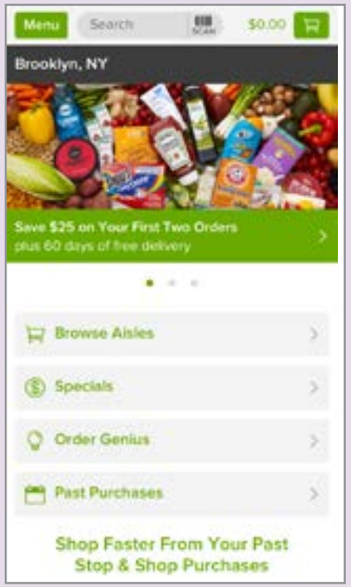
What the Research Shows

Online Grocery Delivery

Introductory Vouchers for Delivered Groceries

A study in Chicago enrolled a diverse group of 60 caregivers of children aged 2-14 who lived in a food desert and provided the adults with an $80 voucher for Peapod in 2011-2012.[102] The majority of study participants were female (77%) and above a healthy weight (obese, 65%; overweight, 13%); 79% had an annual income less than $40,000 and three-quarters had a working computer with internet access at home.

The study found that online grocery shopping was a feasible and acceptable method of delivering food to recipients in food deserts, and that fruits and vegetables comprised a large proportion of the purchases. Nearly all participants (91%) indicated intention to use an internet grocery service in the future; the majority (54%) anticipated using it between 1-6 times per year and 18% thought they might order groceries online once a month.[102]



Perhaps introductory vouchers like those used in the study could be used to help food desert dwellers become comfortable with the concept of online grocery delivery.

Increased Shopping Frequency Can Lead to Better Resource Allocation

Because online grocery shopping can save time for households, they might be able to shop more frequently (although this has to be considered in light of order minimums). Wilde and Ranney found that SNAP recipients who shopped more frequently had better resource allocation and were less likely to have fluctuations in energy intake over the course of the month, in comparison to households that did just one major shopping trip per month.[103]

Grocery shopping, particularly in food deserts or for people without easy access to transportation, can be a major time barrier, and grocery delivery could help households better allocate their resources across the month.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Looking Forward: Tech Opportunities to Increase Access to Healthier Foods in Underserved Areas

Technology, GIS and mapping enable more robust insights into the complex interplays between the built environment and social, interpersonal and economic factors, and have helped identify hunger hot spots and more clearly defined food deserts. Furthermore, these data can be a powerful lens into the impact that a particular program or intervention has on a local area. While mapping data are one resource for identifying areas that could benefit most from a mobile market, this may be most useful from a big-picture view, with regard to resource allocation and long-term planning. For day-to-day and smaller-scale operational support, real-time, mobile technologies like text messaging and apps, as well as social media, can be quite powerful.

There are steps that state and local governments or non-governmental organizations (NGOs) can take to promote the continued growth of mobile markets and the use of food assistance benefits to purchase healthy, locally grown produce. An infusion of mobile technology to mobile markets, for example, could potentially strengthen the programs discussed in this report. The Food and Nutrition Service of the USDA provides wireless EBT terminals for SNAP-eligible farmers markets for free up to three years before requiring markets to pay an annual fee that starts at $220[e] plus the cost of a cellular data plan.[104] New York City provides wireless EBT terminals to Green Carts (mobile food carts that sell fresh fruits and vegetables from the sidewalks in high-need areas) for free, subsidized by a state grant.[105]

Subsidies or new technologies that can help drive these costs down could help the continued growth of EBT acceptance at farmers' markets.

If the USDA's pilot program proves successful and online grocers begin accepting EBT through direct payments online, this could truly revolutionize the way that low-income populations gain access to foods in a convenient way.

- The delivery of healthy foods tailored to a particular budget can save households valuable time and energy, eliminating some of the weekly stressors involved with planning and shopping for food.[106]
- Online grocers can offer a wider range of products than smaller urban stores, particularly fresh and perishable items.
- Online grocery shopping allows those on a tight budget to compare prices of similar products and to carefully monitor the total cost of their basket without doing mental math as they walk through the aisles of a store.[107,108]
- Orders can be placed at any hour of the day, which could be a big advantage for individuals who work long and/or irregular hours and may not be able to get to the store during traditional business hours.
- Deliveries can also be scheduled according to one's availability.

It should be noted that politics can play a significant role in the expansion and reach of these programs. For instance, in 2012, FreshDirect received $128 million in tax breaks and subsidies to expand their services into the Bronx, but they initially failed to include many of the lower-income areas, which was met with considerable criticism.[109] The company's eventual expansion to cover all of the Bronx was also rife with conflict; FreshDirect's prices may have rendered their services out of reach for many community members, and residents would be subjected to increased truck traffic, pollution and loss of green space. Many felt that this large government subsidy would have been better spent on local programs to increase healthy food access, rather than supporting a private company's expansion.[109]

As described in Part 1, Health Tech & Food Insecurity, there are new ways to expand the internet's reach in low-income areas, including the Lifeline program and infrastructure projects such as LinkNYC, which can help low-income households take advantage of the cost and time-saving benefits of purchasing groceries online.

However, many online grocers charge delivery fees and/or have minimum purchase requirements, and often charge slightly higher prices than they do in stores. While higher costs may be offset by fuel, other transportation and/or time saved, these sort of financial trade-offs can be hard to calculate, and higher sticker prices may discourage use among lower-income households.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Urban Agriculture

Background

In light of growing urban populations, sustainability concerns, and the amount of available and viable farmland, there is a pressing need for new models of farming. With increasing urban population density, innovators have recognized the importance of hyper-local food production in supplementing the current agricultural and food supply chain network.

The concept of urban agriculture has undergone considerable growth. Both entrepreneurs and nonprofit organizations have proposed creative solutions to the problem of feeding large numbers of people in concentrated areas by transforming abandoned lots, warehouses and "wasted" space, such as rooftops, into urban farms. Community gardens are also an important part of the urban agriculture landscape, offering a local place for people to grow their own food within their neighborhoods. As of early 2017, there were over 600 GreenThumb community gardens in New York City.[110] The GreenThumb program's website lists gardens by borough, providing garden-specific information (including whether they grow food) and a map of garden locations that is searchable by zip code.

Mapping and Crowdsourcing:

Urban Agriculture Advocacy

The Brooklyn-based nonprofit 596 Acres created a Living Lots NYC map, using Google Maps & Google Street View's APIs, of abandoned public lots in New York City to help bring attention and advocacy to public land that has potential to become community gardens or green spaces. The creator of Living Lots is developing a map for New Orleans as well.

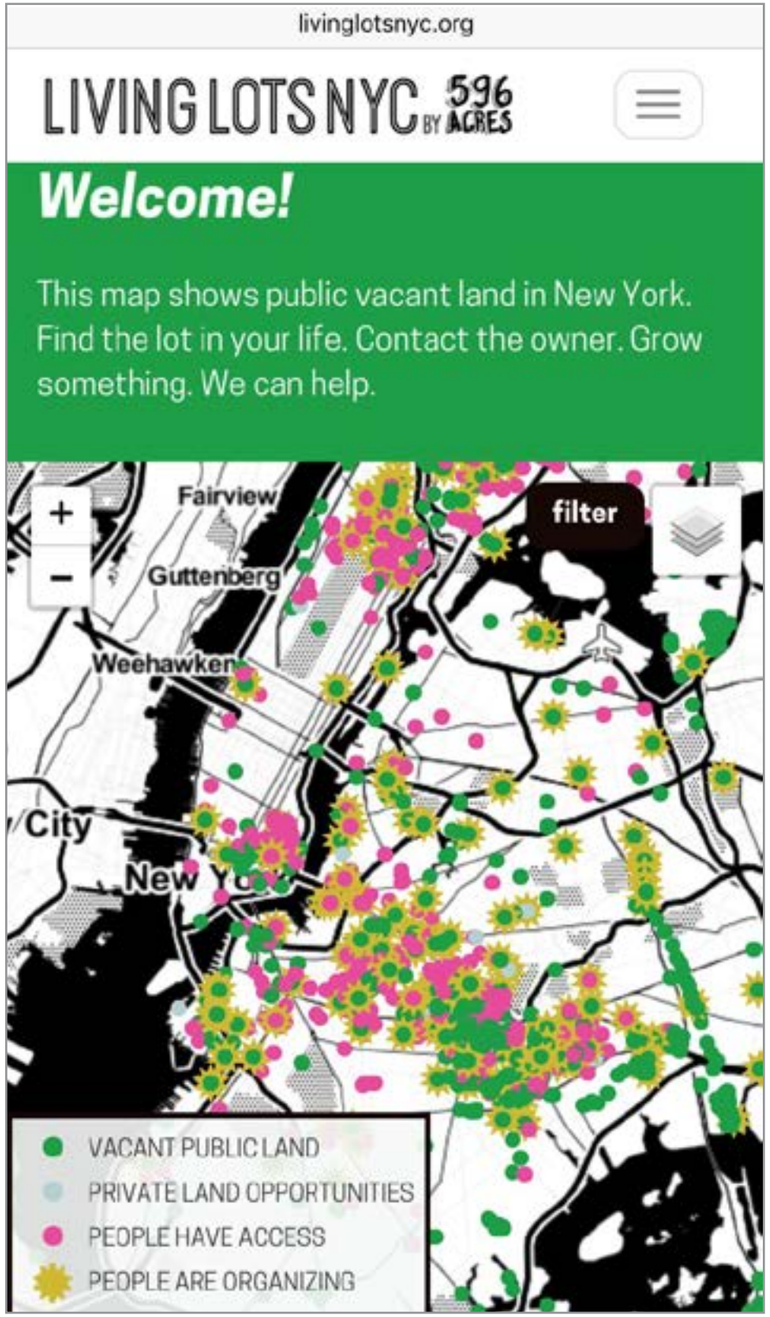
596 Acres built Living Lots NYC using a dataset from the NYC Open Data portal, which contains data on everything from pothole complaints to a directory of public toilets to a census of the city's trees. One of the datasets used was IPIS (Integrated Property Information System), which identified lots that are city-owned, vacant and not in use. 596 Acres used a NYC GIS mapping project called OASIS as another source of data to triangulate their findings and identify potential lots; OASIS has information about every block and lot in the five boroughs (e.g., transit, parks, environmental characteristics), including a list of community gardens. In the next phase of the mapping project, the group worked with a local property expert to corroborate the findings using a combination of OASIS, Google Street View and satellite imagery to remove lots that were unlikely to be useable, such as those inaccessible from the street or lots that were misclassified due to surveying errors.

The final phase of data cleaning and refinement was conducted via crowdsourcing. 596 Acres posted large weatherproof versions of the map on fences surrounding many of the lots. Volunteers, neighbors, and members of the local community submitted details about the lot, such as the history of the space, and could also report missing or mislabeled lots.

While the collection and maintenance of this data resource is of value in itself, the project takes this a step further both by creating community email lists so individuals interested in a particular lot can collaborate and by helping to identify the appropriate government officials who could provide access to those lots.

596 Acres, Credit: 596acres.org

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER



Other urban agriculture projects include those at public housing facilities and schools. The New York City Housing Authority (NYCHA) initiated urban farming projects within public housing complexes, such as at the Red Hook West Houses, which is farmed for and by residents. Residents who volunteer on the farm receive produce in exchange, and residents can also exchange compost pound for pound with produce, to encourage more sustainable household practices. The NYCHA farm also has a job training program focused on urban agriculture.[111] For more information about the NYCHA Farm program, see this article.

Other urban farming initiatives involved partnering with schools as a means to get children more involved and in touch with where their food comes from, through programs like Edible Schoolyard, the NYC Grow to Learn initiative (which has projects at more than 600 of 1800 schools) and the National Farm to School Network.

The urban agriculture movement may have the potential to help overcome the challenges of sustainability and population growth. While rooftop farms and empty lots converted into community gardens can help bring traditional farming methods directly into urban communities, technology has facilitated the development of new agricultural practices that can produce high volumes of produce on relatively small footprints.

Bringing Agriculture Indoors: Hydroponics, Aquaponics, Aeroponics and Vertical Farming

Background

While greenhouse-like structures have been used to grow food indoors since the Romans invented the first specularium in 30 A.D., technological advances have resulted in new ways to grow food indoors with increased efficiency. Indoor environments necessitate reproducing the growing conditions of an outdoor field, in which the soil provides nutrients and the sun provides essential energy for photosynthesis.

There are three main systems that have evolved to eliminate the need for natural soil:

Hydroponic methods replace soil with a nutrient-rich solution that surrounds the plants' roots and are commonly used in indoor farms.

Aquaponic systems build upon hydroponic systems by combining plant and fish farming; the fish produce nutrient-rich waste-water that is then used to water and fertilize the plants. As the plants incorporate the fertilizer they filter and purify the water, which can then be returned to the fish ponds.[112]

Aeroponic indoor growing technology was developed in the 1990s by the National Aeronautical and Space Administration (NASA) as a way to grow plants in space, using a system that mists the plants' roots with water, nutrients and oxygen, further reducing water use over hydroponic systems by 40%.[113] All three systems can employ fluorescent or LED lighting to supplement exposure to natural sunlight.

The concept of **vertical farming** was popularized in 1999 by Dickson Despommier at Columbia University's Mailman School of Public Health and brings architectural and engineering advances to indoor farming. In vertical farms, greenhouse-like operations, which might include any of the three "-ponic" systems, are essentially stacked on top of one another. Some models utilize conveyer belts to rotate crops' exposure to sunlight through the windows. This sort of system can be built as an extension to an existing building, or could be architected as a standalone structure.

The ability to grow food indoors, without methods that require land/soil and sunlight, represents a significant shift in the food production system. Despommier cites that it takes "a landmass the size of Virginia to feed New York City's 8 million people—we have to find another way to farm!"[114] Land and space come at a premium in most cities, and with vertical farming, a large volume of food can be grown with a minimal footprint. Hydroponic systems can be combined vertically to increase yield from indoor farms.

For example, indoor farming methods allow for complete control over environmental conditions. Light, temperature, humidity, carbon dioxide density and pH can be precisely optimized, which dramatically increases growing efficiency while eliminating much of the risk and uncertainty experienced by outdoor agriculture. This also increases the amount of food able to be grown in areas with limited growing seasons and harsh environmental conditions.

Indoor farming also eliminates the need for pesticides and herbicides and results in fresher, more nutritious produce—relative to produce typically sold in a grocery store—as it can be picked at optimal ripeness and does not require lengthy transport times.[115-117]

Indoor Farms

Gotham Greens operates urban farms in New York City and Chicago with high-tech, clean energy–powered, rooftop greenhouses that operate year-round.[118] Their flagship greenhouse opened in 2011 in Greenpoint, Brooklyn, atop an industrial building, and grows over 100,000 pounds of leafy greens per year in 15,000 square feet.[118] The company has since added greenhouses in Gowanus (Brooklyn) on the roof of the borough's first Whole Foods Market, supplying an additional 200,000 pounds of produce (greens and tomatoes) each year, and in Jamaica (Queens), supplying more than 5 million heads of lettuce and other greens annually. In 2015, Gotham Greens expanded to Chicago's south side, in the Pullman neighborhood, with their most productive greenhouse yet, supplying over 10 million heads of leafy greens and herbs to the Chicago region.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Gotham Greens employs computer-controlled hydroponic technology to monitor environmental sensors and adapt to the growing conditions by altering lighting, temperature and water. According to the company, the hydroponic methods use 10 times less water than soil-based methods, with a 20% higher yield.[118]

Metropolitan Farms is an aquaponic farm founded in Chicago that has transformed a 10,000-square foot dairy packaging plant to produce locally sourced tilapia, salad greens and culinary herbs. If properly managed, aquaponic farms can be highly sustainable and, often, all of the waste and nutrients can be recycled within the ecosystem.

Another indoor farming operation in Chicago, The Plant, operates a "circular economy, [in which] conventional waste streams from one process are repurposed as inputs for another, creating a circular, closed-loop model of material reuse."[120] They feed the fish within their aquaponic system with spirulina, produced by an algae bioreactor using waste from an on-site shrimp farm and with spent grains from an on-site brewery.

AeroFarms, based in New Jersey, is the largest indoor vertical farm in the world and owns and operates their patented aeroponic vertical farms, which can be customized to any indoor environment. The 69,000-square-foot AeroFarms warehouse with 36-foot ceilings was originally a steel mill, and has been cited for revitalizing its local area in Newark, as well as creating at least 70 new jobs.[121] Their system uses 95% less water than field farming, and they estimate that with annual yields 390X higher per square foot, [113] they can grow up to 2 million pounds of greens each year. [122]

While these are some of the largest urban, indoor farms in the United States, there are countless other examples. In New York City, public schools, public housing facilities, community centers and senior centers have set up rooftop farms and often employ hydroponic systems to maximize use of space. This highlights one way that food system innovations can be used to address disparities in food access.

Internationally, the "Plantscraper," designed by American-Swedish "agritechture" firm Plantagon, [123] employs a completely novel architectural concept in which levels inside the structure are helical instead of horizontal, allowing more light to reach the center. Along the helical interior surfaces, the plants would move along conveyor belts, according to a patented logistical system that mobilizes the plants to the right lighting condition as they grow. They estimate an annual production of 700,000 to 1.1 million pounds of food on just a 4300-square-foot footprint, and because of the conveyor belt, the crops could be both planted and picked from the same location within the structure, greatly increasing its efficiency.[123] The proposed structure in Linköping, Sweden would also contain an office building for multi-use space.

Case Study:

Optimizing the Indoor Environment after a Natural Disaster

The 2011 earthquake in Japan and the resulting Fukushima nuclear disaster destroyed a large proportion of the country's crops. To help recoup the food supply, the Japanese farming company Mirai, which was already running small-scale indoor farms, converted an abandoned factory into the world's largest indoor farm.[124] The 25,000-square-foot farm can produce up to 10,000 heads of lettuce a day, which is drastically more efficient than traditional outdoor methods, with 100 more heads of lettuce per square foot. A 50- by 75-foot indoor area can produce as much food as a 16-acre farm.[125]

Mirai partnered with General Electric to develop LED lights tailored for plant growth that use 40% less power than traditional fluorescent grow lights while raising yield by 50%.[126] The system also uses 92% less water than industrial methods.[125] These efficiencies allowed for early return on investment in the lighting technology. Furthermore, much of the indoor growing process can be automated; Mirai's Verticrop system uses conveyor belts and sensors to maintain optimal growth conditions and to deliver the plants that are ready to be harvested to the hands of workers. With prototypes for harvesting robots in the works,[124] this high-tech, high-efficiency indoor farm model could represent a solution for meeting food needs throughout the world, especially in places with harsh growing conditions.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

In South London, Growing Underground has tested the limits of growing food "anywhere" by leasing two former air-raid shelters 33 meters (about 108 feet) below ground to build a hydroponic urban farm. Similar to other hydroponic operations, the company grows primarily salad greens, and they sell to local restaurants, a wholesale market and online delivery service, Farmdrop. They advertise that their hyper-local and sustainable model goes from "farm to fork in under four hours."

