JUST AGRICULTURE
multidisciplinary e-Newsletter

Vertical Farming: The Future Food Production System

Imnatemjen Aier, MM Shulee Ariina, Kevineituo Bier, Otto S. Awomi & Dr. Benjongtoshi
School of Agricultural Sciences and Rural Development,
Nagaland University

ARTICLE ID: 095

Introduction

Vertical farming is the practice of producing food and medicine in vertically stacked layers, vertically inclined surfaces and/or integrated in other structures (such as in a skyscraper, used warehouse, or shipping container). The modern ideas of vertical farming use indoor farming techniques and controlled-environment agriculture (CEA) technology, where all environmental factors can be controlled. These facilities utilize artificial control of light, environmental control (humidity, temperature, gases) and fertigation. Some vertical farms use techniques similar to greenhouses, where natural sunlight can be augmented with artificial lighting and metal reflectors. The term "vertical farming" was coined by Gilbert Ellis Bailey in 1915 in his book *Vertical Farming*. His use of the term differs from the current meaning—he wrote about farming with a special interest in soil origin, its nutrient content and the view of plant life as "vertical" life forms, specifically relating to their underground root structures. Modern usage of the term "vertical farming" usually refers to growing plants in layers, whether in a multistory skyscraper, used warehouse, or shipping container. The unremitting trends of increasing population, urbanization, diminishing water supply, and continuing climate change have contributed to declining stocks of arable land per person. As land resources for agriculture decrease, policy makers are faced with the challenge of sustainability and feeding the rapidly growing world population which is projected to reach approximately 9.7 billion in 2050. Solutions for improving future food production are exemplified by urban vertical farming which involves much greater use of technology and automation for land-use optimization. The vertical farm strategy aims to significantly increase productivity and reduce the environmental footprint within a framework of urban, indoor, climate- controlled high-rise buildings. It is claimed that such facilities offer many potential

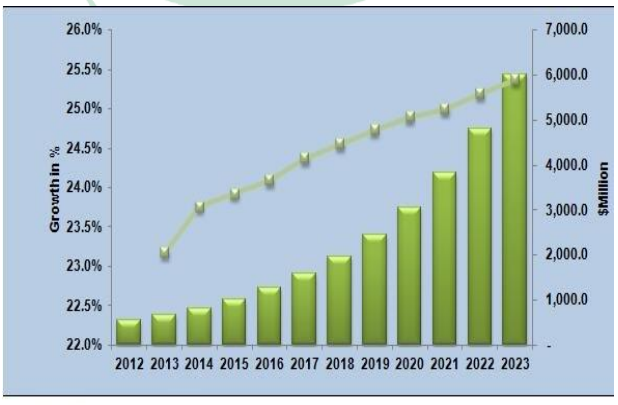
JUST AGRICULTURE
multidisciplinary e-Newsletter

advantages as a clean and green source of food, along with bio-security, freedom from pests, droughts, and reduced use of transportation and fossil fuels.

Why Vertical Farming?

1. **Food Security:-** Food security has become an increasingly important issue. Demographers anticipate that urban population will dramatically increase in the coming decades. At the same time, land specialists (e.g., agronomists, ecologists, and geologists) warn of rising shortages of farmland. For these reasons, food demand could exponentially surpass supply, leading to global famine. The United Nation (UN) estimates that the world's population will increase by 40%, exceeding 9 billion people by the year 2050 (The United Nations, 2017 Revision). The UN also projects that 80% of the world's population will reside in cities by this time. Further, it predicts that by 2050 we will need 70% more food to meet the demands of 3 billion more inhabitants worldwide (The United Nations, 2017 Revision). Food prices have already skyrocketed in the past decades, and farmers predict that prices will increase further as oil costs increase and water, energy, and agricultural resources diminish. The sprawling fringes of suburban development continue to eat up more and more farmland. On the other hand, urban agriculture has been facing problems due to land scarcity and high costs. We desperately need transformative solutions to combat this immense global challenge

