

Comparing the pros and perks of hydroponic farming versus traditional agriculture

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Hydroponics is a contemporary farming technique that doesn't rely on soil and instead supplies plants with nutrient-rich water. In contrast, traditional farming is a soil-based approach that yields limited crops while utilizing substantial amounts of water for irrigation and fertilizers. One advantage of hydroponic farming over traditional methods is the ability to practice vertical farming, which increases crop yields per unit area. Moreover, hydroponics doesn't require fertile land to be effective and requires less water and space compared to traditional soil-based agriculture. This research aims to explore and compare traditional farming and hydroponic farming methods in terms of their efficiency, sustainability and overall impact on the environment and food production.

Keywords: Cultivation, Horticulture, Hydroponic, Irrigation, Traditional farming

Traditional farming and hydroponics are two distinct cultivation methods with their own advantages and considerations. Traditional farming relies on soil as the growing medium, while hydroponics employs a soilless system where plants are exposed to nutrient-rich water or inert mediums. Compared to hydroponics, traditional farming requires more water for irrigation since hydroponics recirculates water, reducing consumption. Nutrient management also differs, as traditional farming depends on soil composition and fertilizers, while hydroponics offers precise control over nutrient supply. Hydroponics maximizes space utilization through vertical farming, whereas traditional farming necessitates more land area. In terms of environmental impact, traditional farming poses risks of soil erosion and water pollution, whereas hydroponics mitigates these concerns. Seasonal variations affect traditional farming, while hydroponics enables year-round cultivation. Traditional farming can experience variability in crop quality

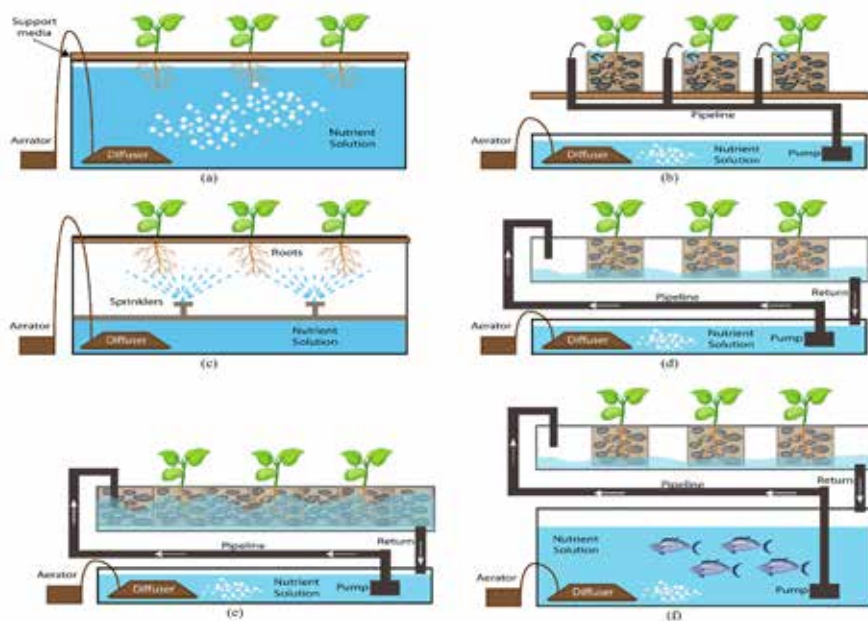
and yield due to environmental factors, whereas hydroponics provides consistent quality and the potential for higher yields. Labour and maintenance requirements also differ, with traditional farming demanding manual labour and hydroponics requiring monitoring and control of system parameters. Both methods have their own merits and are suitable for different agricultural contexts.

Traditional farming methods have remained mostly unchanged for centuries, involving planting seeds in soil, relying on natural sunlight and water, and waiting for the harvest season. Although there have been advancements in irrigation, seed genetic engineering and farming equipment, the fundamental approach has remained consistent. However, it is worth questioning whether this conventional method is the most effective way to achieve large-scale crop production. In Uttarakhand state, which encompasses diverse agro-climatic conditions including plains and hills, agriculture is primarily practiced in the plains.

The main occupation of the people revolves around cultivating subsistence cereal crops in narrow terraced fields, resulting in relatively low yields. Additionally, horticultural practices involving the cultivation of fruits, vegetables, spices and flowers are also undertaken, but the proportion of land dedicated to horticulture is significantly less. In the present day, various emerging farming methods offer new possibilities for businesses in the food industry. We believe that hydroponic systems, particularly vertical farming, represent the future of agriculture. These systems enable the production of large quantities of nutritious fruits and vegetables in a sustainable manner, meeting the needs of a growing population. This article provides an overview of both soil and soilless agriculture systems.

Hydroponic cultivation

Diverging from conventional farming, hydroponics dispenses with the need for soil in cultivating crops. Within this innovative approach, plants are nurtured upon either natural or synthetic



Diverse hydroponic systems: (a) Deep water culture, (b) Drip system, (c) Aeroponics, (d) Nutrient film technique (NFT), (e) Ebb and Flow, and (f) Aquaponics.

Source: Velazquez-Gonzalez (2022).

substrates, facilitating the roots' efficient absorption of nutrients from a meticulously formulated nutrient solution. Various techniques exist for harnessing hydroponics to cultivate crops, their selection contingent upon variables such as the plant variety, prevailing climatic conditions, financial considerations and more. Typically, these systems encompass a reservoir for housing the nutrient solution, accompanied by an aerator.