Further promoting sustainable practices, such as repurposing large materials, companies including Freight Farms, CropBox and Growtainers produce digitally controlled "smart farms" out of old shipping containers, equipped with LED or fluorescent lights, drip irrigation systems plus pH and CO_2 controls.[112] These smaller scale solutions enable food to be grown all year in any climate. All of the environmental controls inside the shipping container, from the lights to the air composition, can be controlled remotely through an app or computer using cloud technology.

Urban Agriculture: Implications and Limitations

Urban agriculture has the potential to generate cheaper sources of produce by eliminating or vastly reducing the costs of transportation, storage and distribution. This type of local agriculture also reduces the need for a "middleman," further helping to cut costs.[127] Urban agriculture was found to be a feasible approach to growing sufficient daily vegetable intake for low-income urban populations in high-income countries, according to an analysis that included population density, land area, and poverty and food insecurity rates .[128]

Some critics of urban agriculture have expressed safety concerns around levels of soil contamination, but studies have shown that these risks are minimal, and that long-term gardening can have positive impacts on soil quality in urban areas.[129,130] One limitation to vertical farms and hydro-/aqua-/aeroponic systems is that they do best with rapidly growing plants with a small footprint. Thus the majority of these operations focus on high-turnover crops like leafy greens and herbs.[112]

Sustainable agriculture experts have also questioned how the nutrient uptake of plants grown via hydroponic systems compares to organic soil-based farming, and argue that hydroponics should not be classified as organic, despite their non-use of pesticides and chemical fertilizers, given that they are grown without soil. Eliot Coleman writes, "hydroponic growing removes the crucial soil factor and replaces it with soluble nutrient solutions that can in no way duplicate the complex benefits of soil....The traditional motto of organic growing is 'Feed the soil, not the plant.' Hydroponic growing is based on the opposite strategy." [131] Further studies should be done to explore the nutritional profile of vegetables grown via hydroponics versus outdoor organic farming.

It should also be noted that while vertical farms can save space and bring food production into areas where it would otherwise be impossible, the systems consume large amounts of energy for their operations. These operations can also face major challenges; despite years of planning, the Plantagon structure has yet to be constructed in Sweden or in Singapore due to zoning regulations and confusion over whether this new model should be considered an industry, an office or some new hybrid model. The Swedish project also faced further delays due to "esthetical reasons" and concern for local birdlife.[132]

Urban agriculture and community gardens have the important social and cultural effect of helping urban dwellers gain insight into the process of growing food. Community gardens can have multitudinous effects, including: promoting healthy behaviors like increased fruit and vegetable intake and exercise; supporting intrapersonal skills, like self-efficacy and self-sufficiency; encouraging interpersonal and intergenerational interaction between neighbors; and increasing time spent outdoors and connecting with nature, a pastime often overlooked in urban environments.[133] Community gardeners have higher fruit and vegetable intake than non-gardeners,[134-137] and children who participate in gardening activities have significantly higher produce intake.[138] Similar benefits have been shown for participants in urban agriculture training programs, who gain awareness about healthy eating and cooking and are generally more engaged with both their health and the health of those in their community.[139]

Looking Forward: Tech Opportunities to Grow Urban Agriculture

The recent innovations in urban agriculture have been growing in momentum, practiced by over 800 million people worldwide.[140] An estimated 15-20% of the world's food is grown in urban areas.[141] Yet in many cities in the United States, urban agriculture currently supplies only a small percentage of the food a city needs to sustain its population (although there is little literature available to quantify levels of self-reliance).[142] Given the generally high prices for land in urban areas, it can be challenging for high-tech urban agriculture projects to compete with the low prices of industrially grown crops.[143]

Continued technological innovation could help bring urban agriculture to scale. Grewal modeled three scenarios for the expansion of urban agriculture in Cleveland, a city that was hard hit by the 2008 recession leading to many foreclosures and high rates of food insecurity.[144] The first model forecasted that if 80% of vacant lots became urban farms, that land area could produce about one-third of the city's demand for produce, one-quarter of the demand for eggs and poultry and 100% of the demand for honey. The next model added 9% of occupied residential lots (e.g., a subset of households using part of their yards for home gardens) and those forecasts rose to about 50% of the produce demands and 94% of egg and poultry demands. The final model, which added 62% of industrial and commercial rooftops, could cover essentially all of the city's demand for produce, poultry, eggs and honey—and retain $115 million within the local economy that would have otherwise been paid to farmers, distributors, etc.[144] The City of Cleveland has since expanded their urban agriculture efforts, through programs like Gardening for Greenbacks, in which the city provides $5000 grants to local urban farming entrepreneurs.[145]

High-tech, indoor, urban farms, such as AeroFarms and Mirai's Verticrop system, require significant start-up capital and are limited in the variety of produce they can grow, but can offer significant return on investment given their efficiencies, high crop turnover and lower susceptibility to environmental risk (e.g., droughts or pest infestations).[146]

The Massachusetts Institute of Technology's (MIT) http://www.verticrop.com/ is developing Food Computers—hardware and software platforms designed for hydroponic and aeroponic systems that are controlled by IoT sensors. By making these technologies within an "open-sourced ecosystem... [they seek to] enable and promote transparency, networked experimentation, education and local production ... to create sustainable, shared systems that will break down the barrier of entry and spark interest, conversation, and maybe even a revolution about the way we view food."[147]

Pathways in Urban Farming

Square Roots: Helping Launch The Next Generation of Leaders in Urban Agriculture

Through their year-long Next-Gen Farmer Training Program, Square Roots, an urban farming company in Brooklyn, NY, seeks to create more opportunities for more people to become farmers—and future leaders in urban farming. Traditional farming careers generally have high startup costs, are located outside of city centers, and have no guaranteed income.

At Square Roots, farmers become vital team members while learning to farm in our tech-enabled farms and studying plant science. During the program, farmers are exposed to business while participating in an immersive, 4-month Entrepreneurship Project and gain community building skills by inspiring and teaching local high school students through a series of workshops. The team of farmers works inside Square Roots' 10 hydroponic shipping containers to grow fresh, local produce that is sold in stores across NYC and Brooklyn.

Credit: Square Roots

Square Roots accepted its first cohort or farmers in late 2016 and hopes to expand the model to other cities including Chicago, Los Angeles, Denver, Memphis, Indianapolis, and Pittsburgh.[148]

On the Farm: Ag Tech

Despite the growth of urban agriculture, rural industrial agriculture still supplies the majority of food to urban environments. While a full discussion of both the politics of industrial agriculture and agricultural technologies is beyond the scope of this report, there are many technological advances that aim to increase yields, improve efficiency, and reduce water, fertilizer and pesticide use.[149]

Background

Industrial agricultural practices, despite their efficiencies at producing large quantities of food cheaply (economies of scale), have a variety of adverse impacts on public health and the environment, and are often associated with significant strains on natural resources.[150] Consolidation has obvious economic impacts in crowding out small producers and thus impacting rural communities, but some of the public health impacts of industrial agriculture are more hidden. Large-scale monoculture, or growing the same crop over and over on the same land, significantly depletes the biodiversity of the soil and the resulting crops that are grown.[151] Soil erosion and compaction (caused by extremely heavy large scale machinery) can destroy the future fertility of that land. Synthetic pesticides and fertilizers also have lasting pollution effects. One study estimated that between 1940 and 1990, 550 million hectares of farmland were damaged due to poor agricultural practices (representing nearly 40% of the current farmland in use).[151,152]

The amount of arable land is decreasing due to global urbanization, increased salt concentration in soil (salination, a consequence of irrigation), erosion and desertification (natural or agriculturally induced drought states).[35] Half of current nitrogen fertilizers in use are derived from natural gas, representing yet another strain on the global economy and a high-demand resource.[153] Chemical fertilizer use is critical to maintaining high yields, but there is a considerable amount of waste in fertilization processes used on industrial farms; plants uptake only 30-50% of applied fertilizers.[154-156] Excess fertilizers contribute to water and air pollution, including ozone damage and methane emissions that are contributors to global warming.[156]

Moreover, the composition of the food supply has an environmental impact. In the United States, two-thirds of the grain grown is used to feed livestock, representing an “energy loss” in the system and a threat to global food security. One kilogram of wheat requires 500-2000 liters of water for production; one kilogram of animal protein requires up to ten times that amount (5,000-20,000 liters).[157]

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Considering the overall use of finite natural resources, particularly fertile land and water, there is a global need for more efficient agricultural practices.[158] To feed a growing population, farmers need to find a way to grow more on the same amount of land, using fewer resources like water and energy. Furthermore, farming is extremely sensitive to severe weather and other environmental conditions such as droughts, severe storms, and insect infestations (which are expected to increase as the climate warms),[159] and such instability and uncertainty requires preparedness and adaptation.

Sustainable methods of agriculture include better soil and nutrient management, crop rotation, and diversification of fields, which leaves them less susceptible to pest infestations, thus requiring fewer pesticides.[151] Technology can help to offset the adverse impacts of industrial agriculture and support new models of sustainable agriculture practices in a variety of ways.

High-Tech Agriculture

More Precise Resource Utilization

Technology has enabled farmers to increase the amount of food produced with fewer resources such as fertilizer and water. These new technologies have spawned the field of **precision agriculture**, which enables farmers to make data-supported decisions about the most efficient use of resources, such as which crops will grow best on which portion of land, and when/where fertilizer or pesticides are needed.

More Efficient Use of Nitrogen Fertilizers

The poor efficiency of fertilizer application on industrial farms, due to problems such as nitrogen leaching from the soil, has led to a wave of technologies seeking to improve nitrogen management. The Nitrogen Index is a smartphone and tablet app released in 2012 that allows users to enter data while out in the fields, and can conduct a detailed analysis of nitrogen loss risk in just a few minutes.[160]

Agronomic Technology Corporation operates a product called Adapt-N, a cloud-based precision nitrogen management solution that uses data on weather, plus soil, crop and field management to help farmers make decisions about fertilizer use. The software helps to identify opportunities for improving yield and can anticipate nitrogen stress, which is a common cause of yield loss.[161]

Better and Bigger Weather Data

Big data analytics have particular appeal for weather forecasting given the complex nature of environmental data and the variety of existing mathematical models that try and often fail to accurately predict the weather. While its relevance to agriculture is obvious, improved weather forecasting has an enormous impact on a number of industries, such as tourism or the airline industry, and there are a variety of technology companies seeking to use supercomputing to improve forecasting accuracy.

IBM's Deep Thunder is a data-modeling service and, in its application to agriculture, it combines data from sensors in fields with sophisticated weather modeling data (applying machine learning techniques based on the analysis of historical weather data) to provide a "hyperlocal forecast" that helps farmers make precise decisions such as when to plant, irrigate, harvest and transport crops.[162] Deep Thunder helps farmers predict rainfall and other weather events with 90% accuracy, up to 36 hours in advance. IBM estimates that weather accounts for 90% of crop losses, and that precision agriculture techniques based on predictive weather modeling could prevent 25% of those damages.[162]

Other companies that are making use of big data and predictive modeling include the "Agricultural Intelligence" platform, aWhere.

Big Data–Driven Weather-Related Insurance and Pushing Farmers to Higher Yields

The Climate Corporation was one of the early leaders in applying big data analytics to weather. Originally called WeatherBill and founded by former Google engineers, the early start-up focused on using freely available government weather data to sell weather-insurance policies to farmers, in addition to construction projects, sporting events and other endeavors that could be disrupted or impacted by bad weather. The company quickly found that agriculture was their most lucrative share of the business and began to focus exclusively on crop insurance. Their policies supplement the U.S. Federal Crop Insurance program (which generally covers about 60% of the total crop value). Michael Specter's article in *The New Yorker* describes how federal insurance disincentivizes innovations in crop yield:

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

> "As is often the case with American industrial agriculture, the incentives actively discourage innovation. The government calculates policy values based on a farm's average yields during the past several years. A farmer who produces a hundred and sixty bushels of corn per acre would normally be covered for about a hundred bushels. Anyone who pushes for a higher yield—two hundred bushels, for example—and falls short risks losing nearly half his crop without any hope of reimbursement. Few farmers can afford such losses, yet under the federal program they receive no additional insurance protection when they try to increase production or make operations more efficient."[163]

While providing data-informed supplemental insurance to farmers helped Climate Corporation to raise funds and grow their business to employ over 200 data scientists, data analytics remain at the core of their innovation. The company's mission is "to help all the world's farmers sustainably increase their productivity with digital tools." Their decision support software provides data on cu rrent and future field conditions that help farmers improve profitability by making better informed operating and financing decisions. In 2013, Climate Corporation was bought by Monsanto, the agribusiness giant with a controversial reputation, for nearly a billion dollars.

A Focus on Water

CropX combines IoT sensors with smart software to help farmers grow more produce with less water by better understanding the soil conditions, which may vary throughout a particular field, and adapt their irrigation accordingly. The sensors themselves cost $600 and the software costs $275 per year, but this investment can help reduce water use, saving money and overall resources.

Farming Drones

New technologies are also being used to collect data that can feed into data-modeling software. Drones, or Unmanned Aerial Vehicles, equipped with near-infrared and thermal sensors are also starting to be used by farmers to check on livestock, plant conditions and growth rates, by collecting and analyzing data, nearly in real-time. Drones can contribute to the collection of big data that can then be aggregated across farms to understand trends and the impact of farm management decisions.[164]

Agribotix is a leading agricultural drone manufacturer, and their software, FarmLens, utilizes image processing and analytics to report on crop health and provide decision support for when action is needed.

The impact of drones on agriculture has not yet been systematically studied, and their use is controversial and fraught with concerns about privacy and the desire for geo-fences that prevent drones from flying over certain residential areas, for example. Future studies should explore the extent to which drones and other precision agriculture technologies improve crop yield.

Tech Highlight

Satellite Technologies for Improved Drought Risk Assessment (SATIDA) App

What it does: SATIDA monitors weather conditions to provide drought risk assessment so that aid organizations can better prepare for periods of food insecurity.

How it works: SATIDA uses earth observation technology to monitor rainfall, temperature, vegetation and moisture to predict drought. This information is provided to humanitarian aid organizations to help them prepare for food insecurity that may be caused by droughts.

Why it's interesting: The app focuses on a practical and approachable use for earth observation technology.

What can be learned from the app: Complicated data can be more useful when made accessible and readable.

Created by: Austrian Research Promotion Agency

Website: https://satida.net

Cost: Free

Future of the app: The first product is still under development and will be an Enhanced Combined Drought Index. The company's next products will focus on three-month forecasts, a mobile Android application to access the forecasting and monitoring data, and a database that links all of these datasets together.

Farming Robots

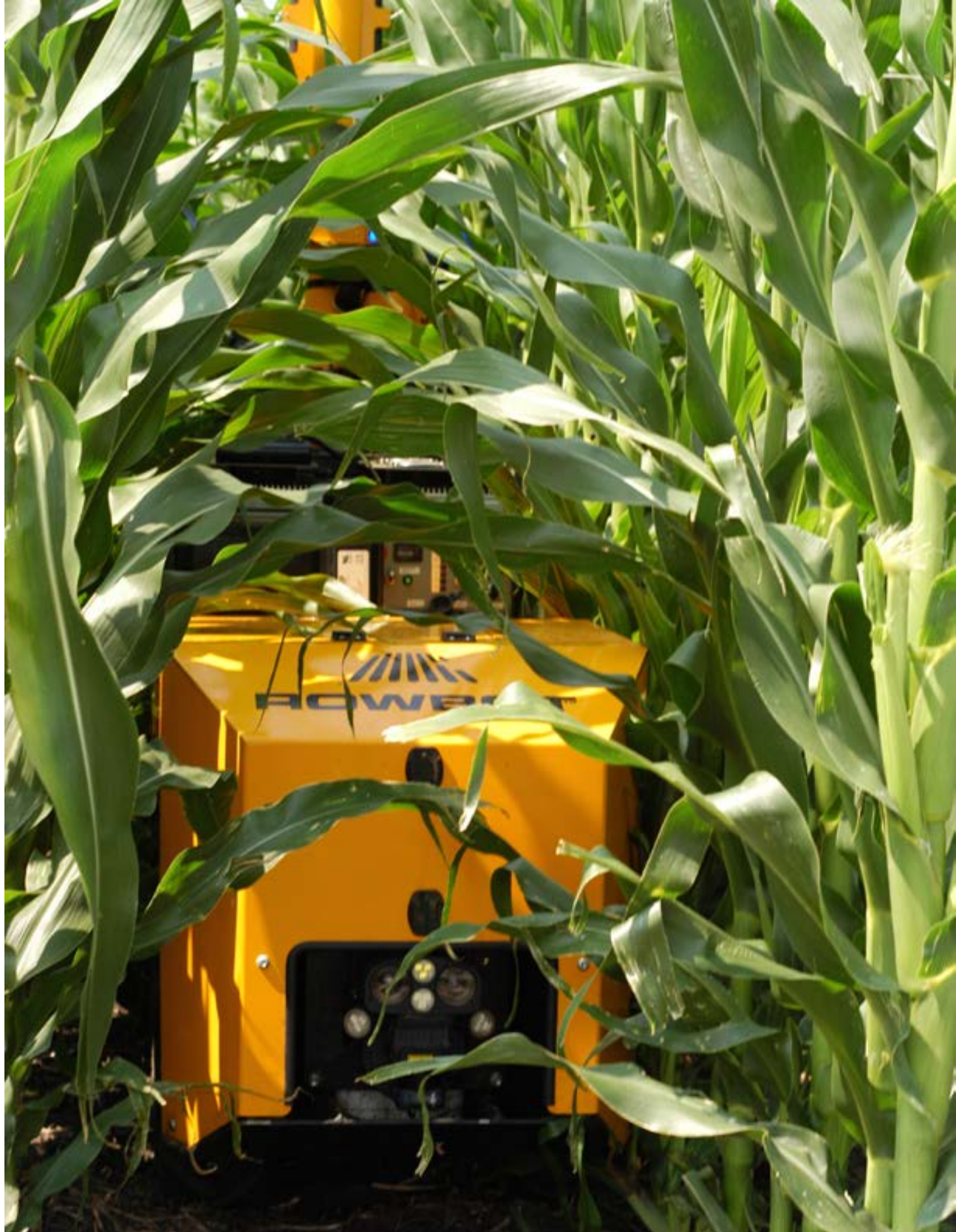
The Rowbot is a small self-driving machine that can fertilize, mulch weeds and sow crops on 50 acres per day. Using smart technology, it analyzes nutrient levels in the soil and drops fertilizer (including organic varieties) only when needed, resulting in less waste and runoff. It also collects data that can help farmers plan for current and future growing seasons.

