Vertical Farming:

A Responsible Future

Whitepaper
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Introduction

Traditional farming is becoming less sustainable as the Earth continues to battle **food insecurity**, **changing climates**, **increasing population**, and **lack of farming space**. In the next 50 years, it is expected that the world's population will increase to **9 billion**, with **80%** living in urban areas, increasing demand for sustainable food production.[1] Lush forests rich with diverse ecosystems are being destroyed in order to create more land for farming in order to keep up with demand. Not only is this unsustainable, but space is running out. Currently, **80%** of the world's capable land for farming is already being used.[2]

Assuming the space issue is solved, we still face problems with $C0_2$ production associated with farming and transport. In 2008, agriculture accounted for **17%** of global $C0_2$ production.[3] Produce is mostly transported by cargo ships and trucks, which creates additional pollution.

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[1] Kalantari, F., Tahir, O. M., Joni, R. A., & Fatemi, E. (2018). Opportunities and challenges in sustainability of Vertical Farming: A Review. *Journal of Landscape Ecology*, *11*(1), 35–60. https://doi.org/10.1515/jlecol-2017-0016

[2] Ellingsen, E., &; Despommier, D. (2008). The Vertical Farm - The origin of a 21st century Architectural Typology. Council on Tall Buildings and Urban Habitat, (3).

[3] Emissions due to agriculture. (2021). *Food and Agriculture Organization of the United Nations*.

How can we make farming sustainable?

One method that can directly solve the aforementioned problems are **vertical farms** (VFs). These types of farms integrate new agriculture technology and robotics to create a fully self-maintained environment for growing produce.

Utilizing VFs can provide the following benefits compared to traditional farming:

- Space efficiency
- Sustainable energy sources and recycling
- Future-proofing
- Pesticide-free produce
- Consistent year-round farming

In addition, VFs can be built to use renewable resources (being connected to a nearby solar farm), or have rain-collecting systems.

Since VFs can be built **anywhere** in the world and grow the same type of produce, this requires less transportation and leads to more local produce being sold in stores.

