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## Food

# Feeding the Future of Agriculture with Vertical Farming

The technology-driven model of agriculture may offer a means to address farm output and food security in the years to come.

By Mark Esposito, Terence Tse, Khaled Soufani, & Lisa Xiong | Dec. 27, 2017

Average global food prices have gone up by **2.6 percent annually**

(<http://www.fao.org/worldfoodsituation/foodpricesindex/en/>) in the past two decades. If that trend continues, not only does it threaten a baseline quality of life as more disposable income goes toward food, it also threatens our overall food security.

Hunger and malnutrition issues persist, especially in developing countries. Food scarcity problems have also been linked to political unrest and violence. According to the United Nations World Food Programme, **record-high food prices** (<https://ourworld.unu.edu/en/food-insecurity-and-the-conflict-trap>) in 2008 prompted riots in 48 countries, including fragile states like Somalia and Yemen.

Rising food costs reflect underlying trends leading to failures with traditional agriculture. Vertical farming, a technology-driven model of agriculture, may offer a means to address farm output and food security in the years to come, even if it may not impact food prices in the many months ahead.

## Why is conventional farming frustrating us?

Field farming requires labor, amenable weather conditions, adequate sunshine for photosynthesis, irrigation, and often pesticides to protect crops. That hasn't changed, but we can detect reasons why

conventional farming is no longer working as well as it used to by using a framework we developed. While it may appear that the world's economies are significantly affected by unforeseeable events, the DRIVE framework is based on the notion that certain interrelated large-scale processes, which drive the behavior of businesses, governments, and societies, also influence the future. By analyzing demographic and social changes, resource scarcity, inequalities, and volatility, scale, and complexity, we can forecast how the future may unfold. Analyzed together, these megatrends can reveal the root causes behind the shifts in conventional agriculture.

- **Demographic and social changes**

The global food supply cannot keep up with the growing global population. According to the **Food and Agriculture Organization of the United Nations** (<http://www.fao.org/>), food production must increase by 70 percent before the year 2050 in order to meet global food needs. This growth must happen against a headwind—urbanization is taking over arable land while simultaneously pushing people away from farming as a profession.

- **Resource scarcity**

Agriculture sucks up 70 percent of our global water consumption, adding to its total cost. Given the estimate that **half of the world's population will experience water scarcity by 2030** (<http://www.un.org/waterforlifedecade/scarcity.shtml>), agriculture's production methods are unsustainable. Supply chain inefficiencies compound the scarcity effect. Perishable crops blemish and spoil during harvesting, packaging, processing, and distribution. According to a Natural Resources Defense Council report on food from field to fork to landfill, **up to 40 percent of all crops are ultimately wasted** (<https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf>) .

- **Inequality**

In addition to longstanding problems with malnutrition and widespread poverty in developing countries, inequalities related to food prices have also arisen in industrialized countries. In places like the United States, the cost of fresh foods have led vulnerable populations to opt for fat- and sugar-laden processed foods with little nutritional value. The consequence of these food “choices” is a nationwide obesity

epidemic as well as an increase in diet-related diseases like diabetes. At the other end of the spectrum, higher-income households are driving demand for more health-conscious “superfoods” like antioxidant-rich kale and protein-packed quinoa. As global food requirements and the costs of agriculture continue to rise, the prospects of improving health and nutrition conditions are dire for low-income families in industrialized and developing countries alike.

- **Volatility**

Agriculture remains one of the most vulnerable industries when it comes to natural disasters. Climate change has caused more frequent extreme weather events, which can damage an entire season’s worth of harvest. Higher temperatures are also leading to **rampant spreading of crop pests** (<https://www.nature.com/articles/501S15a>). In addition, government policy can also affect food production and prices. For instance, in the United States ethanol mandates diverted corn fields used for food production to fuel production, and resulted in **price hikes from \$2 or \$3 to \$7 a bushel** (<https://www.technologyreview.com/s/423385/ethanol-blamed-for-record-food-prices/>). Such forces, which determine the direction of price volatility, are here to stay.

Through the lens of the DRIVE framework, we can see how conventional agriculture alone will be unsustainable as a reliable and affordable source of food production.

## **Vertical farming born out of challenges**

One answer to these food supply problems is emerging from high-tech structures to our dining tables. Vertical farming, a term coined by Dickson Despommier, is the practice of producing food in vertically-stacked layers. These “farms” make use of enclosed structures like warehouses and shipping containers to provide a controlled environment to grow crops in a hydroponic or aeroponic system. Electronic sensors ensure that crops receive the right amount of LED light, nutrients, and heat. The benefits include independence from arable land, year-round growing capacities, less water consumption, and improved crop predictability.