Blue River applies robotics, machine learning and computer vision technologies to assess the needs of individual plants, helping farmers understand why one particular plant might be underperforming and adjust their care for the plant accordingly. While their current technology is specifically geared towards "See & Spray" chemical application, these types of technologies could be adopted for organic and true sustainable farming practices as well.

For the reasons described above and the ability to conserve resources while using less fertilizer and pesticides, precision farming can have significant impacts on reducing carbon dioxide emissions,[165] soil erosion and contaminated water run-off.

Farming Social Networks

Other technology-driven sustainable farming interventions have taken a social networking approach to smarter resource utilization. Farmstacker was an innovative start-up idea that capitalized on the successful models of the sharing economy and social networks including



online dating sites.[166] Farmstacker's product combined these concepts to pair young farmers with compatible farming operations ("eFarmony"), start-up capital ("Landing Club") and underutilized land ("AirBnBeef"), for example, multiple farmers and farming styles sharing the same land. Despite winning a 2013 hackathon with this idea, the app is no longer available.

While farmers have long recognized the benefits of mixed land use, the advent of social media and sharing economy apps have made it easier to connect those with land to lend with those with resources to share. For new farmers, start-up costs can be prohibitively high, and this type of model could help them leverage existing operations in a symbiotic way, such as raising chickens on unused pasture land, which helps to fertilize the grass and brings supplemental income to the farmer with spare land. This type of model directly supports the concept of sustainable intensification (growing more food with fewer resources), by promoting more diverse land use and increasing the food output of existing land. It can also encourage more young people to become farmers and help foster community among farmers.

Looking Forward: Tech Opportunities for More Efficient Agricultural Practices

Precision agriculture is one of the most promising solutions to sustainable intensification.[35,156,167] In general, precision agriculture technologies necessitate expensive equipment and highly technical skills for operation.[168] Several new technologies, including shrinking sensor sizes (e.g., microchips, like those found in smartphones) and Wireless Sensor Networks (combining those sensors through wireless signal connectivity), both key components of existing Internet of Things devices, hold great promise for reducing costs and increasing the reach of precision agriculture.[168]

A Mckinsey report estimates that the global market for agricultural robotics will grow from $1 billion in 2014 to as much as $18 billion by 2020.[169] As these devices become smaller and cheaper, precision farming can be used more broadly. Small farming machinery, such as the Rowbot, can help promote more sustainable, smaller farms that produce more diverse crops.

Farming is also extremely sensitive to severe weather and other environmental conditions such as droughts, severe storms, and insect infestations, and such instability and uncertainty requires preparedness and adaptation. Sustainable methods of agriculture include better soil and nutrient management, crop rotation, and diversification of fields, which leaves them less susceptible to pest infestations, thus requiring fewer pesticides.[151] The technology-fueled sustainable intensification of agricultural practices is of growing global interest, and has many downstream effects on maintaining a reliable food supply and long-term population food security. Technology can play a significant role in helping to meet the growing demand for food while reducing the environmental impact of such practices.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

What the Research Shows:

Precision Agriculture & Sustainable Intensification

A variety of studies have shown that agricultural production must double by 2050 to meet the projected needs of the growing global population, requiring an overall yield increase of 2.4% per year.[170-173] Using a combined database of over 2.5 million statistics, Ray, et al, analyzed current trends in crop yields for 4 key crops (maize, rice, wheat and soybean) and found that yields are increasing by only 0.9 - 1.6% per year.[174]

In a 2015 survey of crop input suppliers conducted by researchers at Purdue University, 82% offered precision services for applying fertilizers and pesticides, and automated precision technologies were used on 68% of the total acreage they applied their products to.[175] Satellite and aerial imagery (e.g., drones) were used by 51% of respondents, compared with 30% in 2011.[175]

Many agricultural policymakers and researchers are excited by the potential of Big Data to transform agricultural best practices. While more farmers are collecting data through Internet of Things-enabled agricultural machinery, drones, robots and other forms of artificial intelligence, these data are not yet commonly downloaded and shared. Indeed, many rural areas have limited cellular and broadband connectivity. The percentage of farmers using telematics, or the wireless transmission of data from machinery to online servers, increased from 7% in 2011 to 20% in 2015.[175]

An economic analysis of precision agriculture showed that while its use led to higher yields and gross revenue for farmers, the technique was more costly than traditional methods.[176] However, the majority of companies using precision agriculture reported generating a profit from techniques like soil sampling to assess nutrient needs before applying fertilizers and these trends are increasing over time.[175] A recent review considers the impact of decision support systems (which use algorithms to interpret data and make recommendations) in helping farmers make choices that are well-aligned with sustainable growth. The authors note that these systems have been developed without incorporating some of farmers' practical needs and their tacit knowledge. These systems thus may be perceived as overly complicated, tedious (e.g., requiring significant data input or having poor user interface designs) or not directly applicable to farmers' needs; furthermore, farmers may be hesitant to disrupt the status quo and learn new practices. [177]

In short, researchers and designers who are building technological innovations to address the problems of sustainable agriculture need to work closely with farmers to understand their needs and the way in which they can best apply the principles of precision agriculture and sustainable intensification while supporting and growing their businesses.

Home Vegetable Gardens

Household food production, including community garden plots, represents a small but important part of a sustainable food system, for those who have land, interest and time to keep a home garden. Internet of Things (IoT)–enabled devices are now available for home gardens to monitor environmental conditions, including soil nutrition, pH, moisture, humidity, temperature and sunlight. Some technology companies have targeted small farms and home gardeners in order to crowdsource and formalize data collection on growing practices and strategies that have traditionally been anecdotal knowledge. Growing one's food successfully can demand a lot of knowledge and careful monitoring, much of which can now be done using digital technologies.

Some start-ups have focused on IoT devices for small, outdoor gardens. The Edyn Garden Sensor connects to a home Wi-FI network and mobile app and cross-references the data with local weather and existing databases on plant and soil science to provide tailored guidance on things like choosing the right fertilizer, and which plants will grow best under local conditions. Edyn also makes a water valve that activates the irrigation system based on exact needs. In addition to these practical uses at the level of the home garden, the company is seeking to quantify and aggregate the anecdotal knowledge that farmers have about optimizing growth conditions and yield, particularly for specialty crops and varieties that are not mass produced or systematically studied.[178] Easy Bloom is another home garden plant sensor (which was sold to Black & Decker).

The FarmBot Genesis takes it even further by performing nearly all of the gardening work via a robot. The FarmBot works in conjunction with an app over Wi-FI to plant seeds, spacing and placing them optimally based on the plants' needs, and then precisely waters them, destroys weeds and monitors the garden's conditions. The developers created the Genesis as open-source so engineers and other developers could modify or add on to the product as they wish (e.g., adding a solar panel).[179]

Other models have brought IoT and aeroponic technologies indoors for household gardeners. Nanofarm is a computer-operated micro-greenhouse (like a scaled down version of Freight Farms or Growtainers) that can be used to grow herbs and other small plants. Nanofarm

completed a Kickstarter campaign in October 2016 to help produce its product after building a successful prototype and is available for preorder at $350. As part of the Kickstarter campaign, supporters who spent $450 sponsored the hand delivery of a Nanofarm to a family in need within a food desert. Nanofarm has the advantage of automating nearly all of the maintenance and care required during the plant's growth cycle.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Home Vegetable Gardens (continued)

Click and Grow has a product line of smart herb and vegetable planter kits that utilize aeroponic techniques and built-in sensors. These smart containers are essentially an "idiot-proof" way to grow fresh produce; the container simply needs to be plugged in and filled with water, and the smart sensors and internal aeroponic system monitor growth conditions while automatically taking care of the growing plants' needs. Its basic herb box with three basil refills retails for $59.95, while its full indoor "wall farm" with three vertically stacked rows of herbs, fruits and leafy greens, retails for $799. The company markets to restaurants, schools and even grocery stores, in addition to households.

Garden Pool is a nonprofit organization founded by a family in Arizona who turned their backyard pool into a closed-loop, fully sustainable mini-farm that uses 98% less water than traditional farming methods and has almost no external inputs. Garden Pool teaches other households how to build their own systems, while conducting research and education on sustainable food production. As new technologies make it easier, more efficient and cheaper to grow food on a small scale, these methods could contribute an increasing percentage to the food supply.

Farm from a Box is delivered as a "turnkey farm kit" full of modern technology-enhanced features, such as IoT sensor technology, micro-drip irrigation, Wi-Fi and cloud connectivity, and geo-spatial data mapping software to help farmers make decisions. The kit supports an outdoor farm on up to two acres of land. Farm from a Box can be operated completely off the grid, and is powered by renewable energy, including solar panels. The company advertises potential uses that include Community Supported Agriculture initiatives, providing food in urban food deserts, food and science education, and farm-to-table food for restaurants or businesses.

Looking Forward: Tech Opportunities to Advance Home Gardening

IoT-enabled gardening sensors and home farming machinery can be quite expensive for the home gardener; the first production batch of the FarmBot came on the market in February 2017 at a cost of $3900. However, over time, innovation and advancing technology generally result in better products at lower prices.[180]

If these products become more accessible to the average consumer, the ability to eliminate the challenges in successful gardening could encourage more widespread adoption of home and community gardens for food production. Aside from the technology investment, home gardening can be a cost effective way to procure produce. Home vegetable gardens can also represent a supplemental source of income for households who grow more than they can consume.

Transportation & Logistics

Background

While growing and producing food is the foundation of the food system, a critical step lies in the connection between farmers and retailers, and how food gets from farm to fork. The invention of refrigerated trucks in 1939[181] dramatically changed the shipping and grocery industries. Fuel subsidies and harvesting methods geared toward longer transportation times have made it cheaper for food producers to transport their products over long distances. A commonly cited but misunderstood statistic claims that the average vegetable travels 1,500 miles from the farm to supermarket.[182] This study had many limitations, however, the idea that food, and especially produce, typically travels a long way before arriving on a supermarket shelf, regardless of where one is purchasing it, holds true.[183]

Produce is often harvested well before its optimal ripeness to accommodate these long transport times (although vine-ripened produce is generally richer in both nutrients and flavor).[184-186] Along the supply chain, food is stored in warehouses and/or processing facilities before being transported directly to a grocery store or food service business.

Consolidation within the industrial agriculture system also contributes to longer transport distances as products pass through centralized warehouses and processing facilities en route to retail locations. Tracing food through the typical system, it follows a convoluted path from farmer to broker to wholesaler to delivery company to restaurant/grocery store or other food retailers. This complex system results in many changes of hands, and thus accumulation of fees and companies taking their cut as the food is transported, stored in refrigerators and transported again.

Competing with the industrial food system is a challenge for small and mid-sized farmers and producers, given the lack of available distribution infrastructure for operations of their size. Small farmers or ranchers often utilize direct-to-consumer outlets to market and sell their products (e.g., farmers' markets and community supported agriculture [CSAs]), but lack the volume and consistent supply desired by most retail and foodservice customers. Mid-sized farms are too large to profit solely from direct-to-consumer models, but are too small to compete in the wholesale market.[187] However, newer models such as regional food hubs (discussed below), and the application of technology can help increase the connectivity and efficiency within the food supply chain, similar to how Uber has increased connectivity and efficiency within the transportation industry.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

How Technology Facilitates Transportation of Food

Across all levels of the food system, food must be transported from point A to point B, whether by a large industrial farm or a local food bank distributing products to food pantries. Google Maps and other navigation tools such as Waze (an app that crowdsources traffic data based on GPS and accelerometer data from its pool of users) have become nearly ubiquitous among drivers for identifying the most efficient route.

The Google Maps API released a predictive travel time feature in 2015 that estimates travel times on a future date by analyzing historical time-of-day and day-of-week traffic data. These data can be incredibly helpful to truckers and those involved in the transportation and delivery of food products, particularly in high-traffic, urban areas. Predicting how long it will take for a certain delivery route, and which alternate routes might be faster at particular times of the day, can help organizations strategize how and when they make pick-ups and deliveries.

In addition to planning, this information can also be helpful for moment-to-moment operations; mobile computers in vehicles combined with GPS not only help logistics coordinators track locations, but can also be used to receive dispatching information in real-time. This can make delivering food products to new locations (e.g., food deserts) in densely-populated urban areas more efficient and cost-effective (e.g., saving staff time and fuel costs).

Other companies have attempted to "Uber-ize" the regional trucking industry. The traditional short-haul shipping system, for transporting food and nearly every other commodity, typically involves dozens of phone calls between trucking companies looking for goods to ship, or companies looking for space on trucks.

Convoy offers a real-time, full-service trucking technology that allows shippers to get upfront quotes and to pay carriers through the app, eliminating the time delays associated with the traditional invoicing process. Seeking to digitize the role of a traditional "broker," the app can provide increased transparency in pricing and helps to match-make trucks with cargo, eliminating unnecessary downtime by making those connections in real time. Cargomatic tried, without much success, to develop a technology that would pair cargo that needed transport to trucks with extra space, also promising a real-time tracking system, however, its model struggled to take hold.

Software for Large Farms

The transportation of food products, many of which are perishable, requires complex logistics, particularly with regard to the quantity of food transported, how long it takes to reach its destination and the way in which it is stored. Halo is a software logistics company that provides mobile supply chain applications for a variety of industries. The company uses big data analytics that combine historical supply, demand and sales data, and uses that in conjunction with current data to help companies make decisions.

Tech Highlight:

Are Self-Driving Trucks the Way of the Future?

Otto, a self-driving truck company bought by Uber soon after its 2016 launch, made its first test delivery in October 2016, delivering a truckload of Budweiser from Fort Collins, CO, to Colorado Springs, CO, between 1 and 3am. Its system, which can be retro-fitted to existing truck rigs with automatic transmission, includes a high-precision camera mounted above the windshield, a radar device on the front bumper, and laser detectors around the perimeter of the truck, and self-drives only while on the highway. A driver is required for all non-highway driving as well as merging on and off the highway, but while on the highway, the driver is free to catch up on paperwork, or even take a nap. If the driver can sleep while the truck makes long-haul highway drives, this could increase the current capacity of trucks and drivers that are already in operation. Uber has since abandoned its interest in Otto and self-driving trucks to focus on self-driving cars.

There are still improvements to be made and countless rounds of tests and iterations required before driverless trucks operate during busier hours and over longer distances. However, driverless trucks, a concept that many believe will become ubiquitous in the near future, could help reduce traffic accidents (in the United States there are approximately 400,000 truck accidents each year, resulting in 4,000 deaths) and help fill the truck driver shortage, which is estimated to be around 48,000, according to the American Trucking Association.[188]

Self-driving cars are not yet foolproof: a Tesla driving in auto-pilot mode resulted in a fatality in 2016[189] and an Uber self-driving taxi collided with a turning vehicle while driving through a yellow light in March 2017, leading Uber to suspend its program.[190] Despite the fact that both of these collisions involved cross traffic and/or unusual situations that are not applicable to typical highway driving, self-driving car and truck technology requires further refinement before it can become a reliable and safe alternative to full-time human vehicle operators.

For example, the software has a Supplier Risk Profile and Ranking algorithm that looks at historical data from one particular supplier and its ability to consistently fulfill orders. Halo can send an alert if there is a disruption on the supply-side so the company can make proactive decisions about how to fill that gap to prevent adversely impacting its level of service. Halo's platform also helps to forecast sales (which promotes better inventory planning).

Taylor Farms, one of the world's largest producer of fresh-cut vegetables, uses Halo to develop national cost comparison tools that can identify which products have faster inventory turn

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

over, or to analyze packaging and warehousing data to identify cost-saving ideas. General advantages of digital technology include real-time data management, remote and in-the-field access to those data and improved visibility of the production process through dashboards and reporting tools (all without having to go through the IT department to gain access to data), resulting in increased cost effectiveness and better compliance.[191] While these enterprise-level software platforms may be out of reach for small food organizations and nonprofits, these models have helped to push the technology forward, and can serve as models for start-ups.

How Technology Assists with Supply Chain Logistics

Software That Helps Farmers and Producers Manage Their Businesses

There are a number of software applications designed to help farmers with their business, from managing "paperwork" and accounting to helping identify buyers for their products.

For example, FarmersWeb offers software for farmers and artisanal food producers to streamline their transactions with wholesale buyers like restaurants or schools. The software helps farmers create product catalogs that enable buyers to purchase directly from the farms with just a few clicks. It can also automate much of the accounting paperwork (e.g., invoices, bulk order pricing calculations), and coordinate deliveries and logistics. For example, farmers can enforce order minimums or lead times, or coordinate deliveries with neighboring farms. FarmersWeb offers a basic plan for free, as well as plans with additional features that range from $40 to $75 per month (or alternatively, a plan that charges a 3% commission on sales instead of charging monthly).

While some technologies are applicable to farms of any size, others are geared towards small or mid-sized farms that can specifically benefit from increased exposure and technology-based tools and resources. An example of technology used by small, independent chicken farmers is Eggzy, a flock and egg production management tool. Eggzy's free software helps to record expenses, calculate and project costs, promote farmers' flocks and connect with local buyers.

Online Direct-to-Consumer Models

There are a number of online direct-to-consumer platforms that enable farmers to sell directly to consumers. Web-based resources help farmers take advantage of the farmers' market model by providing a platform for farmers to create their own online market (locallygrown.net/) or help organize and manage a farmers' market (managemymarket.com/) by facilitating online vendor registration, licensing and mobile payments.

Crowd-sourcing Data:

A Farmer-Owned Data Cooperative

Aside from making day-to-day operations easier and reducing the burden of paperwork, the use of software can automate data collection. Farmers, like other business-owners, can garner important insights from big data.

One interesting idea is the notion of a farmer-owned data cooperative. Building upon Internet of Things solutions for collecting real-time agricultural data, which can improve crop forecasting, a strategy analysis conducted by Justin Sherrard at Rabobank proposes the concept of a farmer-owned data cooperative.[192] Farmers are already sharing their data with processors or suppliers, but these data are not integrated with data from other suppliers or farmers. Sherrard's idea of a farmer-owned data cooperative model proposes a de-identified database for farmers to share data that inform supply chain decisions.

By crowd-sourcing data on crop performance and improving forecasting models, both growers and retailers can "optimize inventory management and pricing… improving market [transparency] and support for farmers' marketing decisions." [192] For example, if a farmer has a very successful tomato crop one season, she might notice in the dataset that other local farmers had a low yield for their tomato crops and might take a risk in lowering her prices to secure a large wholesale order.

