

## Hydroponics- Aquaculture, Nutriculture, Soilless Culture or Tank Farming

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Hydroponics is a form of hydroculture that involves cultivating plants using nutrient-rich solutions instead of traditional soil. In this method, terrestrial plants can thrive with their roots submerged in the nutrient solution exclusively or within a non-soil medium like gravel or perlite. The essential nutrients required for plant growth in hydroponics can be sourced from various inputs, including duck manure, fish waste, and conventional nutrient solutions. Contrary to the typical reliance on soil for plant nourishment, hydroponics operates on the principle of providing all necessary nutrients in an upfront and controlled manner.



### Why Hydroponics?

Today, humanity is confronted with a multitude of pressing challenges that are ushering in significant transformations in our global way of life. These challenges encompass climate change, the emergence of dangerous infectious diseases, the relentless march of urbanization, and the depletion of natural resource reservoirs. Hydroponic farming stands as a promising solution to counteract the threats posed by these issues to our agricultural system.



One of the key advantages of hydroponic farming lies in its ability to cultivate crops under nearly ideal conditions through the utilization of Controlled Environment Agriculture (CEA) technology. The primary benefit of this approach is that it enables the cultivation of crops indoors and hydroponically, overcoming the constraints of geographical location, seasonal variations, adverse weather conditions, limitations in arable land availability, and soil quality. Consequently, hydroponic farming holds the potential to ensure a consistent supply of fresh, locally sourced food, irrespective of factors like extreme droughts and poor soil quality, making it particularly valuable in regions like sub-Saharan Africa, where access to nutritious leafy greens is often scarce.

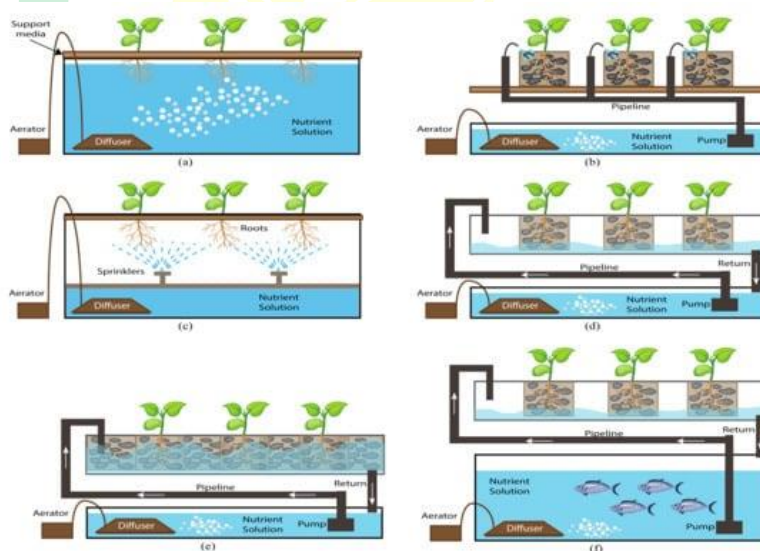
Keeping crop production in a controlled environment enables trained scientists and advanced climate control technology to optimize the inputs of water, nutrients, and light fed to the plants. For example, sensors can measure the amount and nutrient content of the water that each plant transpires. This gives farmers insight into the amount of unused water and nutrients by the plants at each stage of the growth process. From this, farmers are able to ensure the maximum amount and highest quality of yields by optimizing the timing, quality, and amount of inputs to the plants. This technology, along with design features such as precise irrigation methods, helps CEA farmers reduce water waste exponentially: compared to traditional farms, hydroponic farms use up to 90% less water. Light inputs are also optimized to ensure maximal absorption by the plants and maximal yield outputs. Photosynthetic active radiation, or PAR, is a measurement of the amount of usable light (photons) delivered to different plants.

The range between 400 and 600 nanometres represents the usable wavelengths of light energy for plants, though scientists have found that the peak of absorption is often at 440nm (blue light) and 660nm (red light). If the delivery of these optimal wavelengths of light are targeted, the amount of energy being delivered to the plants can be optimized by omitting the wavelengths of light that will not be absorbed by the plants. This is the reason for the purple-is light often seen shining on plants in hydroponic farms. This is also the logic behind the color of greenhouses: the green glass ensures that green light does not pass through to the plants so they only receive the colors that they most readily absorb. Since LED lights are heavy energy users, optimizing the light delivered to plants to the maximum amount of light absorption helps limit wasted energy. The modular design of vertical farms allows farmers to alter the layout of

the plants to maximize space use and optimize ground space. Since vertical farms spread upwards instead of outwards on a horizontal plane, farmers are able to grow 3 to 10 times more crops in the same amount of space as conventional farms, depending on the specific layout. Ground space can be multiplied by stacking horizontal racks on top of each other. This same modular design also offers a highly efficient way to isolate diseased or dying crops with a quick and easy way to neutralize compromised plants. In a traditional farm that might cover many square miles of land, diseased crops are much more difficult to identify and take out of contact with the other crops in the field. As a business model, modular farming also enables a much more efficient growth process, where transferring and packaging plants can be completed without causing any disturbance to other crops. Finally, with the help of soil-less growing, this modular design allows growth space to be in constant use.

### Hydroponic Cultivation Techniques

Hydroponics, unlike traditional farming, does not require soil to grow food. In this technique, plants are grown either on natural or man-made substrates, where the roots easily extract the nutrients from a prepared nutrient solution.