2. **Economic status:-**Proponents of the vertical farm also argue that it will supply competitive food prices. The rising expense of traditional farming is quickly narrowing the cost gap. For example, when vertical farms are located strategically in urban areas, it would be possible to sell produce directly to the consumer, reducing transportation costs by removing the intermediary, which can constitute up to 60% of costs



Source: Acumen Research and Consulting

JUST AGRICULTURE
multidisciplinary e-Newsletter

3. Health:-Conventional farming practices often stress profit and commercial gain while paying inadequate attention to inflicted harm on the health of both human and the natural environment. These practices repeatedly cause erosion, contaminate soil, and generate excessive water waste. Regarding human well-being, the World Health Organization has determined that over half of the world's farms still use raw animal waste as fertilizer which may attract flies, and may contain weed seeds or disease that can be transmitted to plants (Al-Kodmany, 2018). Consequently, people's health is adversely affected when they consume such produce. Further, growing crops in a controlled indoor environment would provide the benefit of reducing the excessive use of pesticide and herbicide, which create polluting agricultural runoff. According to Cho, 2011, pests, pathogens, and weeds have a much harder time infiltrating and destroying crops in a contained environment. When excess fertilizer washes into water bodies (e.g., rivers, streams, and oceans), a high concentration of nutrients is created (called eutrophication), which could disturb the ecological equilibrium. For example, eutrophication may accelerate the proliferation of algae. However, when it dies, microbes consume algae and suck all the oxygen in water, resulting in dead aquatic zones (Despommier, 2009).

4. The Ecosystem:-Traditional agriculture has been encroaching upon natural ecosystems for millennia. Farming has upset more ecological processes than anything else—it is the most destructive process on earth. Indoor vertical farming can reduce the agricultural impact on the world's ecosystems by restoring biodiversity and reducing the negative influences of climate change. By eliminating fertilizer runoff, coastal and river water could be restored, and fish stock of wild fish could increase (Despommier, 2010). Wood *et al.* 2001 summarize this point by stating "The best reason to consider converting most food production to vertical farming is the promise of restoring services and functions of ecosystems.

Structure and working of vertical farms

Fig 3: crops grown in vertical farm.

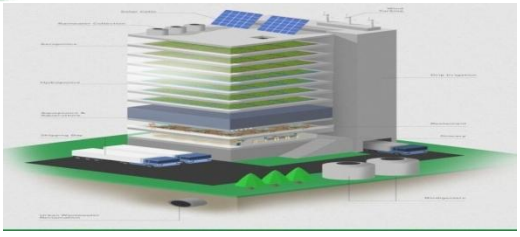


Fig 4: Anatomy of a Vertical farm

JUST AGRICULTURE
multidisciplinary e-Newsletter

How Vertical Farming Works

There are four key areas to analyze the function of urban farming:

(1) physical layout

(2) lighting

(3) growing medium

(4) sustainability features

Key characteristics and functions of a vertical farm are explained as follows:

- The primary goal of vertical farming is to maximize the output efficiency per square meter foot, resulting in a "stacked" tower like structure.
- Often a combination of grow lights and natural light will be used, technologies like rotating beds can increase lighting efficiency and natural light exposure.
- Growing medium can be hydroponic, aquaponic, or even aeroponic (no soil or other medium). Non soil mediums like coconut husks or peat moss are often used.
- Sustainability features that offset the energy costs of the farm may include: rain water collection tanks, wind turbines, multipurpose spaces in the structure not used for cultivation.

Advantages:

Table 1: Benefits of vertical farm over other methods (lettuce crop)

Parameters	Outdoor	Greenhouse	Vertical farm
Growth cycle	70 days	40-50 days	20days
Water consumption per crop	35 l	25 l	1.5 l
Number of Crops per square meter	18	25	250-300
Crop cycles	Seasonal	Seasonal	All year
Pesticides/ Herbicides	Often	Less often	None
Location	Open field	Open field	Anywhere
Post harvest handling	High	Medium	Low

Source: Frank Tobe, 2016.