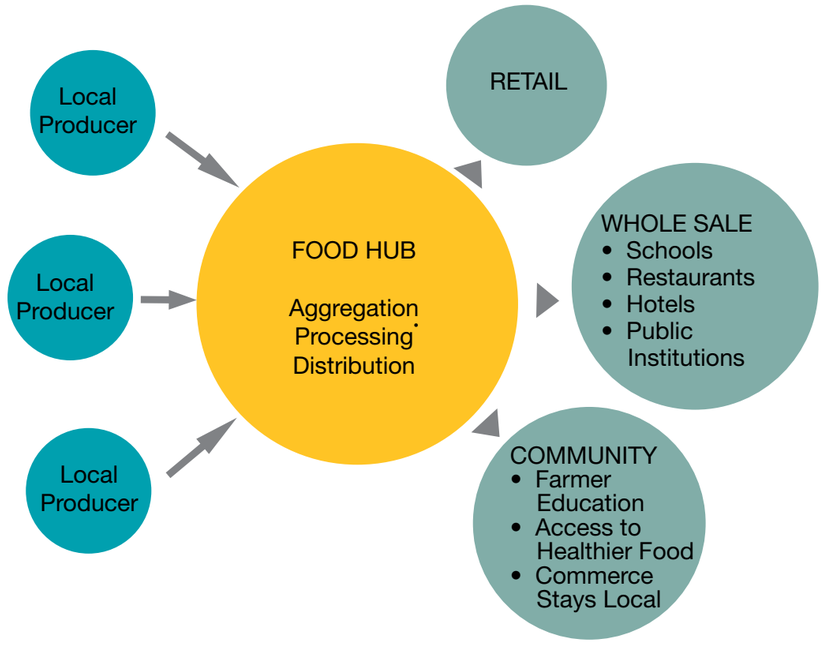
HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Food Hubs

Background

The increasing demand for local/regional food from individual customers, as well as those with more buying power, such as grocery stores and restaurants, has helped spur the development of regional food hubs. Regional food hubs serve to aggregate, distribute and market foods from food producers within a particular region to distributors and wholesale buyers (or even directly to consumers).[187]

Food hubs operate in a variety of models, including farm to business/institution, farm to consumer and hybrid models, and while 40% are privately held, 32% are nonprofit and 21% operate as cooperatives.[187] Some food hubs have their own retail markets with a farmers' market, co-op or wholesale warehouse from which customers can buy directly, eliminating an additional transport step.



A FOOD HUB FOR NYC:

Supporting Local Agriculture

In the summer of 2016, New York State Governor Andrew Cuomo announced a program to promote (and certify) locally grown and produced foods. This program includes plans for a $20 million food hub in the Bronx designed to increase access to fresh and locally grown produce in New York City.[193]

The Greenmarket Regional Food Hub will house a wholesale farmers' market, allowing New York State growers to sell and distribute their products to mid-sized customers, such as senior centers, soup kitchens, and restaurants. The food hub will accept products from small and mid-sized farms and businesses, allowing them to aggregate their products to meet the needs of New York City's population, and access a wholesale market that they otherwise could not compete in against large-scale farming operations, many of which are from out of state.

The food hub will have state-of-the-art infrastructure that supports the needs of local food businesses, such as regular and cold storage, food processing facilities, and transportation and logistics support, including distribution vehicles. Having access to shared distribution vehicles, for example, will save considerable time and money for farmers who would otherwise have to drive into the city themselves to sell their products, facing traffic, fuel costs and parking challenges.

Access to these resources helps keep costs down for the farmers, resulting in lower prices for the wholesale consumers. This significant infrastructure investment promises to bring 245 jobs to the community (95 of which are permanent) and seeks to increase access to high-quality, nutritious, fresh and local food products for underserved communities.[193]

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Grocery stores and other large purchasers rely on consistency and volume to meet customers' demands, which have been shaped by industrial agriculture's ability to supply a wide variety of produce anytime, anywhere (albeit produce that has traveled thousands of miles while ripening during transit).[194] Indeed, "local" has become synonymous with "fresh," and more consumers seek to eat locally grown food than organic food.[187] However, wholesale purchasers, like grocery stores, food service/catering operations and restaurants, seek large volumes of products while minimizing the number of transactions involved in obtaining those products, as fewer transactions require less coordination and administrative work. Thus, food hubs fill an important and growing role in the food system by streamlining the logistics involved in connecting small producers with large buyers.

How Technology Helps Food Hubs

Digital technologies have made communication more cost-effective and instantaneous, inventories easier to track and manage, and allowed for greater ease in data collection and sharing. Electronic payments can make transactions possible with just a few clicks and software can streamline business operations via automated tracking, accounting and forecasting.[187]

Matchmaking Between Producers and Buyers

FoodHub is a food business social networking platform that helps facilitate matchmaking among food buyers (e.g., chefs, food service directors), wholesale producers, distributors and industry suppliers in California, Oregon, Washington, Idaho, Montana and Alaska. Of its 6,600-plus members, 40% are buyers, 37% are sellers, 20% are associates (including miscellaneous other stakeholders like media, logistics and transport providers, NGOs, governments and academic institutions) and 3% are distributors. FoodHub has been described as the "Craigslist" of the regional food movement.

Supply Chain Platforms

Other companies have built comprehensive software platforms for food hub management. Local Orbit is a Michigan-based software company, founded in 2011, that built a supply chain platform for a variety of "connected food" organizations, including food hubs, aggregators, coops and, more recently, non-commercial foodservice operators (like schools, hospitals and museums). Its mobile-adaptive online software allows food aggregators to manage transactions with suppliers (local farmers/producers) by consolidating orders and payments, streamlining communications between buyers and sellers and supporting the logistical needs along the supply chain. The company also provides data analytics tools, such as dashboards, and networking resources.

By connecting many smaller food aggregators and suppliers, Local Orbit can leverage existing resources by filling empty truck space. In 2015, the company launched its LocalEyes platform, which is geared towards large institutional food services, an industry that spends $48 billion annually on food.[195] As of 2016, Local Orbit had a network of 12,500 buyers and suppliers and has helped promote 560% annual growth in local supplier sales. The software starts at $39/year for farmers, $399/year for small and start-up food hubs and co-ops, and $799/year with additional features for larger food hubs, with a custom pricing model for enterprise accounts.

Local Food Marketplace has built flexible technology that can be adapted and branded to any organization. Its "comprehensive, fully integrated platform [allows] food hubs to plan, sell and distribute local food." Food hubs' customers, typically wholesale buyers, can make orders from a computer or mobile device, and can select from "recently ordered items," "favorites," and suggestions based on other items in their cart; these recommendations are easily calculated by Local Food Marketplace's algorithms. Farmers and producers can use ready-built customer, sales and supply/demand reports to help them make business decisions, as well as print packing slips, delivery reports and manage customer service support through its platform. Its pricing plans include one-time setup fees ranging from $499 for start-up food hubs or co-ops, up to $1,499 for large enterprise hubs; on top of that they charge a monthly subscription of $79 to $599, billed annually.

Other examples of apps that help manage food hubs are FoodHub Pro and Farm Logix.

Online Buying Clubs & Co-ops

Growth in the food hub model has been met with innovations from the purchasing side as well. Online buying clubs are a way for a group of people to leverage its collective purchasing power to gain direct access to high-quality produce and food products directly from farmers and producers. These models are often owned by members who volunteer their time and effort to support the operations. Software has made this process more efficient and easier to scale.

The Oklahoma Food Cooperative, founded in 2003, is a producer- and consumer-owned food hub that was one of the earliest examples of an internet-buying club.[196] Its current model sells over 5,000 food products from over 100 Oklahoma producers. Consumers place online orders during the first two weeks of the month and those orders are fulfilled and delivered for pickup at specific locations throughout the state during the third week of the month. A lifetime membership costs $51.75, an annual pass is $25, and a monthly pass is $6 (with membership grants available for low-income households). Individual orders are paid for either online at the time of purchase or at pick-up by credit/debit card or check (at the time of publication, cash and EBT were not accepted).

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

The Oklahoma Food Co-op relies heavily on the Internet to connect people across the state in real time, at a low cost.[196] Consumers and producers both pay a 10% fee to the co-op, but producers have no minimum volume requirements and are permitted to set their prices through the website. By allowing farmers to pool crops and food products and offering central pick-up locations for these aggregated orders, the Oklahoma Food Co-op has been able to maintain a successful model with steady growth, moving from a volunteer-reliant system to one that now has paid staff and dedicated trucks.

The Co-op's software was developed under a general public-use license, meaning that the code and any subsequent updates are publicly available. It quickly spread to co-ops in other states and the software, now called Open Food Source, is applicable to a wide range of organizations that sell goods to many buyers. It is most commonly used for online farmers' markets and buying clubs, where sellers can post photos and descriptions of products sold by volume or weight, manage their inventory, accounting and general finances, as well as track sales and generate pre-populated shipping or routing labels for distributing the goods.

Coopdirectory.org has a list of local food co-ops throughout the United States as well as in Canada, Australia, Northern Ireland United Kingdom. There are several online guides with suggestions for how to start a cooperative buying club, like startabuyingclub.com and foodcoopinitiative.coop.

Case Study:

Food Hubs and the Market Economy

While food hubs and co-ops generally help keep prices down for consumers, in some circumstances the increased variety of choice allows producers more flexibility in setting prices. An interesting effect of the co-op model in Oklahoma is that "competition" online actually helped producers to *raise* their prices because they were competing in terms of quality rather than simply who had the best price.

"With no restrictions on price setting or volume requirements, the Oklahoma Food Cooperative is in many ways a perfect example of the free market in action. The internet-based ordering lubricates this action as consumers and producers interact across wide distances in real time, adjusting their purchases and offerings in response to market signals. In general, the combination of the software interface, the laissez-faire approach to pricing, the month-long open order window, and the large number of producers and consumers (3,800) allows for a fluid, functional marketplace in which buyers and sellers are able to meet their needs in a transparent and highly accountable trading system."[196]

Tech Opportunities to Strengthen Food Hubs

Food hubs represent a way for producers to join together in order to share resources and combine their market share. In conjunction, the model of a buying club, in which a group of people band together to buy in bulk directly from farmers or other producers, cuts out the middleman and can help keep costs down. Digital technology offers new ways for consumers to link up to take advantage of combined purchasing power and can help push models for buying directly from producers into new markets, in essence serving as a next-generation CSA. Social media can be a powerful way to organize neighbors and other social networks around this sort of model. Equipped with wireless terminals at the pickup points, these programs can accept EBT, and have locations within food desert areas or underserved communities.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Supply Chain Innovation

The Food to Market Challenge

The Food to Market Challenge was a 2016 supply chain competition with the goal of improving access to local and sustainable foods in the Chicago area. The winning team, "Team Leverage," was a collaboration among three existing food innovators that proposed to create a scalable model for bringing nutritious local foods to underserved communities:

Top Box Foods creates and delivers healthy and affordable grocery boxes to food-insecure neighborhoods in Illinois and Louisiana at prices that are approximately 40% below retail. Boxes are available for pick-up at set times and locations and the program accepts SNAP benefits paid at the time of pick-up. The second partner, This Old Farm, is a food hub network of sustainable farmers and producers. The third partner is FarmLogix, a software solution that connects farmers with buyers and food hubs, facilitates online orders, and provides tools for inventory, pricing, logistics, invoicing and reporting. Team Leverage won $500,000 to build out their idea.

This sort of interdisciplinary collaboration can be an important driver of innovation by bringing together different experiences and skill sets within a particular sector to think about problems in a new way. Renne Michaels, Vice President of Kinship Foundation, one of the challenge sponsors, reflects, "we're excited… to see the momentum that has built behind all of the [challenge] ideas. The energy that the Challenge has brought to farmers, nonprofits, small businesses, and others all along the supply chain has been remarkable. We hope to continue to see ripples of collaboration and innovation in the sector in the months ahead."[197]

The food hub model is having a growing impact on the purchasing power of local food producers. Building on the momentum of the local food movement, the University of Maine committed to having 20% of its food sourced locally by 2020. A local Maine-based food co-op that was bidding for the contract was credited with influencing food service giant Sodexo to meet that goal, and promised 20% local food within the first year, with up to 30% by 2020. Sodexo's contract will replace the mammoth Aramark's 10-year agreement with the University system, and solidifies Sodexo's move towards greater transparency and shortening supply chains.[198] The University of Michigan is also under a mandate to source 20% of its food products sustainably.[195]

Tech Highlight:

The Real Food Calculator

Further driving their mission of transparency in the food supply chain, Sodexo has partnered with the Real Food Challenge to make information on their products available to the students and universities they serve. The Real Food Calculator is a web-application that tracks products used by food service companies, evaluating them on criteria that include locality, ecological soundness, and humaneness. The Calculator assigns a color-coded rating system (green/yellow/red) to classify foods as "real." Disqualifying, red-labeled foods are tied to poor treatment of animals, workers, or the environment.[199,200]

The Real Food Calculator allows those in charge of food service decisions and interested consumers to make purchasing decisions based on environmental and ethical considerations. Making such data available to consumers is an important way to promote transparency and accountability throughout the food system.[199]

The food sector is a key contributor of jobs and has great potential for creating and sustaining jobs that "pay a living wage, offer safe working conditions, promote sustainable economic development, [all while] making healthier food more accessible"[201] Programs such as the Real Food Challenge, which highlight food companies with ethical employment practices, can help promote fair labor principles on a larger scale. (See the NYC Food Policy Center at Hunter College's report Jobs for a Healthier Diet and a Stronger Economy.)

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

The Sharing Economy for Smaller Farmers

Another innovative development is the application of sharing economy models to supply chain resources. Some start-ups have capitalized on the concept of "wasted space" within the supply chain in which food warehouses sit partially empty. FLEXE is the "Airbnb for warehousing," and its digital marketplace connects customers in need of storage with landowners who have spare warehouse capacity.[202] Its cloud-based platform can improve inventory management problems, such as handling seasonal variations in inventory (e.g., summer produce, like tomatoes, that have a shorter shelf-life versus large, bulky stocks of fall/winter produce, like squash, that can be stockpiled).

A start-up launching a new food product in the spring may not have the resources for a long-term warehouse lease, but could take advantage of a Christmas-decoration warehouse that is sitting empty in the off-season.[203] Offering up empty warehouses is a cost-efficient use of existing resources (from staff to electricity to forklifts), and offers considerable flexibility for small companies; space can be leased down to the size of one pallet. FLEXE's current network of over 200 warehouses in 39 US states and 5 Canadian provinces has a total available capacity of 400,000 pallets. The company also streamlines business processes involved with warehousing, such as contract management and insurance transactions.

Supply Chain: Lessons Learned

The literature on supply chains is vast,[204-206] but this report highlights some key lessons learned that are most relevant to feeding an urban population. Software logistics companies, like Infor, a competitor to Halo, claim to gain companies 20% higher gross margins, 35% shorter cash-to-cycle times and 15% less inventory by "[optimizing] the supply chain, from forecasting to production to customer delivery to boost profits. [They also] account for volume-based constraints, such as tanks, ovens and freezers, to maximize throughput, [improve] productivity and [reduce] waste."[207]

Supply chain innovation can help those involved in every stage, including on the retail side. For example, the founder of Dig Inn, a farm-to-table franchise in New York City, describes how "by weaving innovative tech into everything we do—from accounting and data analytics, to people management and forecasting—we're able to maximize our efficiency and invest meaningfully… Forecasting, menu performance analytics and planning and inventory management tools help us accurately predict our needs and the needs of our [farmers and partners], which allows us to develop mutually beneficial menus."[208]

Cargomatic App:

Challenges in Disrupting an Entrenched Logistics System

Certain start-up companies have learned that a firmly rooted supply chain can be difficult to disrupt. Cargomatic set out to become the Uber and Lyft of trucking, pairing cargo haulers who have extra space with shippers, offering both pre-arranged and on-demand pickup services.[209] The company launched in 2013 in Los Angeles and opened in the New York region in the summer of 2015 before expanding to San Francisco. The company quickly noted the challenges inherent in trucking in New York City compared to Los Angeles: tolls, bottleneck river crossings like bridges and tunnels, snow and even different trucking terminology.[210]

Despite what seemed like consistent growth, Cargomatic struggled from a density problem, with weak demand for its product and slow adoption of the app. Furthermore, the company struggled to maintain repeat customers through the app; the random fluctuations that lead to having excess freight were inconsistent and impossible to predict. It eventually pivoted, finding more business opportunity by functioning like a traditional truck brokerage business.

At the root of the issue was that its mobile applications were not performing as intended, and they were unable to keep up with the company's core technology model. Cargomatic's customers were drawn to the idea of having real-time data to track their shipments, rather than waiting for a warehouse employee to call, notifying of the freight's arrival. Yet the application could not deliver on this promise, and Cargomatic staff were actually manually inputting data into the app. A former employee recalls, "It was a show-game. Customers thought this process was automated, but we were asking people behind-the-scenes to make it look automated."[210]

While the tremendous success of Uber has inspired "copy-cat" models in other industries, there are inherent challenges in the transportation logistics industry due to the number of players and the business model itself (business to business rather than individual to individual). "When you're moving freight, you have six different players touching the cargo. The cargo is worth X, there's insurance, the driver, the dispatcher, pickup at the warehouse, drop-off with the warehouse manager, sometimes there's a broker, a shipper. Things happen all the time—the cargo is not ready, the truck broke down, the driver needs to rest because he drove 12 hours—all that type of stuff makes it more complex than on the consumer side."

However, with any start-up, there are a myriad of factors that influence success, many of which have nothing to do with the success of the technology itself. With the fragmented and inefficient short-haul trucking industry claiming an annual revenue of $77 billion, it remains an area ripe for innovation.[211]

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Looking Forward: Tech Opportunities to Ease Supply Chain Challenges

Improved transportation logistics and real-time updates have a wide range of implications. For example, imagine a food bank that uses an app (see Part 1, Health Tech & Food Insecurity) to solicit donations based on current needs in real-time. A potential donation is identified through the app by a local supermarket that has an oversupply of tomatoes, and a food bank's truck might be out making deliveries to a small food pantry around the same time. GPS and Google mapping data could help identify where the truck is, and where that restaurant is in relation to the current route. It could then send an alert to the driver's phone and even automatically re-route the truck so that it passes by the restaurant on the way to the food pantry.

As with many software products, the increased ease of data collection enables new uses for such data. Technology enables increased transparency across a variety of industries, and consumer demand for more sustainable food products is increasing. A marketing survey found that 94% of respondents reported being more likely to be loyal to a brand that has full transparency, particularly when it comes to food products.[212]

Whole Foods specifically hopes to use Infor's supply chain technology to track data on the amount of water used to produce a particular product, for example, and leverage that data to market the products.[213] By passing those data on to customers, who compare two boxes of lettuce and see that hydroponically grown option uses 95% less water,[113] the customer may be more likely to buy the option from a nearby vertical farming operation, in turn supporting sustainable business. A caveat is that these store-generated labeling systems can be skewed for marketing purposes in a variety of directions and may detract from other differences between the products, such as nutrient profiles.