Components of a Vertical Farm

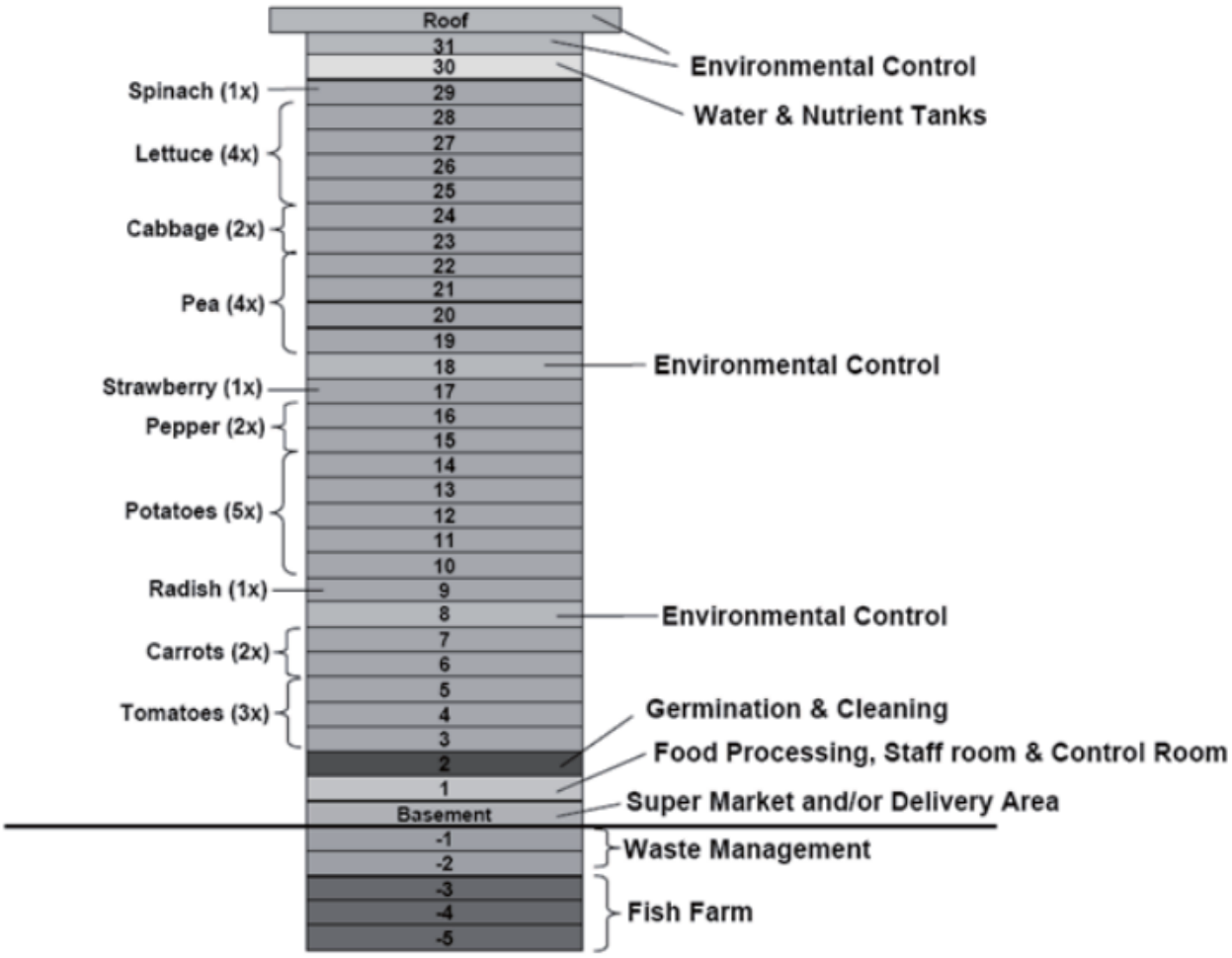
VFs look like a mix between factories and farms. On the outside, they resemble commonplace manufacturing buildings. Inside is a complex system of parts that work together to ensure maximum output and efficiency to grow produce.

Automation
Imagine a car manufacturing plant with robotic arms, conveyor belts, and moving platforms. This is what automation looks like in a VF. Automation is used to perform repetitive tasks such as seed planting, watering, and shelving. VFs are managed by algorithms to calculate the best humidity, temperature, and lighting conditions for plants to grow. Some tasks need human assistance such as trimming leaves.

Hydroponics
Instead of the traditional use of soil to grow produce, VFs use hydroponics instead. Only water and nutrients are used to grow seeds into produce. This ensures that **99%** of the water used to grow produce is efficient, whereas with traditional farming not all the water used is absorbed by the roots of the plants; wasting resources. The water not absorbed is recirculated through the system.

Aeroponics
While similar to hydroponics, produce is grown by misting the roots rather than submerging them completely in water. The plants will absorb nutrition through the roots, as mist is occasionally sprayed underneath the plant. This concept is similar to how air plants absorb water through the humidity in the air.

Light Emitting Diodes (LEDs)
LEDs are used instead of sunlight and are calibrated to provide the optimal types of ultraviolet light that benefit plants, while conserving energy. While LEDs alone can consume up to 30% of the operational cost for VFs, price and efficiency are improving steadily and are becoming more affordable. Optimizing LED configurations can improve nutrition or taste in produce (ex. crispier kale).



Sample structure of a vertical farm.[4]

[4] Banerjee , C. (2014). Up, Up and Away! The Economics of Vertical Farming. Journal of Agricultural Studies, 2(1). https://doi.org/10.5296/jas.v3i1

Challenges

Cost. VFs can cost up to 3x more than traditional farms and are not currently drawing enough attention from investors. Agriculture technology is not yet mass produced, and costs are high. Like with most technologies, new machines become more cost-effective with time.