**Figure 1.** Different types of hydroponic systems. (a) Deep Water Culture. (b) Drip System. (c) Aeroponics. (d) Nutrien Film Technique (NFT). (e) Ebb and flow. (f) Aquaponics.

There are different methods for growing food using hydroponics, and their application depends on the specific plant, local climate, and budget, among other

factors. Most systems comprise a storage tank for the nutrient solution and an aerator.

### **Floating Root System or Deep-Water Culture (DWC)**

In this setup, the plant's root is submerged in the nutrient solution, while the remaining portion is upheld above the water's surface using materials like polystyrene, cork bark, or wood, among other options.

### **Drip Irrigation**

This method is best suited for tomato and pepper-like crops. In this case, the nutrient solution is pumped directly to the roots of the plants with regulated flow. The solution is administered at predetermined time intervals and, for closed systems, the leftover solution is returned to the storage tank (Figure 1b).

### **Aeroponics**

Tubers and roots thrive when cultivated with aeroponics. In this setup, plants have their roots suspended in the air and receive nutrients through intermittent misting from a sprinkler system. The primary benefit of this method is its independence from an additional ventilation system, as oxygen is carried along with the nutrient solution when sprayed. (Figure 1c).

### **Nutrient Film Technique**

This technique, often referred to as NFT (Nutrient Film Technique), resembles the floating root system but with a distinction: instead of fully immersing plant roots in the nutrient solution, they are positioned within a liquid stream that flows through a network of pipes. While NFT consumes less nutrient solution compared to the floating root system, it necessitates additional energy and equipment for its operation. Any surplus solution is directed back to the storage tank due to gravity, and the flow of the nutrient solution can be either continuous or intermittent. (Figure 1d).

### **Ebb and Flow**

In this method, plants are situated within a tray that is intermittently supplied with nutrient-enriched water drawn from a reservoir positioned beneath it. The system efficiently employs gravity to send the water back to the reservoir for recycling. (Figure 1e).

### **Aquaponics**

This technique exploits the symbiosis of flora and fauna to achieve an efficient system in which fish feces afford the nutritional requirements of the plants. The absorption of nutrients



by plants, combined with the microbial process of nitrification and denitrification, allows the recycling of water from the fish tank, forming a balanced micro-ecosystem (Figure 1f)

### **Costs and Challenges**

While hydroponic farming offers numerous advantages, it also presents several challenges. For aspiring small-scale farmers venturing into hydroponics, there are substantial initial expenses to consider. These costs encompass renting or purchasing suitable space, renovating buildings or areas to accommodate hydroponic infrastructure, acquiring essential materials like LED lights, irrigation systems, plant racks, seeds, and advanced environmental control technology, as well as covering labor and electricity expenses to operate the farm. Despite these significant entry costs, hydroponic farms have the potential to repurpose underutilized structures into productive farmland, benefiting the local community and creating job opportunities.

As an example, Zip Grow has provided a simplified estimate of startup costs for a typical indoor hydroponic farm in a 500 square foot area with automated nutrient dosing and energy-efficient LED lighting. The initial investment is approximately \$110,000, excluding facility upgrades. The daily energy costs for hydroponic lettuce, using 48 LED lighting units running for 18 hours a day, amount to \$31.80 for commercial use and \$38.52 for residential use. Over a 3.6-week crop cycle with a mix of basil and lettuce, the farm can generate revenue of up to \$10,482.

Once these initial financial hurdles are overcome, hydroponic farmers must address additional challenges to ensure the productivity and security of their operations. Stacked rack systems, in contrast to vertical growth towers, may encounter issues related to airflow, heat, and humidity. In horizontal models, more space between each level is required to mitigate problems associated with inadequate airflow, such as elevated humidity, increased susceptibility to pests and diseases, and reduced plant growth due to lower CO<sub>2</sub> levels. Moreover, the energy costs associated with hydroponic farming and maintaining optimal growth conditions for plants can be substantial. The combination of high-intensity LED lighting and climate monitoring and control systems results in significant electricity consumption on hydroponic farms. It is crucial for hydroponic farms to explore renewable energy sources, such as solar panels or wind power, to minimize their environmental impact. Some farms, like Jones Food Company, derive all their energy from solar panels installed on

their facility roofs.

### Conclusion

Hydroponic farming presents a viable path toward a sustainable food approach that prioritizes the well-being of our food, our health, and the environment, all while minimizing the heavy reliance on chemicals. This innovative farming method is not merely a fanciful idea; it is swiftly becoming an integral part of our current food supply chains. An illustration of this integration is seen in Ocado, a prominent British online supermarket, which has recently forged partnerships with Priva and 80-Acres, leading players in the vertical farming industry. This collaboration empowers Ocado to provide its customers with fresh, locally sourced, hydroponically cultivated ingredients.

Moreover, as competition within the hydroponic industry intensifies, more partnerships of this nature are likely to emerge, contributing to the reduction of prices for hydroponically grown produce and enhancing the competitiveness of hydroponic farms compared to traditional agricultural practices. While addressing our global climate challenges involves multifaceted approaches and is the result of various practices, mitigating the agricultural industry's impact represents a significant stride forward. At the dawn of the 21st century, hydroponic farming had not yet been conceived. However, in just two decades, this industry has firmly established itself and is already profoundly reshaping our agricultural methods and the trajectory of our food system.

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