Indeed, companies like Whole Foods have helped meet the growing consumer demand for local, sustainable and ethically produced foods. While Whole Foods caters to a high-income population, growing awareness of sustainability metrics can help push reform across the food system. These types of data can have an impact on the supply side as well. Companies like Nestle use Software-as-a-Service company EcoVadis's platform to track metrics on supplier sustainability, which in turn helps the suppliers improve their performance.[214] This transparency and accountability, with clearly traced data on how and where food products are produced, could begin to put pressure on the industrial food system to pursue more sustainable methods.

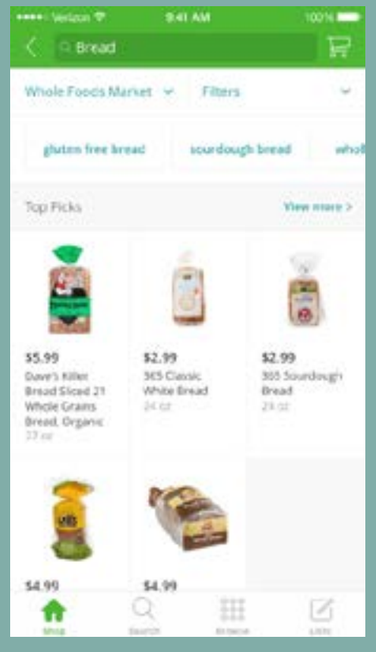
New and Innovative Online Food Retail Models

Online Ordering and Delivery from Brick-and-Mortar Stores

Given the popularity of web-based grocery delivery companies like Peapod and Fresh Direct (see p. 28), new models have emerged. **Instacart** is a company that facilitates online or app-based ordering of products from specific local grocery stores. Rather than using dedicated employees with their own delivery vehicles and warehouses, Instacart employs couriers who go to the brick-and-mortar store, buy the requested items and deliver them within a predetermined window.

As a technology platform, Instacart can help existing retailers (e.g., Whole Foods, Food Emporium, Costco) sell their grocery products online. Smaller, independent retailers like food co-ops can also take advantage of Instacart's platform to sell their products. Rainbow Grocery in the California Bay Area, Central Co-op and Puget Consumers Co-op in Seattle, Harvest Co-op in Boston and Good Grocer in Minneapolis all use Instacart to expand their membership base beyond the catchment area of their local stores. Co-op members can enter their membership number into Instacart to receive the same discount they would receive in stores.

One food co-op in Portland, OR, Food Front, began selling through Instacart, which helped offset the impact of a large chain grocery retailer opening down the block from their flagship location; with Instacart, the co-op can deliver groceries to customers anywhere in Portland within two hours.[215]



What the Research Shows:

The Future of Online Grocery Shopping
While online grocery market share was only 3.5% in 2014, forecasting models suggest that it may be as much as 14% by 2023,[216] and could be a $9.4 billion industry by 2017.[217] Of those who already shop for other products online, one third anticipate buying groceries via the Internet in 2016.[218] Online grocery shoppers cite reasons such as saving time, money and gas, or ordering items in bulk.[219]

Google has also come up with its model, Google Express, which began including perishable food items in early 2016. The company works with retailers like Costco and Walgreens and employs drivers to pick up and deliver the items. In some areas, Google Express offers same-day delivery; all orders are delivered within three days. For non-members, Google Express charges $4.99 per store for a delivery fee; memberships cost $10 per month or $95 per year.

In their current iterations, Instacart and Google Express are not viable alternatives for low-income households. On top of the expectation to tip one's delivery courier, Instacart charges a delivery fee.[220] Wealthier households are willing to pay this premium for a personal grocery shopper and the convenience of ordering through an app. Instacart, as its name suggests, meets the need for "on-demand" groceries, often fulfilling orders placed within one to two hours.

Is there a way to apply an Instacart-like technology platform to make grocery shopping more convenient and accessible in underserved areas? For instance, this type of software could be used to aggregate orders from public housing residents to make wholesale or bulk purchases from a local food hub, delivering the groceries to a central location.

On-Demand Food Delivery Services

Amazon's proven success with online delivery logistics made them an obvious choice to enter the on-demand food delivery market. Amazon Prime Fresh is a supplement to Amazon's Prime membership ($99 per year, which covers free 2-day shipping). For an extra $14.99 per month, Prime Fresh customers get free same-day delivery on all grocery orders over $50.

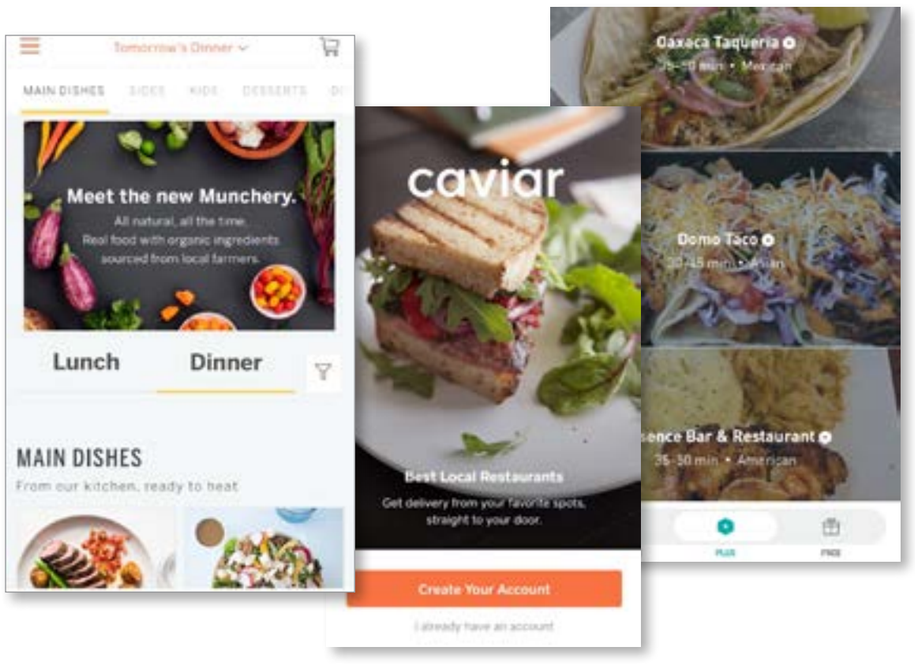
Amazon even offers the Amazon Dash, a small device with a microphone and barcode scanner that allows consumers to dictate their shopping lists, or add items to their shopping cart by scanning barcodes on products in their home that are running low.

Obtaining food "on-demand" is most often associated with ordering prepared foods from

restaurants for take-out. Early online food delivery platforms include Seamless, founded in NYC in 1999 and Grubhub, founded in Chicago in 2004. The two have since merged into Grubhub, Inc. While these services offer a convenient way for customers to browse menus, place orders and pay online, Grubhub/Seamless charges restaurants an approximately 13-30% commission (with higher commissions resulting in a restaurant appearing more prominently in user searches); the company pushes back when restaurants raise their prices for take-out, promising restaurants that increased volume will make up for the lower profit margins. The long-term effects of online delivery on restaurants are uncertain, and should be weighted against low wages and misdirected tips for delivery staff; for example, one restaurant owner in NYC withheld $15,000 worth of delivery staff's tips from orders placed through online platforms.[221]

There are many competitors, including delivery.com, Postmates, Yelp's Eat24, Caviar, Uber Eats and Amazon Prime Now. Some of these models provide their own delivery staff. Uber Eats capitalizes on Uber's proven logistical efficiencies and was able to use their existing network of bike messengers and "taxis" to deliver food from select restaurants.

Other companies like Munchery focus exclusively on delivering meals and do not have brick-and-mortar restaurants. These models will be further discussed in a future report in this series (Part 5, Health Tech & Diet-Related Diseases).



Online Wholesalers

Thrive market is an online retailer that takes a different approach, adopting a Costco- and Sam's Club-like model that charges a $59.95 annual membership fee for wholesale prices on groceries and household products. The retailer offers free shipping on orders over $49 and delivers to 48 states (excluding Hawaii and Alaska). Thrive emphasizes natural and organic products and also has a philanthropic approach; it gives a free membership to a low-income family, teacher or veteran for each membership purchased.

Large corporations like Amazon and Google could use a similar model to subsidize their grocery delivery memberships for underserved communities.

Farm to Household

Other companies have taken a community supported agriculture (CSA)–like approach to bringing farm-fresh products directly to consumers.

Farmigo is a company that began by building CSA management software, helping subscribers place orders through an online portal while streamlining payment and order management on the back end for the farmers. In 2015, Farmigo initiated an Avon-like model for ordering products directly from farmers by launching "Food Communities," which served as local, customized online farmers' markets. Their model employed local Food Champions who could invite at least 20 people to join and organize a pick-up location.

CSAware is another CSA management software, which focuses on enabling their CSA customers to customize their software package.

Good Eggs is an online marketplace for local and organic products that operates in the San Francisco Bay area. Good Eggs' transaction platform connects wholesale and consumer buyers directly with food producers (see box p. 74).

Innovation Lessons from a Food System Start-up

Turning Good Eggs from Failure to Revival

Good Eggs, an organic food delivery start-up based in San Francisco, provides an online marketplace for buying local produce, meat and dairy products directly from farms. After initial successes in San Francisco, the company began expanding to Los Angeles, New York and New Orleans, but discovered that it had attempted to scale too quickly in cities with entirely different logistical challenges and local food landscapes. In August 2015, it shuttered its operations outside San Francisco, laying off over 140 employees.[222]

At the end of December 2015, Good Eggs hired a new CEO, Bentley Hall, an experienced food product and logistics executive, who has since employed several key strategists to turn its business model around. Hall was interviewed by Food+Tech Connect and shared the following take-aways:[223]

- Focus on human-centered design, which starts with user research. Good Eggs was able to improve profitability by talking directly with their customers and learned that
  - Customers wanted more variety so that the service would cover all of their grocery needs. For example, customers wanted bananas, which Good Eggs had not included because they could not be sourced locally in the San Francisco Bay Area. To counter this, the company found a sustainable source of bananas to add to its product list while still falling within their mission to sell ethically sourced food products.
  - Customers were often disappointed when their orders were not complete (e.g., due to changes in inventory between the time of order and the delivery, the company's average fill rate was 75%). To counter this, GoodEggs used software to help improve inventory management so that their website was more accurate.
  - Customers wanted more convenience in terms of delivery times, product choices and customization.
- Identify areas of high variable cost (e.g., packaging, order picking and delivery) and look for ways to save money in those areas.
- Food systems start-ups should prioritize the food side of the business over the technology side, although the two are complementary. Hall told Food Tech Connect, "(W)e're a food company that's enabled by tech, we're not a tech company enabled by food—and there's a huge difference there."
- Careful, technology-enhanced inventory management helps Good Eggs understand what products are moving.
  - Local produce means longer shelf lives.
  - Online delivery models can have faster inventory turns.
- Wait until the business model has demonstrated success and profitability *before* scaling.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

The website FarmBox Direct, started by a single mother who grew up in a food desert, crafted its CSA-style weekly vegetable and/or fruit delivery boxes to fit an average SNAP budget for a family of four.[24] The website offers organic boxes with options for only fruit, only vegetables or mixed, as well as "all-natural" boxes at a lower price point. FarmBox Direct delivers for free, nationwide, and prices for the all-natural boxes start at $41.95 per week for a small size and up to $51.95 per week for the largest size, which is enough to feed a large family who cooks five or more times a week.

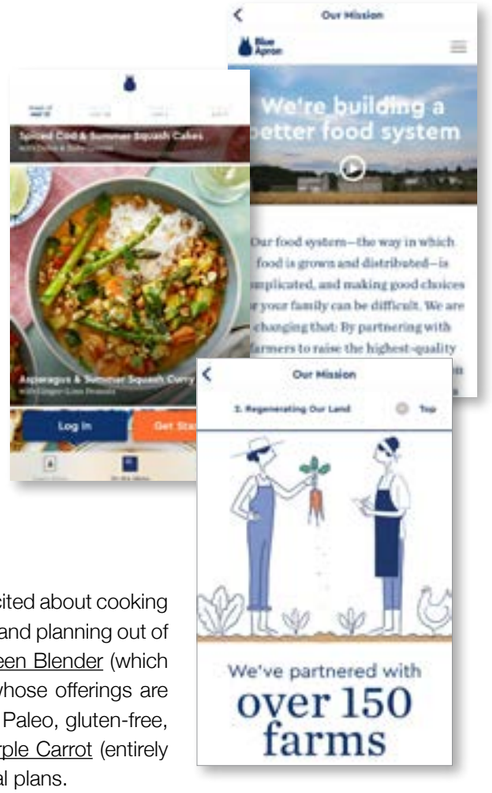
In London, FarmDrop's innovative model connects consumers directly with farmers, which the company claims results in food five-times fresher than that from supermarkets, by cutting the average distribution time from 106 hours to 19, with prices 15% cheaper than the major local grocery chain.[224] FarmDrop can keep their prices lower for consumers by increasing the share of profits that farmers and other producers receive (70-80%). In contrast, when farmers sell their products at a traditional supermarket they yield only 10-15% of the sale price.

Relay Foods was an online grocery store that stocked healthy, responsibly sourced groceries. Users could order groceries a la carte, browsing and filtering by "aisle" (e.g., produce, meat, dairy), by local supplier or by special diets (e.g., Paleo, vegan, gluten-free). Users could also shop from a meal planning section that populated the online shopping cart with the necessary ingredients for a set of recipes, which equated to a price of approximately $4-8/serving. Orders could be picked up at specific locations on certain days of the week or delivered for a per-order fee or a flat monthly rate. Relay Foods was bought by Door to Door Organics which then closed operations in late 2017. The company struggled to raise funds to continue growing after Amazon's acquisition of Whole Foods as investors felt that Amazon was fated to rule the online grocery market.

Local Roots is an app based in Atlanta that aims to connect local food producers directly with customers in metropolitan areas across the country. The platform allows small food entrepreneurs to set up their online food business, similar to the service Etsy provides to small artisans and retailers. Users enter their location and can see a list of nearby farmers or small batch food producers, place orders and make payments through the app, and the farmer or producer then delivers the product. Local Roots' website also helps connect local buyers and sellers. These type of platforms can reduce barriers to entry into the commercial market; for example, someone with a home garden could sell excess produce to neighbors via Local Roots.

Meal Kits

Finally, some companies have focused on meal-oriented delivery models, like Plated, Blue Apron and Hello Fresh. Other meal kit models have been launched by existing food production companies, like Tyson Tastemakers. These companies offer chef-created menus in which customers pick a group of recipes for that week's shipment and receive all of the portioned ingredients necessary to cook each recipe. Each recipe generally makes two portions and is priced at around $9-12 per plate. These models have great appeal to consumers who want to cook delicious meals at home without needing to think, plan or shop for a menu of recipes each week.



The meal kit model can help people get excited about cooking at home by taking much of the guesswork and planning out of cooking. Newer meal kit start-ups like Green Blender (which focuses on smoothie kits), Green Chef (whose offerings are 95% organic and include plans tailored to Paleo, gluten-free, pescatarian and vegetarian diets) and Purple Carrot (entirely plant-based) have focused on healthy meal plans.

While meal kits are not the most affordable solution, should new iterations of this model take hold and/or if prices drop sufficiently, meal kits could be a way for underserved populations to cook fresh and healthy at home with minimal up-front planning and time investment.

Challenges with Online Grocery Delivery

While large companies like FreshDirect and PeaPod have established successful delivery business models, other start-ups that have sought to disrupt traditional supply chain models have faced logistical challenges inherent in the transportation of fresh, perishable goods. In July 2016, Farmigo announced that it was shutting down its delivery model; as a software company they felt ill-equipped to handle the complex logistics involved in the local food delivery system.[225] Similar companies, such as Good Eggs, also scaled back operations, citing logistical challenges. Door to Door Organics closed after not being able to the raise funds needed to grow fast enough to stay profitable.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

The delivery of groceries in urban areas is complicated by traffic patterns, parking limitations and the challenges of delivering to unstaffed apartment buildings where residents may not be home. Larger delivery services can benefit from economies of scale as they may end up having multiple orders on the same block, which makes delivery much more efficient. An additional challenge is presented by competition from companies like Amazon Fresh and Instacart, which can offer food delivery within the span of several hours. Direct farm-to-consumer models like FarmDrop and Good Eggs require at least a two-day turn-around in order to streamline operations.[226]

Looking Forward: Tech Opportunities to Improve and Extend New Food Retail Models

New food retail models, such as online grocery delivery models can save households considerable amounts of time and offer the convenience of shopping according to one's schedule. Online shopping platforms allow customers to easily repeat a prior order, or populate their shopping cart with a core list of products. These platforms can also suggest recommended items based on other customers' purchase histories and allow customers to compare and contrast products, sort by price and use other tools to help with decision making and budgeting. These types of features could eventually be used to steer people towards healthier food choices as well (which will be further discussed in a future report in this series, Part 5, Health Tech & Diet-Related Diseases).

Will Innovation Eventually Drive Prices Down?

For businesses, using technology can help keep operational costs down by streamlining various processes, and companies that operate exclusively online can keep profit margins higher without the large expense of renting a brick-and-mortar store. Direct-to-consumer companies like Farmdrop in the United Kingdom advertise that their prices are 15% lower, on average, than major grocery stores, given the reduction in overhead costs, like rent and electricity. Another way the company keeps costs down for consumers is by offering free delivery if within a flexible six-hour window, which helps to combat many of the logistical challenges with home delivery and the inherent delays in navigating crowded city roads. For customers who want a more precise schedule, the company charges a $4 delivery fee. Farmdrop's model allows better margins for farmers of at least 75% of the retail price.

Overall, online grocery shopping has seen rapid growth. Big, chain stores like Walmart, Kroger and ShopRite are now offering the option to shop online and then pick up the order at a nearby store.[227] While the lack of delivery option does not solve the problem for those with limited transportation options, this method retains many of the other advantages of online

Tech Highlight:

Grocery Delivery by Drone

Other technological developments, like drone delivery, could eventually bring costs down even further by eliminating the need for a delivery worker and vehicle. The co-founders of Skype have launched a start-up called Starship Technologies, which builds small, self-driving refrigerated delivery bots in cities throughout Europe.

The bots are stocked from a "portable warehouse," essentially a truck or cargo container in a nearby area, and deliver groceries or drugstore items within a two-mile range, moving between four and ten miles per hour. Starship estimates that they could reduce delivery time down to just 30 minutes after placing an online order.