Consumer hesitancy. Some may think that hydro/aeroponic-grown produce is “less natural” than traditional farming. Despite how much produce in grocery stores today is already hydro/aeroponically grown, more education and awareness about newer types of farming will be necessary to ease any consumer doubts.

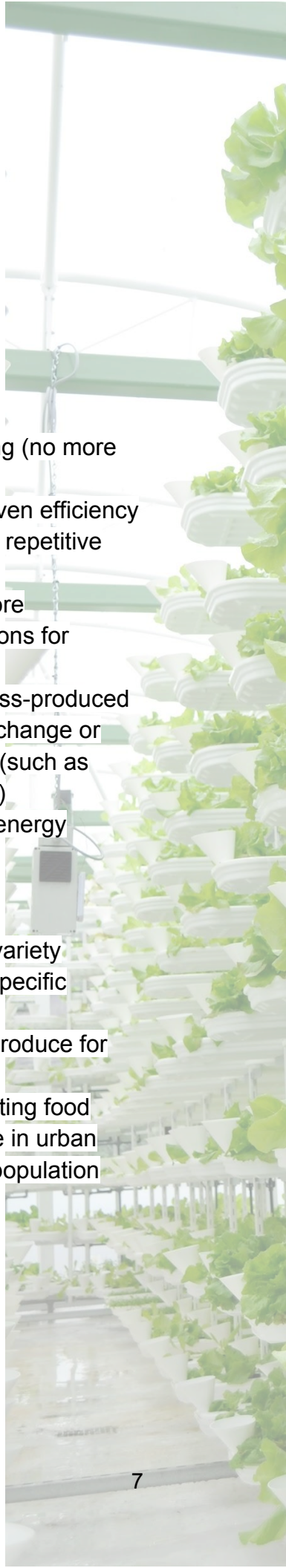
Loss of farm identities. While VFs help with food security and expanding diets of specific geographical locations by making uncommon produce available, they may make farming communities monotonous. As VFs need specific layouts and machinery, most farms will look and function the same. An effort to diversify farms with restaurants, bars, or community centers can help maintain identity in a farming community.

Price parity. Matching prices to be competitive with locally grown produce is not yet possible due to operation costs, resulting in food that is more expensive for consumers to buy. However, Plenty (a VF located in Wyoming, USA) has been able to match the price parity between their produce and imported produce.[5] Since foods produced by a VF can be grown locally, this saves transportation costs compared to imported produce, which may have arrived by ship. For consumers, this results in food that is more nutritious and fresh for the same price.

Limited produce. While VFs offer a wide range, it is not currently possible to grow vertically tall produce such as wheat or corn.

[5] Howd, L. (2021). *Vertical farms could take over the world*. *YouTube*. YouTube. Retrieved March 26, 2022, from https://www.youtube.com/watch?v=J4SaSfnHK3I.

Advantage of Vertical Farms



Sustainability

- Less space used for comparable amounts of produce (compared to traditional farming methods)
- Less $C0_2$ emissions (none, if using renewable resources)
- Operation in urban cities instead of in rural areas
- No deforestation to create farming space
- Shutdowns of traditional farms; giving space back to nature (ecosystem recovery)

Efficiency

- 365 days a year farming (no more seasonal growing)
- Data and algorithm-driven efficiency
- Robotic automation for repetitive tasks
- Global freedom (no more region-specific restrictions for planting)
- VF facilities can be mass-produced
- Unaffected by climate change or most natural disasters (such as hurricanes or droughts)
- Can utilize renewable energy

Quality & Safety

- More nutritious produce compared to traditional produce
- No use of pesticides
- Significantly less risk of contamination of E.Coli or other harmful bacteria
- Better quality control with nutrition and flavour

Food Security

- Increase in local food variety (especially in climate-specific regions)
- More access to fresh produce for healthy diets
- Less reliance on importing food
- Provides fresh produce in urban areas with increasing population density

References

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