For example, AeroFarms, a 70,000-square-foot vertical

farm in a renovated steel plant in New Jersey, claims 95 percent less water use and 390 times more productivity than a commercial field farm with the same square footage. The company Growtainer sells easy-to-operate 20- or 40-foot shipping containers set up as insulated hydroponic farms. The goal is to help communities grow leafy vegetables in the same places where they will be consumed, such as schools, **food banks**



(iStock)

(<https://civileats.com/2017/11/17/with-vertical-farms-some-food-banks-are-growing-their-own-produce-to-fight-hunger/>) , restaurants, and military bases.

Vertical farms can help meet our growing population's needs by offering an additional way to produce food that does not share the same volatility and risk as conventional agriculture. While vertical farms require less water and arable land than conventional farms, they are not carbon neutral. Their climate footprint depends heavily on the source from which they draw their electricity to power lighting and control the indoor environment. As renewable energy sources become adopted more widely, the carbon cost of vertical farming will continue decreasing. From a market perspective, it may not bring down prices, but on a societal level, the hope is that vertical farming can help address gaps in overall food demand where conventional agriculture fails.

### **Tasty prospects but not one-size-fits-all**

The social, ecological, and economic promise of vertical farming has been embraced but not yet scaled. Due to various factors related to geographic location, cultural difference, political support, investor dynamics, and local agricultural market conditions, what works for the companies described above might not work for others entering vertical farming. Moreover, there are limitations to what plant species can be grown in an indoor environment. For instance, fruits and vegetables that have a lot of inedible weight, such as leaves, stems, and roots, would not make good use of vertical farming space or resources. For commercial farmers interested in expanding into vertical farming and social entrepreneurs who see potential for using vertical farming to address local food and hunger issues, there are ways to minimize the expensive learning curve and improve their chances of success:

## **Change the perception of the farming profession**

Traditional farming has been characterized as labor-intensive and remote to a modern and urbanized lifestyle. In some places, farm work is associated with poverty and isolation, but in the vertical farm, farmers must be data analysts, bio-scientists, and system supervisors in addition to working with crops. Should urban farms continue to scale, this could result in displacement of existing low-skilled labor. Such a shift is typical of any major industry transformation—economists call this the rebound effect. Understanding this transformation in farming provides professionals who are either entering or already in the vertical farming industry with leverage when communicating the need to embrace vertical farming with different stakeholders.

## **Educate consumers**

Vertical farming is not Frankenstein food, but might as well be without any efforts to educate the public. Companies can use promotional campaigns to clarify the value of non-field farming crops and educate consumers on the nutritional and environmental benefits of vertical farming. Food-tasting events can also provide consumers the opportunity to sample hydroponic and aeroponic produce and judge the taste for themselves.

## **Support local food economies**

Governments and industry groups can be valuable allies who view local food production as economic development. In Canada, for example, the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) actively supports a regional food strategy, with project support ranging from promotional campaigns to the creation of farmers markets and funding for agricultural companies to buy new equipment. With OMAFRA's support, the sector added \$1.3 billion in GDP and created more than 34,000 jobs between 2013 and 2015. Such government support is a sign that local food movements are a credible source of economic development with no signs of abating.

## **Encourage continued investment**

Investors are essential to helping vertical farming scale. While some major investments in vertical farming

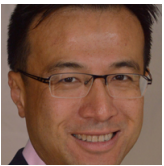
are already happening—Silicon Valley startup Plenty recently **received \$200 million** (<https://www.bloomberg.com/news/articles/2017-07-19/softbank-s-vision-fund-leads-200-million-bet-on-indoor-farming>) to support its global expansion—others may have to strategize a bit more, particularly since **some vertical farm startups have failed** (<https://www.bloomberg.com/news/articles/2017-07-19/softbank-s-vision-fund-leads-200-million-bet-on-indoor-farming>) in that same timeframe. AeroFarms, for instance, secured equity funding of \$95.8 million by positioning itself not as a nontraditional farm but rather as “an urban agriculture and cleantech company.” Other trends that are attracting investment include using vertical farming technology to grow nutrient-specific crops like **Fujitsu’s low-potassium lettuce** (<http://www.japantimes.co.jp/news/2014/05/13/national/science-health/fujitsu-harvests-low-potassium-lettuce-grown-plant-clean-room/>) .

## Revamping the future of agriculture

Though vertical farms can never be expected to replace traditional farms, it is likely that they will have to complement each other if we are to meet the food demands of tomorrow. It is economically sensible, environmentally friendly, tech-savvy, and most importantly, health-sensitive. Vertical farming is not a fairytale; it is happening now.



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