San Francisco ran a small pilot with the Starship drones, and Washington, D.C., is the first city in the United States to legally allow them to deliver via sidewalk. As of early 2017, it has begun using the drones for restaurant delivery, promising delivery within 15-30 minutes for a fee of $1-3.[228]

While there are certainly challenges (and controversies) to be overcome by having robotic rolling-coolers on crowded city sidewalks, this line of innovation represents a potential early stage disruptor. It has the potential to change the way products are purchased, by streamlining many of the logistical issues and costs associated with delivery, especially in urban areas, such as traffic and parking challenges.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

shopping that include more careful budgeting and time conveniences.

Conclusions

Bringing New Food Business Models to Underserved Populations

Digital technologies have clear benefits for streamlining business operations and logistics, automating data collection and analysis, and increasing convenience for consumers. While technological innovations across industries have often been targeted at high- and middle-income households, there is great opportunity to iterate on existing models, or develop new models that meet the needs of low-income households and other underserved populations (see Part 1, Health Tech & Food Insecurity on UX for the Underserved, pp. 57-58). Oftentimes, interventions for the underserved rely on grant funding (e.g., Garden on the Go, p. 25, and Crisp!, p. 29). As such, grant programs should require that part of the funding be used towards planning and testing the long-term financial viability of these interventions to ensure their longevity in serving the community.

Other financial models that could improve access to food for underserved populations should be explored, such as setting up a food or grocery delivery business as a nonprofit or subsidizing access for low-income populations with the proceeds made from high-income populations (e.g., Thrive Market, p. 73). Cost savings for the consumer can also be achieved through new models that reduce the total number of transactions from farm to fork; for example, urban food hubs represent one way to offer lower prices on local produce (see p. 60).

The move for online grocers to begin accepting EBT funds represents considerable progress towards these goals, and should be paired with careful assessment of how end-users take advantage of the new policy, and follow up on how well it actually meets their needs.

Policymakers, researchers and food advocates should be aware of the ways these different technologies can interface with each other and significant value can be garnered by connecting the dots between the various parts of the food system. This includes encouraging social responsibility and new, interdisciplinary partnerships that highlight the impact of food business on socioeconomics. The entrenched food system is ripe for disruption and requires continued innovation to produce enough food and enough *access* to healthy foods for everyone.

Appendix 1. Food-Tech Glossary

The tech world has common lingo; the following are some key terms, phrases and oncepts that are important in the context of technology's impact on the food system:

Tech Terms[i, ii]

Algorithm: a set of rules or processes that perform a calculation or solve a recurrent problem and can be used to automate decision-making[iii]

Application (app): type of software that is often developed for and used on mobile devices, like smartphones and tablets

Application Program Interface (API): a set of routines, protocols and tools for building software applications that allows different components of software to communicate with each other and operate as one unified program or app (e.g., Google Maps API allows any application to "plug" in Google's mapping features)

Architecture: the way data and components of a given software application are collected, stored and accessed

Back end: the "behind the scenes" components of a web page, including servers, databases or applications that support the functions of that web page and make it work

Cloud computing: storing and accessing data and programs through the internet instead of the computer's hard drive

Content curation: choosing what content is shared online, whether through an app, via social media or on a website

Content management systems (CMS): a range of systems that provide the actual content for a website or application

Customer relationship management (CRM) software: software that helps a business or organization collect, track and manage data about its clients

Data mining: gathering new or useful information from large datasets

Database: a collection of electronic information (data)

i Martin M. 35 technology terms every entrepreneur should know. http://www.businessnewsdaily.com/4684-technology-terms-for-small-business.html. March 1, 2016. Accessed 10/15/2016.
ii Smith K. 99 terms you need to know when you're new to tech. https://skillcrush.com/2015/03/26/99-tech-terms/. March 26, 2015. Accessed 10/15/2016.
iii Merriam-Webster. Algorithm. http://www.merriam-webster.com/dictionary/algorithm. Updated 2016. Accessed 11/07/2016.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Engagement: how much people interact with social media, such as posting tweets about a particular topic on Twitter or liking posts on Facebook

Front end: the part of a website that users see and interact with

Hardware: the physical components of technology, such as computers, hard drives and microchips

Impressions: the number of times a piece of content is viewed on social media

Machine learning: a form of artificial intelligence that allows algorithms to "learn" from the data collected as people use the product (e.g., Siri)

Minimum viable product (MVP): the smallest piece of software that a company releases to its users, generally to gain feedback to help continued development

Open source: programming code that is publicly available for anyone to use. Open source code can be used as is to replicate an existing application, and developers agree to share improvements and updates they make to the code; it can also be "borrowed" to use as a starting place for developers to modify for a new purpose

Pain Point: a real or perceived problem that technologies attempt to solve

Reach: the number of people who see social media content (related to the number of followers someone has on Facebook, Instagram, Twitter, etc.)

Search engine optimization (SEO): a strategy that increases a website's ranking in online search results by incorporating keywords and other elements

Software: a program or set of instructions that help users do work or some other task that they want to complete; software tells a computer, phone or tablet what to do (e.g., Microsoft Word)

Software as a Service (SaaS): software that is delivered over the internet, and paid for monthly, helping make it more affordable

Traffic: the number of people who visit a website

User: the person who interacts with and uses a technology product

User-generated content: this generally applies to social media, but is any content (e.g., text, photos, videos) shared online that is created by an individual user, rather than an organization

User experience (UX): the overall experience people have when using a website, app or product

User interface (UI): the way a website is laid out and how users interact with it, including elements such as buttons, forms, etc.

Web app: Short for web application, a web app can have many of the same features as a regular application, but it is a web page that can be accessed from any browser on any device (often without requiring any special downloads or configuration)

Tech Phrases and Concepts

The following phrases and concepts represent broad categories of technologies that are being used to innovate throughout the food system:

Sharing Economy

- What it is: The sharing economy increases peer utilization of existing resources, facilitating access to others' resources and providing new customers to those with existing resources
- Best known examples:
  - Uber
  - AirBnB
- Examples from the food system:
  - Connecting people who have goods to ship or store with excess space on trucks or in storage warehouses
  - Matching food donors to nonprofit recipients
  - Enlisting volunteers to collect food waste from restaurants and distribute it to the hungry

Internet of Things (IoT)

- What it is: Everyday objects that have network connectivity and communication amongst those objects based on cloud computing. IoT devices and objects generally have sensors that measure and evaluate data within a network that can leverage those data in some meaningful way.
- Best known examples:
  - Wireless key locators
  - Interactive dolls and toys
  - Smart lighting systems, such as in parking lots, that provide targeted light where illumination is most needed, to save energy and costs
- Examples from the food system:
  - Smart sensors for precision agriculture
  - Sensors to predict and prevent food waste in storage facilities
  - Smart kitchen appliances

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

Small Data

- What it is: Small data is generally collected and used by individuals or IoT devices, and contains very specific attributes on what that person or object is doing
- Best known examples:
  - Tracking activity level via wearable devices
  - Smart labels on medicine bottles that monitor shelf life and improper storage conditions
- Examples from the food system:
  - Smart labels on food packaging
  - Tracking caloric intake and physical activity

Big Data and Analytics

- What it is: Using computers to collect and analyze very large datasets to reveal patterns, trends and associations
- Best known examples:
  - The National Security Agency uses big data to track potential terrorist plots; the financial industry uses High Frequency Trading
  - In 2012 President Obama's team used big data analytics to drive its campaign strategy; IBM's Watson uses natural language processing to answer questions based on large volumes of text and other data
- Examples from the food system:
  - Retailers target coupons to customers based on purchase history
  - Anti-hunger groups track operational data to maximize their impact
  - Government agencies use transaction data to reduce SNAP and WIC fraud
  - Precision agriculture collects and aggregates environmental data to inform decisions about food production, processing and distribution, improving the speed and accuracy of those forecasts[iv]
  - Individuals analyze online recipes and ratings to determine which ingredients are associated with the highest ratings or make recommendations for healthier substitutions (e.g., this food "social network" analysis conducted by University of Michigan computer scientist Lada Adamic)
  - The food industry invents recipes based on food chemistry and flavor preference data

iv Rabobank. More data, more food. https://www.rabobank.com/en/about-rabobank/background-stories/food-agribusiness/more-data-more-food.html. Updated 2016. Accessed 07/21/2016.

Social Media

- What it is: Sharing ideas, posting content and maintaining connections with social networks
- Best known examples:
  - Facebook
  - Twitter
  - Instagram
  - LinkedIn
- Examples from the food system:
  - Using keywords like “food poisoning” on Twitter or Yelp (the restaurant review website) for food safety surveillance
  - Conducting social media scraping to collect information based on what people are saying about a product or organization online
  - Disseminating healthy nutrition and cooking tips — there are countless Instagram, Twitter, Facebook, YouTube and Tumblr accounts plus blogs and message boards dedicated to recipes, cooking, cuisines, brands or even individual products
  - Using hashtags to promote campaigns (e.g., #FightHunger), gain views for a particular post or generate discussion around a particular idea

Crowdsourcing

- What it is: Obtaining ideas, services, funding or data from large groups of people using the internet or mobile technologies to collect and aggregate those data
- Best known examples:
  - Waze, a traffic crowdsourcing app that provides real-time navigation
  - Crowdfunding platforms like Kickstarter, Crowdrise and GoFundMe
  - Wikipedia for ideas
  - Amazon’s Mechanical Turk workers who receive small payments to perform “human intelligence” tasks online
- Examples from the food system:
  - The Reddit Food Pantry connects people in need of short-term relief with a social network of strangers willing to help
  - Crowdsourcing nutrition feedback based on photos posted to apps like PlateMate, which uses the Mechanical Turk pool
  - Micro-giving for anti-hunger groups

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

References

1. Harlow S, Guo L. Will the revolution be Tweeted or Facebooked? Using digital communication tools in immigrant activism. J Comput Mediat Commun. 2014;19(3):463-478.

2. Purcell K, Heaps A, Buchanan J, Friedrich L. How teachers are using technology at home and in their classrooms. Pew Research Center. http://www.pewinternet.org/2013/02/28/how-teachers-are-using-technology-at-home-and-in-their-classrooms/. February 28, 2013. Accessed 06/18/2016.

3. Samson R, Mehta M, Chandani A. Impact of online digital communication on customer buying decision. *Procedia Econ Finance*. 2014;11:872-880.

4. Toumache R, Rouaski K, Talbi B, Djelloul B. The impact of the information and communication technology (ICT) on economic growth: statistical econometric approach. *Bus Manage Rev*. 2014;5(1):256.

5. Helbing D. What the digital revolution means for us. Science Business. http://www.sciencebusiness.net/news/76591/What-the-digital-revolution-means-for-us. June 12, 2014. Accessed 06/17/2016.

6. Drucker PF. Beyond the information revolution. *The Atlantic*. October 1999. http://www.theatlantic.com/magazine/archive/1999/10/beyond-the-information-revolution/304658/. Accessed 10/10/2016.

7. International Telecommunication Union. End-2017 Estimates for Key ICT Indicators. Downloaded from https://www.itu.int/en/ITU-D/Statistics/Pages/facts/default.aspx. 2017. Accessed 09/15/2018.

8. Smith A, Anderson M. Social Media Use in 2018. Pew Research Center. http://www.pewinternet.org/2018/03/01/social-media-use-in-2018/. March 1, 2018. Accessed 09/15/2018.

9. Mobile Device Fact Sheet. Pew Research Center. http://www.pewinternet.org/fact-sheet/mobile/. February 5, 2018. Accessed 09/15/2018.

10. Pew Research Center. Internet/ Broadband Fact Sheet. http://www.pewinternet.org/fact-sheet/internet-broadband/. February 5, 2018. Accessed 09/15/2018.

11. Smith A. U.S. smartphone use in 2015. Pew Research Center. http://www.pewinternet.org/2015/04/01/us-smartphone-use-in-2015/. April 1, 2015. Accessed 06/18/2016.

12. Anderson, M, Perrin A. Tech Adoption Climbs Among Older Adults. Pew Research Center. http://www.pewinternet.org/2017/05/17/tech-adoption-climbs-among-older-adults/. May 17, 2017. Accessed 09/15/2018.

13. International Telecommunication Union. ICT statistics. http://www.itu.int/en/ITU-D/Statistics/Pages/default.aspx. Updated 2018. Accessed 09/15/2018.

14. International Telecommunication Union. ICT Facts and Figures 2017. https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2017.pdf. 2017. Accessed 09/15/1018.

15. Facebook. Facebook: Newsroom. http://newsroom.fb.com/company-info/. Updated 2018. Accessed 09/15/2018.

16. Youtube. Youtube statistics. https://www.youtube.com/yt/press/statistics.html. Updated 2018. Accessed 09/15/2018.

17. Instagram. Stats. https://www.instagram.com/press/?hl=en. Updated 2018. Accessed 09/15/2018.

18. Twitter. Twitter usage/company facts. https://about.twitter.com/company. Updated 2018. Accessed 09/15/2018.

19. Federal Communications Commission. Lifeline program for low-income consumers. https://www.fcc.gov/general/lifeline-program-low-income-consumers. Updated 2016. Accessed 10/26/2016.

20. Kang C. FCC approves broadband subsidy for low-income households. *New York Times.* March 31, 2016. http://www.nytimes.com/2016/04/01/technology/fcc-approves-broadband-subsidy-for-low-income-households.html?_r=0. Accessed 10/26/2016.

21. Glaser L, Morrison RM. Ag and food sectors and the economy. U.S. Department of Agriculture, Economic Research Service. http://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/ag-and-food-sectors-and-the-economy.aspx. Updated October 14, 2016. Accessed 10/26/2016.

22. Fox KH. Another step toward the cashless society? The 1978 federal electronic fund transfer act. *Am Bus Law J*. 1980;18(2):209-224.

23. U.S. Department of Agriculture, Food and Nutrition Service. Supplemental Nutrition Assistance Program (SNAP): A short history of SNAP. http://www.fns.usda.gov/snap/short-history-snap. Updated 2014. Accessed 10/20/2016.

24. Grenier-Trivedi L. Some online grocery companies are about to start taking 'food stamps.' Civil Eats. http://civileats.com/2016/02/23/some-online-grocery-companies-are-about-to-start-taking-food-stamps/. February 23, 2016. Accessed 06/20/2016.

25. The United Nations. World's population increasingly urban with more than half living in urban areas. http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html. Updated 20142016.

26. de Zeeuw H, Drechsel P, eds. *Cities and Agriculture: Developing resilient urban food systems.* New York, NY: Routledge; 2015. http://www.iwmi.cgiar.org/Publications/Books/PDF/cities_and_agriculture-developing_resilient_urban_food_systems.pdf?galog=no. Accessed 01/16/2017.

27. Alkon AH, Agyeman J. *Cultivating food justice: Race, class, and sustainability.* MIT Press; 2011.

28. Cohen N, Reynolds K. Resource needs for a socially just and sustainable urban agriculture system: Lessons from New York City. *Renewable Agriculture and Food System*s. 2015;30(01):103-114.

29. Cohen N, Reynolds K. Urban agriculture policy making in New York's "New political spaces" Strategizing for a participatory and representative system. *Journal of Planning Education and Research*. 2014;34(2):221-234.

30. Gottlieb R, Joshi A. *Food Justice.* Cambridge, MA: MIT Press; 2010.

31. Reynolds K. Disparity despite diversity: social injustice in New York City's urban agriculture system. *Antipod*e. 2015;47(1):240-259.

32. Slocum R, Cadieux KV. Notes on the practice of food justice in the US: Understanding and confronting trauma and inequity. *Journal of Political Ecology*. 2015;22:27-52.

33. Union of Concerned Scientists . Industrial Agriculture. .

34. Grace Communications Foundation . Sustainable Agriculture - The Basics. http://www.sustainabletable.org/246/sustainable-agriculture-the-basics. Updated 2017. Accessed 04/01/2017.

35. Godfray HC, Beddington JR, Crute IR, et al. Food Security: The Challenge of Feeding 9 Billion People. *Science*. 2010;327(5967):812-818.

36. Garnett T, Appleby MC, Balmford A, et al. Sustainable Intensification in Agriculture: Premises and Policies. *Science*. 2013;341(6141):33-34.

37. Garnett T, Godfay C. Sustainable intensication in agriculture. Navigating a course through competing food system priorities. 2012. UK: Food Climate Research Network and the Oxford Martin Programme on the Future of Food, University of Oxford. http://www.futureoffood.ox.ac.uk/sites/futureoffood.ox.ac.uk/files/SI%20report%20-%20final.pdf. Accessed 04/04/2017.

38. National Research Council (US). . 2009.

39. Ver Ploeg M, Breneman V, Dutko P, et al.
Access to Affordable and Nutritious Food - Updated Estimates of Distance to Supermarkets Using 2010 Data . 2012;143. Washington, D.C.: United States Department of Agriculture - Economic Research Service. http://www.ers.usda.gov/media/956784/err143.pdf.

40. Beaulac J, Kristjansson E, Cummins S. A systematic review of food deserts, 1966-2007. *Prev Chronic Di*s. 2009;6(3):A105.

41. Carlson A, Frazao E. Food costs, diet quality and energy balance in the United States. *Physiol Behav*. 2014;134:20-31.

42. Donald B. Food retail and access after the crash: rethinking the food desert problem. .

43. WhyHunger. Introduction: Food Deserts. 2014. https://whyhunger.org/connect/item/140-introduction-food-deserts. Accessed 03/17/2017.

44. Koch T, Denike K. Crediting his critics' concerns: remaking John Snow's map of Broad Street cholera, 1854. *Soc Sci Med*. 2009;69(8):1246-1251.

45. Eisen RJ, Eisen L. Use of Geographic Information Systems in Infectious Disease Surveillance. In: *Concepts and Methods in Infectious Disease Surveillance.* John Wiley & Sons, Ltd; 2014:219-229. 10.1002/9781118928646.ch20.

46. Kamel Boulos MN, Resch B, Crowley DN, et al. Crowdsourcing, citizen sensing and sensor web technologies for public and environmental health surveillance and crisis management: trends, OGC standards and application examples. *Int J Health Geogr*. 2011;10:67-072x-10-67.

47. Allen C, Tsou M, Aslam A, Nagel A, Gawron J. Applying GIS and Machine Learning Methods to Twitter Data for Multiscale Surveillance of Influenza. *PLoS ONE*. 2016;11(7):e0157734.

48. Cavazos-Rehg PA, Krauss MJ, Sowles S, et al. A content analysis of depression-related Tweets. *Comput Hum Behav*. 2016;54:351-357.

49. Moreno MA, Christakis DA, Egan KG, et al. A pilot evaluation of associations between displayed depression references on Facebook and self-reported depression using a clinical scale. *J Behav Health Serv Res*. 2012;39(3):295-304.