JUST AGRICULTURE
multidisciplinary e-Newsletter

1. Increased crop production:-Unlike traditional farming in non-tropical areas, indoor farming can produce crops year-round. All-season farming multiplies the productivity of the farmed surface by a factor of 4 to 6 depending on the crop. With crops such as strawberries, the factor may be as high as 30 (Despommier, 2008). Furthermore, as the crops would be consumed where they are grown, long-distance transport with its accompanying time delays, should reduce spoilage, infestation and energy needs. Globally some 30% of harvested crops are wasted due to spoilage and infestation, though this number is much lower in developed nations (Despommier, 2009).

2. Weather disruption:-Crops grown in traditional outdoor farming depend on supportive weather, and suffer from undesirable temperatures rain, monsoon, hailstorm, tornado, flooding, wildfires and drought. Changes in rain patterns and temperature could diminish India's agricultural output by 30 percent by the end of the century (Pollan, Michael., 2009). VF productivity is mostly independent of weather, although earthquakes and tornadoes still pose threats.

3. Conservation:-Up to 20 units of outdoor farmland per unit of VF could return to its natural state, due to VF's increased productivity (*Despommie, 2009).* Vertical farming would thus reduce the amount of farmland, thus saving many natural resources. Deforestation and desertification caused by agricultural encroachment on natural biomes could be avoided. Producing food indoors reduces or eliminates conventional plowing, planting, and harvesting by farm machinery, protecting soil and reducing emissions.

4. Resource scarcity:-The scarcity of fertilizer components like phosphorus poses a threat to industrial agriculture. The closed-cycle design of vertical farm systems minimizes the loss of nutrients, while traditional field agriculture loses nutrients to runoff and leeching (Timmons *et al.* 1973).

5. Mass extinction:-Withdrawing human activity from large areas of the Earth's land surface may be necessary to address anthropogenic mass extinctions. Traditional agriculture disrupts wild populations and may be unethical given a viable alternative In comparison, vertical farming would cause nominal harm to wildlife (Davis, 2001).

6. Human health:-Traditional farming is a hazardous occupation that often affects the health of farmers. Such risks include: exposure to infectious diseases such as malaria and schistosomes, exposure to toxic pesticides and fungicides, confrontations with

JUST AGRICULTURE
multidisciplinary e-Newsletter

wildlife such as venomous snakes, and injuries that can occur when using large industrial farming equipment. VF reduces some of these risks. The modern industrial food system makes unhealthy food cheap while fresh produce is more expensive, encouraging poor eating habits. These habits lead to health problems such as obesity, heart disease and diabetes.

7. Poverty and culture:- Food security is one of the primary factors leading to absolute poverty. Constructing farms will allow continued growth of culturally significant food items without sacrificing sustainability or basic needs, which can be significant to the recovery of a society from poverty.

8. Urban growth:- Vertical farming, used in conjunction with other technologies and socioeconomic practices, could allow cities to expand while remaining substantially self-sufficient in food. This would allow large urban centers to grow without food constraints.

9. Energy sustainability:- Vertical farms could exploit methane digesters to generate energy. Methane digesters could be built on site to transform the organic waste generated at the farm into biogas that is generally composed of 65% methane along with other gases. This biogas could then be burned to generate electricity for the greenhouse.

Disadvantages

1. Issues Regarding Economic Viability Due to Costs:-Different concerns regarding economic feasibility collectively comprise one of the notable limitations or disadvantages of vertical farming. Note that this modern type of farm depends heavily on modern engineering and architecture, as well as the application of different technologies. There is also a challenge over costs and competition for commercial spaces in cities. Building vertical farms in expensive cities can add to the total investment and operational costs. Furthermore, endorsing the building of vertical farms could also increase occupancy cost and real estate value due to additional demand.

