The Evolution of Urban Farming

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Cubic agriculture is defined as the use of a modular growing apparatus that can be stacked vertically or horizontally. Each module is identical, meaning that plants can be grown in any climate-controlled building, regardless of shape, floor plan, or ceiling height. Cubic agriculture has been developed with the increased focus on urban farming initiatives to supply food in large cities. Governments are worried about sustainability of the food supply, as current farming methods are resource-intensive. Cubic agriculture has been raised as an additional solution to issues of sustainability and food safety, food security and traceability.

Background

Since the 1950's, agriculture has undergone intensification, concentration and specialization. The new standard is referred to as "Intensive Agriculture."

Concerns have been raised over the sustainability of intensive agriculture. It often leads to a vicious cycle of overuse of soil and an exhaustion of soil fertility, followed by a decline of agricultural yields, which in turn requires farmers to overuse their soil even more.[35] Traditional methods of crop rotation allowed soil to recover, but industrial farmers need to produce large volumes of one crop just to keep the farm financially solvent. As such, they have had to resort to monoculture, the repeated use of the same field for one crop, as this is the only way to produce sufficient quantities. Monoculture allows farms to produce commercial quantities in the short term, but it causes long-term damage to the quality of the soil. Moreover, it takes only a few decades for herbicide-resistant weeds to adapt, and insects become resistant to insecticides within about a decade.[40] Approximately 40% of the world's agricultural land is seriously degraded.[36] In Africa, if current trends of soil degradation continue the continent might be able to feed just 25% of its population by 2025, according to UNU's Ghana-based Institute for Natural Resources in Africa.[37] As of December 2007, 37 countries faced food crises, and 20 had imposed some sort of food-price controls. Some of these shortages resulted in food riots and deadly stampedes.[17][18][19]

Farm yields have increased dramatically because of monoculture, selectively bred high-yielding varieties, fertilizers, pesticides, irrigation, and machinery. For example, yields in eastern Colorado increased by 400% from 1940 to 1997.[39] In 2009, the agricultural output of China was the largest in the world, followed by the European Union, India and the United States, according to the International Monetary Fund (*see below*).

Economists use total factor productivity as a metric for agriculture. By this measure agriculture in the United States is roughly 2.6 times more productive than it was in 1948.[43] These advances have led to efficiencies enabling certain modern farms in the United States, Argentina, Israel, Germany, and a few other nations to output volumes of high-quality produce per land unit at what may be the practical limit. In spite of this, many crops have not seen yield increases in the past 15–20 years.[40] The genetic "yield potential" has increased for wheat, but the yield potential for rice has not increased since 1966, and the yield potential for maize has "barely increased in 35 years".[40] While some yields have increased, there has been widespread ecological damage to habitats and the water supply, and negative human health effects.[4]

A number of civil society organizations[37] have criticized the IMF's policies for their impact on people's access to food, particularly in developing countries. In October 2008, former U.S.

president Bill Clinton presented a speech to the United Nations World Food Day, which criticized the World Bank and IMF for their policies on food and agriculture:

> "We need the World Bank, the IMF, all the big foundations, and all the governments to admit that, for 30 years, we all blew it, including me when I was president. We were wrong to believe that food was like some other product in international trade, and we all have to go back to a more responsible and sustainable form of agriculture."—Former U.S. president Bill Clinton, *Speech at United Nations World Food Day, October 16, 2008*[38]

Food Security

Food security is the ability of a population to have a supply of safe food at all times. Similar to a bank being sufficiently solvent and having enough cash on hand to honour all its clients withdrawals, a secure food supply requires food to be grown or imported on a continuous basis in large enough quantities. Food security involves more than the actual quantity of food produced; if a population is isolated in a desert or on an island, a shutdown of a major road or port will threaten the population's ability to access food. As such, the more food can be grown locally, the more secure the food supply is.

Two commonly used definitions of food security come from the UN's Food and Agriculture Organization (FAO) and the United States Department of Agriculture (USDA):

- Food security exists when all people, at all times, have physical, social[23] and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. (FAO)[24]
- Food security for a household means access by all members at all times to enough food for an active, healthy life. Food security includes at a minimum (1) the ready availability of nutritionally adequate and safe foods, and (2) an assured ability to acquire acceptable foods in socially acceptable ways (that is, without resorting to emergency food supplies, scavenging, stealing, or other coping strategies). (USDA)[25]

As of November 2007, approximately 3.3 billion people, about half of the planet's population, live in urban areas, away from farms. In the US, there are approximately 2,000,000 farmers, less than 1% of the population. Globally, 2 billion people lack food security due to varying degrees of poverty (source: FAO, 2003). Any disruption to food supplies may precipitate a uniquely urban food crisis in a relatively short time.[20] Recently, food riots have taken place in many countries across the world.[17][18][19]

Cubic farming grew out of questions of sustainability and environmental degradation. These questions have inspired different schemes of urban agriculture across the developed and developing world [4]. Community gardens and rooftop greenhouses have limited outputs. They do not produce enough to fundamentally change modern agriculture. Recently, governments have actively promoted urban farming initiatives in less affluent communities, as families who suffer from poverty are the most at risk during food shortages and famines. This places one further constraint on the solution: Governments cannot always build a suitable facility "from scratch." Sometimes, an old and potentially dilapidated building must be adapted. It is apparent that a few motivated "green thumbs" are not enough. The solution requires technology.