50. Moreno MA, Jelenchick LA, Egan KG, et al. Feeling bad on Facebook: depression disclosures by college students on a social networking site. *Depress Anxiety*. 2011;28(6):447-455.

51. Eckert J, Shetty S. Food systems, planning and quantifying access: Using GIS to plan for food retail. *Appl Geogr*. 2011;31(4):1216-1223.

52. Bosona T, Gebresenbet G. Food traceability as an integral part of logistics management in food and agricultural supply chain. *Food Control*. 2013;33(1):32-48.

53. Charreire H, Casey R, Salze P, et al. Measuring the food environment using geographical information systems: a methodological review. *Public Health Nutr*. 2010;13(11):1773-1785.

54. Zhang M, Ghosh D. Spatial Supermarket Redlining and Neighborhood Vulnerability: A Case Study of Hartford, Connecticut. *Transactions in GIS*. 2016;20(1):79-100.

55. Martin KS, Ghosh D, Page M, Wolff M, McMinimee K, Zhang M. What Role Do Local Grocery Stores Play in Urban Food Environments? A Case Study of Hartford-Connecticut. *PLoS ONE*. 2014;9(4):e94033.

56. Salinas JJ, Abdelbary B, Klaas K, Tapia B, Sexton K. Socioeconomic context and the food landscape in Texas: results from hotspot analysis and border/non-border comparison of unhealthy food environments. *Int J Environ Res Public Health*. 2014;11(6):5640-5650.

57. Economic Research Service (ERS), U.S. Department of Agriculture (USDA). Food Access Research Atlas. http://www.ers.usda.gov/data-products/food-access-research-atlas.aspx/ Updated 2013. Accessed July 29/2016.

58. Economic Research Service (ERS), U.S. Department of Agriculture (USDA). Food Environment Atlas. http://www.ers.usda.gov/data-products/food-environment-atlas.aspx. Updated 2015. Accessed July 29/2016.

59. Economic Research Service (ERS), U.S. Department of Agriculture (USDA). ERS GIS Map Services and API User Guide. http://www.ers.usda.gov/developer/geospatial-apis.aspx. Updated 2016. Accessed July 29/2016.

60. Gundersen C, Engelhard E, Waxman E. Map the Meal Gap: Exploring Food Insecurity at the Local Level. *Applied Economic Perspectives and Policy*. 2014;36(3):373-386.

61. Gordon C, Purciel-Hill M, Ghai NR, Kaufman L, Graham R, Van Wye G. Measuring food deserts in New York City's low-income neighborhoods. *Health Place*. 2011;17(2):696-700.

62. Sharma S, De Choudhury M. Detecting and Characterizing Nutritional Information of Food and Ingestion Content in Instagra*m. Proc. WWW Companio*n. 2015.

63. De Choudhury M, Sharma S, Kiciman E. Characterizing Dietary Choices, Nutrition, and Language in Food Deserts via Social Media. 2016:1157-1170. http://dl.acm.org/citation.cfm?id=2819956&preflayout=flat.

64. Kawachi I, Berkman L. *Neighborhoods and health.* New York: Oxford University Press; 2003.

65. Juarez PD, Matthews-Juarez P, Hood DB, et al. The public health exposome: a population-based, exposure science approach to health disparities research. *Int J Environ Res Public Healt*h. 2014;11(12):12866-12895.

66. Schootman M, Nelson E, Werner K, et al. Emerging technologies to measure neighborhood conditions in public health: implications for interventions and next steps. *International Journal of Health Geographic*s. 2016;15(1):20.

67. Sadler RC. Integrating expert knowledge in a GIS to optimize siting decisions for small-scale healthy food retail interventions. *International Journal of Health Geographic*s. 2016;15(1):19.

68. LeDoux TF, Vojnovic I. Going outside the neighborhood: The shopping patterns and adaptations of disadvantaged consumers living in the lower eastside neighborhoods of Detroit, Michigan. *Health Plac*e. 2013;19:1-14.

69. Libman K. Has New York City fallen into the local trap? *Public Healt*h. 2015;129(4):310-317.

70. United States Department of Agriculture. 2012 Census of Agriculture: Highlights. *National Agricultural Statistics Servic*e. 2014.

71. Tropp D. Why Local Food Matters: the rising importance of locally grown food in the US food system- a national perspective. *National Association of Counties Legislative Conferenc*e. 2014.

72. Prelec D, Simester D. Always Leave Home Without It: A Further Investigation of the Credit-Card Effect on Willingness to Pay. *Mark Let*t. 2001;12(1):5-12.

73. NYC Health. Texting. http://www1.nyc.gov/site/doh/services/texting.page. Updated 2016. Accessed August 13/2016.

74. United States Department of Agriculture. Local Food Directories: National Farmers Market Directory. https://www.ams.usda.gov/local-food-directories/farmersmarkets. Updated 2016. Accessed August 13/2016.

75. Indiana University Health. Garden on the Go. http://iuhealth.org/about-iu-health/in-the-community/obesity-prevention/garden-on-the-go/. Updated 2016. Accessed August 10/2016.

76. Young C, Karpyn A, Uy N, Wich K, Glyn J. Farmers' markets in low income communities: impact of community environment, food programs and public policy. *Community Developmen*t. 2011;42(2):208-220.

77. Bertmann FMW, Ohri-Vachaspati P, Bunam MP, Wharton CM. Implementation of Wireless Terminals at Farmers' Markets: Impact on SNAP Redemption and Overall Sales. *American Journal of Public Healt*h. 2012;102(7).

78. Buttenheim AM, Havassy J, Fang M, Glyn J, Karpyn AE. Increasing Supplemental Nutrition Assistance Program/Electronic Benefits Transfer Sales at Farmers' Markets with Vendor-Operated Wireless Point-of-Sale Terminals. *Journal of the Academy of Nutrition and Dietetic*s. 2012;112(5):636-641.

79. Jones P, Bhatia R. Supporting equitable food systems through food assistance at farmers' markets. *Am J Public Healt*h. 2011;101(5):781-783.

80. US Department of Agriculture. Feasibility of implementing electronic benefit transfer systems in farmers' markets: report to Congress. 2010. Washington DC: Food and Nutrition Service.

81. McGuire S. State Indicator Report on Fruits and Vegetables, 2013, Centers for Disease Control and Prevention, Atlanta, GA. *Adv Nutr*. 2013;4(6):665-666.

82. Quintana M, O'Brien J. SNAP redemptions at markets continue to increase, and new federal support is on the way. . 2014. Kimberton, PA: Farmers' Market Coalition. http://farmersmarketcoalition.org/2014-snap-update/.

83. USDA. Benefit Redemption Dividion 2010 annual report. 2010: US Department of Agriculture: Food and Nutrition Service.

84. Lee JS. Sales Using Food Stamps Double at Greenmarkets. *The New York Time*s. November 23 2009;City Room. Available from: https://cityroom.blogs.nytimes.com/2009/11/23/food-stamp-sales-double-at-citys-greenmarkets/?_r=1. Accessed 03/31/2017.

85. McGuirt JT, Jilcott SB, Liu H, Ammerman AS. Produce price savings for consumers at farmers' markets compared to supermarkets in North Carolina. *J Hunger Environ Nutr*. 2011;6(1):86-98.

86. Pearson AL, Winter PR, McBreen B, et al. Obtaining Fruit and Vegetables for the Lowest Prices: Pricing Survey of Different Outlets and Geographical Analysis of Competition Effects. *PLOS ONE*. 2014;9(3):e89775.

87. Wheeler AL, Chapman-Novakofski K. Farmers' Markets: Costs Compared With Supermarkets, Use Among WIC Clients, and Relationship to Fruit and Vegetable Intake and Related Psychosocial Variables. *Journal of Nutrition Education and Behavior*. ;46(3):S65-S70.

88. Larsen K, Gilliland J. A farmers' market in a food desert: Evaluating impacts on the price and availability of healthy food. *Health Place*. 2009;15(4):1158-1162.

89. Laraia BA, Leak TM, Tester JM, Leung CW. Biobehavioral Factors That Shape Nutrition in Low-Income Populations: A Narrative Review. *Am J Prev Me*d. 2017;52(2, Supplement 2):S118-S126.

90. Evans AE, Jennings R, Smiley AW, et al. Introduction of farm stands in low-income communities increases fruit and vegetable among community residents. *Health Place*. 2012;18(5):1137-1143.

91. Oberholtzer L, Dimitri C, Schumacher G. Linking farmers healthy foods and undeserved comsumers. *Journal of Agricultural Food Systems and Community Developmen*t. 2012;2(4):63-77.

92. Freedman DA, Mattison-Faye A, Alia K, Guest MA, Hébert JR. Comparing Farmers' Market Revenue Trends Before and After the Implementation of a Monetary Incentive for Recipients of Food Assistance. *Preventing chronic disease*. 2014;11(130347).

93. Volpp KG, Asch DA, Galvin R, Loewenstein G. Redesigning employee health incentives—lessons from behavioral economics. *N Engl J Me*d. 2011;365(5):388-390.

94. NYC Health. Health Bucks. https://www1.nyc.gov/site/doh/health/health-topics/health-bucks.page2016.

95. Payne GH. Implementing a farmers' market incentive program: perspectives on the New York City Health Bucks Program. *Preventing chronic disease*. 2013;10.

96. NYC Health. Health Bucks Program Marks 10 Year Anniversary: More Than $2 Million Redeemed in Fresh Fruits & Vegetables from 2005 to 2015. https://www1.nyc.gov/site/doh/about/press/pr2015/pr044-15.page. Updated 20152016.

97. An R. Effectiveness of subsidies in promoting healthy food purchases and consumption: a review of field experiments. *Public Health Nutr*. 2013;16(7):1215-1228.

98. Cruz J. FreshDirect and Peapod face off over the citys well-heeled stomachs. *Bloomberg*. 2013(March 14, 2013). New York:. https://www.bloomberg.com/news/articles/2013-03-14/freshdirect-vs-dot-peapod-new-yorks-online-food-fight. Accessed 03/17/2017.

99. Fresh Direct. Details About the FreshDirect EBT Pilot Program. https://www.freshdirect.com/browse.jsp?id=about_ebt. Updated 2016. Accessed August 10/2016.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

100. Platkin C. What's Happening to Our Supermarkets. *WNYC, The Leonard Lopate Show*. 2016;Public Radio(August 26, 2016). New York:. http://www.wnyc.org/story/charles-platkin-supermarkets/. Accessed 10/10/2016.

101. Hyzy M. Crisp - Fresh Affordable and Mobile Food. *Social Enterprise Alliance Chicag*o. May 1 2015. Available from: http://www.socialenterprisechicago.org/portfolio/crisp-fresh-affordable-and-mobile-food/. Accessed 12/01/2016.

102. Appelhans BM, Lynch EB, Martin MA, Nackers LM, Cail V, Woodrick N. Feasibility and Acceptability of Internet Grocery Service in an Urban Food Desert, Chicago, 2011-2012. *Preventing Chronic Disease*. 2013;10:E67.

103. Wilde PE, Ranney CK. The Monthly Food Stamp Cycle: Shooping Frequency and Food Intake Decisions in an Endogenous Switching Regression Framework. *American Journal of Agricultural Economic*s. 2000;82(1):200-213.

104. Farmers Market Coalition. Free SNAP EBT Equipment Progra*m. 201*6. Washington, D.C.: United States Department of Agriculture, Food and Nutrition Service. https://www.fns.usda.gov/sites/default/files/snap/2016_FMCEquipmentProgramHandout_160422.pdf. Accessed 04/30/2017.

105. NYC Health. NYC Green Carts. http://www1.nyc.gov/site/doh/health/health-topics/green-carts.page. Updated 2016. Accessed August 10/2016.

106. Morganosky MA, Cude BJ. Consumer response to online grocery shopping. *Intl J of Retail & Distrib Mg*t. 2000;28(1):17-26.

107. Anesbury Z, Nenycz-Thiel M, Dawes J, Kennedy R. How do shoppers behave online? An observational study of online grocery shopping. *Journal of Consumer Behaviour*. 2015.

108. de Kervenoael R, Elms J, Hallsworth A. Influencing online grocery innovation: Anti-choice as a trigger for activity fragmentation and multi-tasking. *Future*s. 2014;62, Part B:155-163.

109. Hu W. FreshDirect Expands Delivery to Serve All of the Bronx. *The New York Time*s. May 23 2012;N.Y. / Region. Available from: http://www.nytimes.com/2012/05/24/nyregion/freshdirect-expands-delivery-to-all-parts-of-the-bronx.html. Accessed 03/17/2017.

110. GreenThumb NYC. GreenThumb Garden Map. http://www.greenthumbnyc.org/gardensearch.html2016.

111. Americorps: Green City Force. Green City Force and NYCHA Farm Featured on News 12. http://www.greencityforce.org/green-city-force-and-nycha-farm-featured-on-news-12/. Updated 20142016.

112. ATTRA Sustainable Agriculture. Vertical Farming. https://attra.ncat.org/attra-pub/viewhtml.php?id=512. Updated 20162016.

113. Aerofarms. Our Technology. http://aerofarms.com/technology/. Updated 20162016.

114. The Vertical Farm. The Vertical Essay. http://www.verticalfarm.com/?page_id=362016.

115. Hunter KJ, Fletcher JM. The antioxidant activity and composition of fresh, frozen, jarred and canned vegetables. *Innovative Food Science & Emerging Technologie*s. 2002;3(4):399-406.

116. Tomasi N, Pinton R, Dalla Costa L, et al. New 'solutions' for floating cultivation system of ready-to-eat salad: A review. *Trends Food Sci Technol*. 2015;46(2, Part B):267-276.

117. Treftz H, Omaye ST. Comparison between Hydroponic and Soil-Grown Strawberries: Sensory Attributes and Correlations with Nutrient Content. *Food and Nutrition Science*s. 2015;6(15):1371.

118. Gotham Greens. Our Farms. http://gothamgreens.com/our-farms/greenpoint2016.

119. Metropolitan Farms. http://www.metro-farms.com. Accessed 09/15/2018.

120. Plant Chicago. Who We Are. http://plantchicago.org/who-we-are/. Updated 20162016.

121. Hughes CJ. In Newark, a Vertical Indoor Farm Helps Anchor an Area's Revival. *The New York Time*s. April 7 2015. Available from: http://www.nytimes.com/2015/04/08/realestate/commercial/in-newark-a-vertical-indoor-farm-helps-anchor-an-areas-revival.html?_r=0.

122. Garfield L. The world's largest vertical farm will produce 2 million pounds of lettuce every yea*r. Business Insider*. 2016;2016(10/30). http://www.businessinsider.com/photos-aerofarms-worlds-largest-vertical-farm-2016-8/#aerofarms-renovated-and-expanded-a-former-steel-mill-in-newark-this-will-be-the-companys-ninth-farm-all-of-the-farms-are-in-the-newark-area-aerofarms-chief-marketing-officer-marc-oshima-tells-business-insider-1.

123. Plantagon.
Plantagon International: Feeding the city. Building the future. http://www.plantagon.com. Accessed 2016/.

124. Mellino C. World's Largest 'Vegetable Factory' Revolutionizes Indoor Farming. http://www.ecowatch.com/worlds-largest-vegetable-factory-revolutionizes-indoor-farming-1882004257.html. Updated 20152016.

125. Verticrop. Verticrop. http://www.verticrop.com/2016.

126. GE Lighting. One of the world's largest all-LED indoor-farms completed in Miyagi prefecture. State-of-the-art agriculture from Japan's Tohoku region to the world. http://www.gelighting.com/LightingWeb/apac/news-and-media/press-room/press-releases/2014/Japan%20Case.jsp2016.

127. Mission 2014: Feeding the World. Urban Agriculture. http://12.000.scripts.mit.edu/mission2014/solutions/urban-agriculture2016.

128. Badami MG, Ramankutty N. Urban agriculture and food security: A critique based on an assessment of urban land constraints. *Global Food Securit*y. 2015;4:8-15.

129. Kaiser ML, Williams ML, Basta N, Hand M, Huber S. When Vacant Lots Become Urban Gardens: Characterizing the Perceived and Actual Food Safety Concerns of Urban Agriculture in Ohio. *J Food Pro*t. 2015;78(11):2070-2080.

130. Brown SL, Chaney RL, Hettiarachchi GM. Lead in Urban Soils: A Real or Perceived Concern for Urban Agriculture? *J Environ Qua*l. 2016;45(1):26-36.

131. Coleman E. Why You Can't Have Organic Food Without Soi*l. Civil Eat*s. 2015;04/13/2015. http://civileats.com/2015/04/13/why-you-cant-have-organic-food-without-soil/. Accessed 04/01/2017.

132. Plantagon. History. http://www.plantagon.com/about/brand/history/. Updated 2016. Accessed 10/25/2016.

133. Alaimo K, Beavers AW, Crawford C, Snyder EH, Litt JS. Amplifying Health Through Community Gardens: A Framework for Advancing Multicomponent, Behaviorally Based Neighborhood Interventions. *Current Environmental Health Report*s. 2016;3(3):302-312.

134. Litt JS, Soobader M, Turbin MS, Hale JW, Buchenau M, Marshall JA. The influence of social involvement, neighborhood aesthetics, and community garden participation on fruit and vegetable consumption. *Am J Public Healt*h. 2011;101(8):1466-1473.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

135. Alaimo K, Packnett E, Miles RA, Kruger DJ. Fruit and vegetable intake among urban community gardeners. *Journal of nutrition education and behavio*r. 2008;40(2):94-101.

136. Barnidge EK, Hipp PR, Estlund A, Duggan K, Barnhart KJ, Brownson RC. Association between community garden participation and fruit and vegetable consumption in rural Missouri. *International Journal of Behavioral Nutrition and Physical Activit*y. 2013;10(1):1.

137. Blair D, Giesecke CC, Sherman S. A dietary, social and economic evaluation of the Philadelphia urban gardening project. *J Nutr Edu*c. 1991;23(4):161-167.

138. Hermann JR, Parker SP, Brown BJ, Siewe YJ, Denney BA, Walker SJ. After-school gardening improves children's reported vegetable intake and physical activity. *J Nutr Educ Beha*v. 2006;38(3):201-202.

139. Hatchett L, Brown L, Hopkins J, Larsen K, Fournier E. "Something good can grow here": chicago urban agriculture food projects. *J Prev Interv Communit*y. 2015;43(2):135-147.

140. FAO. Urban Agriculture. 2009: Food and Agriculture Organization of the United Nations. ftp://ftp.fao.org/docrep/fao/012/ak824e/ak824e00.pdf.