2. Possible Environmental and Energy Implications:-There are also concerns over pollution and sustainable use. Crops grown indoors depend on artificial light. Note that sunlight can be exploited for natural lighting or self-sufficient generation of electricity through photovoltaic solar panels. The use of light-emitting diode or LED lamps also drives down the cost of electricity consumption. Of course, other than artificial lighting, a vertical farm includes complex machinery and automated systems. Hence, when compared to field farming, vertical farming has an additional energy input. While renewable and alternative

JUST AGRICULTURE
multidisciplinary e-Newsletter

sources of energy can promote the ecological soundness of vertical farming, the practice can still have a considerable carbon footprint if it still depends on the use of fossil fuels. There is a need to improve first renewable and alternative energy technologies to guarantee environmental sustainability and energy efficiency of vertical farming.

3. Likely Disruption to the Rural Sector and its Communities:-Another foreseen challenge and disadvantage of vertical farming involves the potential for disrupting the rural sector, especially those communities with economies that are dependent on agriculture. Vertical farms can render traditional farming jobs obsolete. Farmers who do not have competencies in vertical farming would be left jobless. Communities dependent on agriculture would certainly suffer. Essentially, urban farming would compete with rural farming. The review study of Benke and Tomkins noted that to transition to vertical farming effectively, there is a need to devise and implement strategies or plans intended to educate government officials, create relevant laws or policies, and familiarize farmers to new trends in agriculture.

4. Requires Advance Technologies and Complex Processes:-Aligned to the high startup cost of building and operating a vertical farm, another possible disadvantage is the need to apply various technologies and design complex processes. Vertical farming is more complicated to initiate and maintain than traditional field agriculture.

Conclusion

"We live vertically, so why can't we farm vertically?"

The global megatrends of decreasing water supply, increasing population, urbanization, and unabated climate change have contributed to globally decreasing stocks of arable land per person. Under these circumstances, the sustainability of the traditional farming model based on large rural farms is likely to come under threat in coming decades. One approach for engaging with this challenging problem is vertical farming, which is based on controlled environment agriculture and greenhouse designs suitable for urban settings.

The best reason to consider converting most food production to vertical farming is the promise of restoring ecosystem services and functions. There is good reason to believe that an almost full recovery of many of the world's endangered terrestrial ecosystems will occur simply by abandoning a given area of encroachment and allowing the land to "cure" itself .

Vertical Farming presents a unique investment opportunity as it aims to revolutionize our understanding of food production and urban development.

JUST AGRICULTURE
multidisciplinary e-Newsletter

Reference

Al-Kodmany K. 2018. The Vertical City: A Sustainable Development Model. WIT Press: Southampton, UK.

Cho R. 2011. Vertical Farms: From Vision to Reality. *State of the Planet, Blogs from the Earth Institute.*

Davis S L. 2001. The least harm principle suggests that humans should eat beef, lamb, dairy, not a vegan diet.

Despommier D. 2010. The Vertical Farm: Feeding the World in the 21st Century; *Thomas Dunne Books: New York*, USA.

Despommier D. *2009*. The Rise of Vertical Farms. *Scientific American*. ***301*** *(5): 60–67*.

Frank Tobe. 2016. Rising need for nursery, indoor and vertical farming.(https://www.therobotreport.com/rising-need-for-nursery-indoor-and-vertical-farming/)

Pollan Michael. 2009. Opinion | Big Food vs. Big Insurance". *The New York Times*

The United Nations. World Population Prospects. 2017. United Nations: New York, NY, USA.

Timmons D R.Burwell R E, Holt R F. 1973. Nitrogen and Phosphorus Losses in Surface Runoff from Agricultural Land as Influenced by Placement of Broadcast Fertilizer. *Water Resources Research*.**9(3)**: 658-667

Wood S, Sebastian K and Scherr S J, 2001. Pilot Analysis of Global Ecosystems: Agroecosystems. *International Food Policy Research Institute and World Resources Institute*. Washington, DC, USA. pp 110.