Worldwide around 852 million people are chronically hungry due to extreme poverty, while up to Six million children die of hunger every year - 17,000 every day.[5] As of late 2007, export restrictions and panic buying, US Dollar Depreciation,[6] increased farming for use in biofuels,[7] world oil prices at high levels,[8] global population growth,[9] climate change,[10] loss of

agricultural land to residential and industrial development,[11][12] and growing consumer demand in China and India[13] are claimed to have pushed up the price of food [14][15].

Controlled Environment Agriculture (CEA)

Controlled Environment Agriculture, sometimes called indoor farming, is the use of technology to adjust the conditions inside a building to make it more accommodating to plant growth. This could be as simple as regulating the temperature inside a greenhouse to a theoretical optimum, or it could involve equipping an entire building with growing lights and climate control machines.

The sustainability problem has prompted research at leading universities. Professors are looking into the secure, healthy, and cost-effective production of food.

The University of Arizona sponsors a facility devoted to "controlled environment agriculture," the use of technology to optimize crop growth, hydroponics, and medicinal plants in a closed area. Researchers seek the ideal growth conditions by using machines to adjust a building's humidity, temperature, light, gases, and water. The university also offers programs in "protected agriculture." Protected agriculture is the growth of horticultural crops out of season. A common solution uses agricultural plastics to maximize productivity while remaining environmentally friendly.

At Cornell, 0.15 acres of greenhouse space were constructed to demonstrate the feasibility of commercial production of hydroponically grown lettuce. This facility started production in July 1999. It originally produced 1,000 heads of butter head lettuce per day, year round. Improved plant spacing has increased output to 1,245 heads (70 heads per square foot). This is the equivalent of 3,049,200 heads per acre/year. Intensive farming only produces 96,000 heads per acre/year.

Nevertheless, this solution is not economically viable. The generally accepted published statistics show that intensive farming is more cost efficient to produce commercial quantities of vegetables due to expense of lighting, heating and other greenhouse operations.

Vertical Farming

Vertical farming is a form of controlled environment agriculture. Columbia University ecologist Dickson Despommier has become one of the leading proponents in recent years, after developing the concept of a high-rise building with a separate controlled environment on each floor. While the concept of vertical farming has been around since at least 1915, Despommier's "skyscraper as spaceship" concept has garnered attention, even though no prototype has yet been built. The idea has appeared in several popular science magazines in recent years, but there appear to be practical limitations. For example, the idea seems limited to an environment like Manhattan that is densely populated with existing infrastructure developed for tall buildings.

Critics have questioned the economics of a vertical farm, noting the operation costs of lighting, heating, and cooling a large building. The advantage would be a reduction in food miles, but this advantage is only seen in big cities. In a smaller city, less fuel is needed to ship sufficient food to feed everyone. As such, the heavy use of energy to operate a vertical farm may not be the more environmentally friendly option. In smaller cities, the economic advantages are reduced significantly. As such, even if the vertical farm is feasible for the world's largest cities, it would not be a global solution. Nevertheless, Despommier is working with businessmen and architects to develop the world's first vertical farm.

To increase the yield from greenhouses, several companies have recently developed hydroponic apparatuses that grow in vertical cylinders. These companies have also named their inventions

vertical growing machines. This integrating hydroponic technology and greenhouse technology has paved the way for the modern concept of the vertical farm. Some claim to be able to produce per-unit yields from 20 to 30 times higher than of field crops This compares with the 28 times per-unit yields from the CEA greenhouse at Cornell (see above).

Cubic Farming

In recent years, a handful of innovators have shifted their focus towards adapting buildings, as opposed to designing the "perfect" facility. In 2009, Jacob Benne and Dan Meikleham developed a "Growing Cube," a 10 x 10 box shaped apparatus that is mechanized to increase output by moving the plants under a light source at the same time utilizes second generation line production principles to reduce labor inputs.

By using a modular system, rows of Growing Cubes can be stacked on top of each other like building blocks. Thus, any climate-controlled building can be filled with automated growing machines effectively creating a total cubic growing environment.

As the modular machines have already been proven effective and efficient, urban agriculture research has evolved from creating an environment to adapting an environment. The cubic farming concept is unique in that it makes use of a building's entire cubic volume, instead of its footprint - a warehouse with 40-foot ceilings and 1,000 square feet of floor space is (in theory) as good as a building with 20-foot ceilings and 2,000 square feet of floor space. The technology will not be limited by the inability to find a building with an appropriate floor plan as in vertical farming.

When combined with standard indoor climate control, the Growing Cube can produce yields of 88 times that of conventional industrial farming per square foot of area with a 32 foot high ceiling. The per-acre yield of cubic farming increases as each layer of cubes is stacked on top of the last layer. The inventors developed a propriety system for the Growing Cube and filed with the United States Patent Office on 8 May 2011.

Worldwide Landscape:

- **1 Billion** people in the world are chronically undernourished
- **100,000** people die of starvation each day, including one child every 5 seconds
- **70%** of our fresh water and **20%** of our energy is used for agriculture
- **80%** of the world's population will live in urban areas by 2050
- **3 Billion** more people by midcentury

Source: http://www.nytimes.com/2011/05/19/business/smallbusiness/19sbiz.html?_r=1&ref=urbanagriculture