141. Karanja N, Njenga M. Feeding the Cities. In: *State of the World 2011: Innovations that Nourish the Planet.* The Worldwatch Institute; 2011:109-119. https://books.google.com/books?id=R4TCBgAAQBAJ&pg=PA109&lpg=PA109&dq=feeding+the+cities+state+of+the+world+2011&source=bl&ots=ISyNkyOWLV&sig=Ttho-UjjFJ1GVgHMkefFXCYtflc&hl=en&sa=X&ved=0ahUKEwiu-63Ep4DQAhVMQiYKHb8wC88Q6AEIOjAF#v=onepage&q=feeding%20the%20cities%20state%20of%20the%20world%202011&f=false.

142. Mok H, Williamson VG, Grove JR, Burry K, Barker SF, Hamilton AJ. Strawberry fields forever? Urban agriculture in developed countries: a review. *Agronomy for Sustainable Development*. 2014;34(1):21-43.

143. Goodier R. The Future of Urban Agriculture. http://www.popularmechanics.com/technology/infrastructure/a5858/future-urban-rooftop-agriculture/. Updated 20102016.

144. Grewal SS, Grewal PS. Can cities become self-reliant in food? *Citie*s. 2012;29(1):1-11.

145. City of Cleveland Economic Development,. Gardening for Greenbacks. http://rethinkcleveland.org/About-Us/Our-Programs/Gardening-for-Greenbacks.aspx. Updated 2017. Accessed 03/17/2017.

146. *Plantagon: The future of urban food.* https://www.youtube.com/watch?v=0ur-FRb6Gis: ; 2012.

147. Open Agriculture. Welcome to the MIT Open Agriculture Initiative. http://openag.media.mit.edu2016.

148. Peters A. Kimbal Musk's New Accelerator in Brooklyn Will Train Vertical Farmer*s. Fast Company*. 08/23/2016. https://www.fastcoexist.com/3063092/kimbal-musks-new-accelerator-in-brooklyn-will-train-vertical-farmers. Accessed 01/17/2017.

149. Berman J, Zhu C, Perez-Massot E, et al. Can the world afford to ignore biotechnology solutions that address food insecurity? *Plant Mol Bio*l. 2013;83(1-2):5-19.

150. Schmidhuber J, Tubiello FN. Global food security under climate change. *Proc Natl Acad Sci U S* A. 2007;104(50):19703-19708.

151. Horrigan L, Lawrence RS, Walker P. How Sustainable Agriculture Can Address the Environmental and Human Health Harms of Industrial Agriculture. *Environmental Health Perspectiv*e. 2002;110(5).

152. Oldeman LR, Hakkeling RTA, Sombroek WG. World Map of the Status of Human-induced Soil Degradation: An Explanatory Note. 1991.

153. Royal Society of London. Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture. 2009. London: Royal Society.

154. Smil V. Nitrogen in crop production: An account of global flows. *Global Biogeochem Cycles*. 1999;13(2):647-662.

155. Cassman KG, Dobermann A, Walters DT. Agroecosystems, nitrogen-use efficiency, and nitrogen management. *AMBIO: A Journal of the Human Environment*. 2002;31(2):132-140.

156. Tilman D, Cassman KG, Matson PA, Naylor R, Polasky S. Agricultural sustainability and intensive production practices. *Nature*. 2002;418(6898):671-677.

157. International Water Management Institute (IWMI). Does food trade save water? Water Policy Briefing. 2011. Colombo, Sri Lanka: International Water Management Institute.

158. Food and Agriculture Organization of the United Nations,. FAO in the 21st century - Ensuring food security in a changing world. 2011. Rome: United Nations. http://www.fao.org/docrep/015/i2307e/i2307e.pdf.

159. Gornall J, Betts R, Burke E, et al. Implications of climate change for agricultural productivity in the early twenty-first century. *Philos Trans R Soc Lond B Biol Sc*i. 2010;365(1554):2973-2989.

160. Delgado JA, Kowalski K, Tebbe C. The first Nitrogen Index app for mobile devices: Using portable technology for smart agricultural management. *Comput Electron Agri*c. 2013;91:121-123.

161. adapt- N. Scientifically based, independent, and unbiased nitrogen recommendations that improve grower profit and environmental performance. http://www.adapt-n.com2016.

162. IBM Research. Precision agriculture: Using predictive weather analytics to feed future generations. http://www.research.ibm.com/articles/precision_agriculture.shtml. Updated 2012. Accessed August 14/2016.

163. Specter M. Climate By Numbers: Can a tech firm help farmers survive global warming*?. The New Yorke*r. 2013(November 11). http://www.newyorker.com/magazine/2013/11/11/climate-by-numbers. Accessed 11/11/2016.

164. Coble K, Griffin T, Ahearn M, et al. Advancing U.S. Agricultural Competitiveness with Big Data and Agricultural Economic Market Information, Analysis, and Research. 2016. Washington, D.C.: The Council on Food, Agricultural & Resource Economics. http://www.cfare.org/UserFiles/file/10-7-2016BigData_v1.pdf. Accessed 03/31/2017.

165. Brown RM, Dillon CR, Schieffer J, Shockley JM. The Impact of Precision Agriculture Techniques on Kentucky Grain Farmers' Carbon Footprint. 2012;2012 Annual Meeting:119802. Birmingham, AL:Southern Agricultural Economics Association. https://ideas.repec.org/p/ags/saea12/119802.html. Accessed 03/15/2017.

166. Imperfect Produce: Ugly Produce Delivered. http://www.imperfectproduce.com/home/#ugly-produce-delivered2016.

167. Cassman KG. Ecological intensification of cereal production systems: yield potential, soil quality, and precision agriculture. *Proc Natl Acad Sci U S* A. 1999;96(11):5952-5959.

HUNTER COLLEGE
NEW YORK CITY
FOOD POLICY CENTER

168. Ferrandez-Pastor FJ, Garcia-Chamizo JM, Nieto-Hidalgo M, Mora-Pascual J, Mora-Martinez J. Developing Ubiquitous Sensor Network Platform Using Internet of Things: Application in Precision Agriculture. *Sensors (Basel*). 2016;16(7):10.3390/s16071141.

169. Magnin C. How big data will revolutionize the global food chai*n. Digital McKinse*y. 2016: McKinsey & Company. http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/how-big-data-will-revolutionize-the-global-food-chain. Accessed 03/17/2017.

170. Pingali P. Westernization of Asian diets and the transformation of food systems: Implications for research and policy. *Food Policy*. 2007;32(3):281-298.

171. Godfray HCJ, Beddington JR, Crute IR, et al. Food Security: The Challenge of Feeding 9 Billion People. *Scienc*e. 2010;327(5967):812-818. doi: 10.1126/science.1185383.

172. Tilman D, Balzer C, Hill J, Befort BL. Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Science*s. 2011;108(50):20260-20264.

173. Foley JA, Ramankutty N, Brauman KA, et al. Solutions for a cultivated planet. *Natur*e. 2011;478(7369):337-342.

174. Ray DK, Mueller ND, West PC, Foley JA. Yield trends are insufficient to double global crop production by 2050. *PloS on*e. 2013;8(6):e66428.

175. Erickson B, Widmar DA. 2015 Precision Agricultural Services Dealership Survey Results. 2015. West Lafayette, IN: Purdue University, Department of Agricultural Economics/ Department of Agronomy. http://agribusiness.purdue.edu/files/resources/2015-crop-life-purdue-precision-dealer-survey.pdf.

176. Silva CB, LeiteRibeiro do Vale, S. M., Pinto FAC, Müller CAS, and Moura AD. The Economic Feasibility of Precision Agriculture in Mato Grosso do Sul State, Brazil: A Case Study. *Precision Agricultur*e. 2007;8:255-265.

177. Lindblom J, Lundstrom C, Ljung M, Jonsson A. Promoting sustainable intensification in precision agriculture: review of decision support systems development and strategies. *Precision Agricultur*e. 2016:1-23.

178. Shah N. The Wireless Garden of Edyn: Changing How Gardeners Grow Food. http://foodtank.com/news/2016/07/the-wireless-garden-of-edyn-changing-how-gardeners-grow-food. Updated 2016. Accessed July 24/2016.

179. Hayward A. The FarmBot Genesis Brings Precision Agriculture To Your Own Backyard. http://modernfarmer.com/2016/06/farmbot-genesis/?utm_source=farmbot-genesis&utm_medium=smithsonian&utm_campaign=partner. Updated 20162016.

180. Rosoff M. Every type of tech product has gotten cheaper over the last two decades — except for on*e. Business Insid*er. 2015. http://www.businessinsider.com/historical-price-trends-for-tech-products-2015-10.

181. Chamberlain G. Fred Jones. http://blackinventor.com/fred-jones/. Updated 20162013.

182. Pirog R, Benjamin A. *Checking the Food Odometer: Comparing Food Miles for Loval Versus Conventional Produce Sales to Iowa Institutions.* Ames, IA: Leopold Center; 2003.

183. Day-Farnsworth L, Miller M. Networking Across the Supply Chain: Transportation Innovations in Local and Regional Food Systems. *Center for Integrated Agricultural System*s. 2014.

184. Rickman JC, Barrett DM, Bruhn CM. Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 1. Vitamins C and B and phenolic compounds. *J Sci Food Agri*c. 2007;87(6):930-944.

185. Rickman JC, Bruhn CM, Barrett DM. Nutritional comparison of fresh, frozen, and canned fruits and vegetables II. Vitamin A and carotenoids, vitamin E, minerals and fiber. *J Sci Food Agri*c. 2007;87(7):1185-1196.

186. Arias R, Lee T, Specca D, Janes H. Quality comparison of hydroponic tomatoes (Lycopersicon esculentum) ripened on and off vine. *J Food Sc*i. 2000;65(3):545-548.

187. Barham J, Tropp D, Enterline K, Farbman J, Fisk J, Kiral S. Regional Food Hub Resource Guide. 2012. Washington, D.C.: U.S. Dept. of Agriculture, Agricultural Marketing Service. http://dx.doi.org/10.9752/MS046.04-2012.

188. Davies A. Uber's Self-driving Truck Makes its First Delivery: 50,000 Beers. https://www.wired.com/2016/10/ubers-self-driving-truck-makes-first-delivery-50000-beers/. Updated 20162016.

189. Boudette NE. Tesla's Self-Driving System Cleared in Deadly Crash. *The New York Time*s. Jan 19 2017;Business Day. Available from: https://www.nytimes.com/2017/01/19/business/tesla-model-s-autopilot-fatal-crash.html?_r=0. Accessed 04/01/2017.

190. Higgins T. Uber Self-Driving Car Crash Detailed in Police Report. *The Wall Street Journa*l. March 29 2017;Tech. Available from: https://www.wsj.com/articles/uber-self-driving-car-crash-detailed-in-police-report-1490841322. Accessed 04/01/2017.

191. Halo. How is Mobile Technology Impacting the Food and Beverage Supply Chain? https://halobi.com/2015/10/how-is-mobile-technology-impacting-the-food-and-beverage-supply-chain/. Updated 20162016.

192. Rabobank. More data, more food. https://www.rabobank.com/en/about-rabobank/background-stories/food-agribusiness/more-data-more-food.html. Updated 2016. Accessed 07/21/2016.

193. New York Governor's Press Office,. Governor Cuomo Launches New York State Grown & Certified Food Program. 2016;August 11. Albany, NY. https://www.governor.ny.gov/news/governor-cuomo-launches-new-york-state-grown-certified-food-program. Accessed 03/18/2017.

194. Purdue Extension - Local Food Program. Food Hubs. https://www.purdue.edu/dffs/localfood/food-and-business/food-hubs/. Updated 2015. Accessed 10/28/2016.

195. Ignaczak NM. Can software loosing Big Food's grip on institutions. http://newfoodeconomy.com/local-eyes-software-institutions/. Updated 20162016.

196. Diamond A, Barham J. Moving Food Along the Value Chain: Innovations in Regional Food Distribution. 2012. Washington, D.C.: U.S. Dept. of Agriculture, Agricultural Marketing Service. https://www.ams.usda.gov/sites/default/files/media/Moving%20Food%20Along%20the%20Value%20Chain%20Innovations%20in%20Regional%20Food%20Distribution.pdf.

197. Food to Market Challenge Awards $500K to Bring Healthy Food to Underserved Communities. https://www.foodtomarketchallenge.org/#news. Updated 20162016.

198. Cox K. Verdict: In Maine, Big Food Service Wins Again. http://newfoodeconomy.com/follow-up-university-of-maine-goes-big-again/. Updated 20162016.

199. Real Food Challenge . Sodexo and Real Food Challenge Sign Food Chain Transparency Agreement. http://www.realfoodchallenge.org/blog/sodexo-and-real-food-challenge-sign-food-chain-transparency-agreement. Updated 2013. Accessed 03/17/2017.

200. Real Food Challenge . Real Food Standards 2.0. 2016. https://www.realfoodchallenge.org/documents/15/RF_Standards_2.0.pdf. Accessed 03/17/2017.

201. Freudenberg N, Silver M, the Good Food Jobs Research Team. Jobs for Healthier DIet and a Stronger Economy: Opportunities for Creating New Good Food Jobs in New York City. 2013. New York: Hunter College New York City Food Policy Center. http://www.nycfoodpolicy.org/wp-content/uploads/2013/05/JOBS_NOEXSUM.pdf. Accessed 01/20/2017.

202. Flexe: The Marketplace for Space Warehouse. https://www.flexe.com/. Updated 20162016.

203. Morris DZ. This startup could change the game for same-day shipping. http://fortune.com/2015/10/09/flexe-warehousing-startup/. Updated 20152016.

204. Manzini R, Accorsi R. The new conceptual framework for food supply chain assessment. *J Food Eng*. 2013;115(2):251-263.

205. Bosona T, Gebresenbet G. Food traceability as an integral part of logistics management in food and agricultural supply chain. *Food Control*. 2013;33(1):32-48.

206. Bosona TG, Gebresenbet G. Cluster building and logistics network integration of local food supply chain. *Biosystems Engineering*. 2011;108(4):293-302.

207. Infor Supply Chain Management. Read the latest SCM SoftwareBuying Guide http://www.infor.com/solutions/scm/. Updated 20162016.

208. Guest. Why Dig Inn Uses Tech So We Can Eat Like Our Grandparents. https://foodtechconnect.com/2016/03/28/how-tech-is-helping-dig-inn-pioneer-a-veggie-forward-food-future/. Updated 20162016.

209. Cargomatic. About Us | Who is Cargomatic. https://www.cargomatic.com/. Updated 20152016.

210. O'Reilly L. How 'Uber for truckers' Cargomatic burned through $15 million as it quietly pivoted away from being a tech company at all. http://www.businessinsider.com/cargomatic-uber-for-truckers-history-founders-investors-2016-8. Updated 20162016.

211. Solomon MB. Brokerage uber alles! http://www.dcvelocity.com/articles/201503-brokerage-uber-alles/. Updated 20152016.

212. Sustainable Brands. Study: Many Consumers Willing to Pay More for, Switch to Completely Transparent Brand*s. Marketing and Comm*s. 2016;August 31. http://www.sustainablebrands.com/news_and_views/marketing_comms/sustainable_brands/study_many_consumers_willing_pay_more_switch_compl?mc_cid=ce84c83002&mc_eid=f5f109cda2. Accessed 11/11/2016.

213. Hepler L. 9 supply chain tech companies you should know. https://www.greenbiz.com/article/9-supply-chain-tech-companies-you-should-know. Updated 20152016.

214. Ecovadis. Sustainable Procurement Solution. http://www.ecovadis.com/buyer-solutions/2016.

215. Bauer K. Can Online Sales Bring Food Co-ops into the Modern Age? *Civil Eat*s. 08/30 2016. Available from: http://civileats.com/2016/08/30/can-online-sales-bring-food-co-ops-into-the-modern-age/?mc_cid=ce84c83002&mc_eid=f5f109cda2. Accessed 01/20/2017.

216. Statista: the statistical portal. Online grocery market share in the United States from 2013 to 2023. http://www.statista.com/statistics/531189/online-grocery-market-share-united-states/2016.

217. Frojo R. Online grocery shopping: Boom or bust? http://www.bizjournals.com/sanfrancisco/blog/2013/01/online-grocery-shopping-boom-or-bust.html?page=all. Updated 20132016.

218. Morgan Stanley. Are Groceries the Next Big Driver of Global eCommerce?. https://www.morganstanley.com/ideas/online-groceries-could-be-next-big-ecommerce-driver. Updated 20162016.

219. The Hartman Group. What's the Future for Online Grocery Shopping? http://www.forbes.com/sites/thehartmangroup/2015/06/17/whats-the-future-for-online-grocery-shopping/#3e0783fa7cff. Updated 20152016.

220. Bensinger G. Grocery-Delivery Startup Instacart Cuts Pay for Couriers. *The Wall Street Journa*l. March 11 2016. Available from: http://www.wsj.com/articles/grocery-delivery-startup-instacartcuts-pay-for-couriers-1457715105.

221. Vasel K. Restaurant owner pocketed tips paid through Seamless, GrubHub. *CNN*. March 15 2016;Money. Available from: http://money.cnn.com/2016/03/15/pf/tips-seamless-grubhub-delivery/. Accessed 03/31/2017.

222. Ha A. Good Eggs Will Shut Down All Operations Outside San Francisco, Lay Off Nearly 140 Employees. *TechCrunc*h. August 5 2015. Available from: https://techcrunch.com/2015/08/05/good-eggs-layoffs/. Accessed 12/01/2016.

223. Gould D. Meet the Man Who's Making Good Eggs Profitable. *Food + Tech Connec*t. August 29 2016. Available from: http://foodtechconnect.com/2016/08/29/bentley-hall-good-eggs-profitable/?mc_cid=ce84c83002&mc_eid=f5f109cda2. Accessed 12/01/2016.

224. Farmdrop. How it works. https://www.farmdrop.com/how-it-works. Updated 2016. Accessed 10/25/2016.

225. Ronen B. Farmigo Blog - Thank you. http://blog.farmigo.com/thank-you-farmigo-csa-software/. Updated 2016. Accessed July 30/2016.

226. Gould D. Why Farmigo Is Shutting Down Its Online Farmers Market. *Food + Tech Connec*t. July 22 2016. Available from: https://foodtechconnect.com/2016/07/22/farmigo-shutting-down-online-farmers-market/.

227. Levine B. Step by step, physical grocery stores are becoming back ends for online shopping. http://marketingland.com/step-step-physical-grocery-stores-becoming-backends-online-shopping-189627?mc_cid=ce84c83002&mc_eid=f5f109cda2. Updated 20162016.

228. Sidman J. These Robots Will Be Delivering Food in DC Very Soon. https://www.washingtonian.com/2016/10/03/these-robots-will-be-delivering-food-in-dc-very-soon/. Updated 20162016.