Water efficiency: Hydroponics is a soilless cultivation technique that uses up to 90% less water compared to traditional farming methods. This efficiency is achieved through recirculating water systems, where nutrient-rich water is continuously reused. Additionally, hydroponics eliminates water loss through evaporation and runoff, making it a sustainable option in regions with water scarcity.

Nutrient control: In hydroponics, plants receive a precise and controlled balance of nutrients directly to their root systems. This allows for optimal nutrient uptake and reduces the risk of nutrient deficiencies or excesses that are common in traditional farming due to unpredictable soil conditions. The nutrient solution can be adjusted based on the specific needs of

different plant varieties, resulting in healthier and more productive crops.

Year-round cultivation: Hydroponic systems can be set up indoors or in greenhouses, enabling year-round cultivation regardless of external weather conditions. This capability eliminates the seasonal limitations of traditional farming, allowing farmers to grow crops consistently and meet market demands throughout the year. By providing a controlled environment, hydroponics also reduces the risk of pests, diseases and extreme weather events that can damage crops in outdoor settings.

Hydroponics offers space efficiency: Hydroponics is particularly advantageous in urban or land-constrained areas where available farming space is limited. The vertical farming technique, often associated with hydroponics, allows plants to be stacked in layers, maximizing the use of vertical space. As a result, hydroponic systems can produce higher yields per unit area compared to traditional farms, making it an ideal solution for urban agriculture and food production in densely populated areas. One of the prominent benefits associated with adopting hydroponic farming as the primary cultivation method is its remarkable capacity to conserve space. In traditional soil-based growth, plants extend their roots extensively in search of essential water and nutrients for sustenance.

Superior crop quality: The meticulous regulation of environmental variables in hydroponics results in enhanced crop quality. Through the optimization of factors such as temperature, light, humidity, and CO₂ levels, farmers can establish the perfect growth conditions for their crops. This level of control often yields crops with superior taste, texture, colour, and nutritional content when compared to those cultivated in traditional soil-based systems.

Reduced dependency on chemicals: Hydroponics decreases the necessity for pesticides, herbicides, and fungicides by



Nutrient Film Technique (NFT) automated solar based hydroponic at Uttarakhand State Council for Science and Technology (UCOST)



Lettuce varieties in Nutrient Film Technique (NFT) hydroponic greenhouse system at Uttarakhand State Council for Science and Technology (UCOST)

creating a controlled environment that lowers the likelihood of pest and disease invasions. By operating without soil, hydroponic systems eradicate numerous soil-based pests and pathogens. Additionally, the enclosed water circulation in hydroponics diminishes the potential for nutrient runoff, which could pollute water sources and add to water pollution. Automation and precision farming techniques find a natural fit in hydroponic systems. By incorporating sensors and monitoring systems, hydroponic setups can continuously observe and adjust environmental factors, nutrient levels, and water usage. This automation enables meticulous control and optimization of growing conditions, resulting in enhanced resource efficiency and increased crop yields.

Enhanced growth in hydroponic systems: A noticeable outcome of cultivating plants within a hydroponic system is the marked increase in growth. Plants nurtured

through hydroponics exhibit a growth rate that is notably accelerated, typically ranging between 30 to 50% faster compared to conventional agricultural practices. This accelerated growth can be attributed to the optimal provision of nutrients and reduced exposure to environmental stressors.

In traditional farming, plants often contend with stressors such as pests and weather fluctuations, which can impede their development. However, hydroponic systems mitigate these stressors, fostering an environment conducive to swift and robust growth. Notably, certain plant species display a more pronounced acceleration in growth within hydroponic setups. For instance, crops like tomatoes and lettuce are recognized for their heightened growth rates when cultivated through hydroponics. By judiciously selecting compatible plant varieties for hydroponic system, one can harness the potential for exceptionally bountiful yields. By embracing a hydroponic system, you can cultivate a substantially greater quantity of plants compared to conventional agricultural techniques. While there exist alternative farming approaches aimed at space conservation, hydroponic farming stands out as the most advantageous method in this particular aspect.



Tomatoes grown hydroponically in grow bags
Source: Sensorex hydroponic farming

the land is limited, doesn't exist, or is heavily contaminated or degraded. Hydroponics has been considered the farming of the future to grow foods for astronauts in space (where there is no soil).

- **Make better use of space and location:** As all that plant's needs are provided and maintained in a controlled environment/system, it can be grown indoors and vertically multiplied produce per square feet to multifold.



Benefits of hydroponic farming

Source: Greenoponics agricultural services

- **Climate control:** Like in greenhouses, hydroponic growers can have total control over the climate temperature, humidity, light intensification, and the composition of the air. In this sense, you can grow foods all year round, regardless of the season. Farmers can produce foods at the appropriate time to maximize their business profits.
- **Water-saving:** Plants grown hydroponically can use only 10–25% of water compared to field-grown ones. In this method, water is re-circulated. Plants will take up the necessary water, while run-off ones will be captured and returned to the system. Water loss only occurs in two forms - evaporation and leaks from the system (but an efficient hydroponic setup will minimize or don't have any leaks).
- **pH control of the solution:** All of the minerals are contained in the water. That means one can measure and adjust water mixture's pH levels more quickly than the soil. That ensures optimal nutrient uptake for plants.

Benefits of hydroponics farming

- **No soils needed:** In a sense, you can grow crops in places where

- **Better growth rate:** Hydroponically, plants grow faster than in soil if plants are placed in ideal conditions, while nutrients are provided in sufficient amounts, and come into direct contact with the root systems. Plants no longer waste valuable energy searching for diluted nutrients in the soil. Instead, they shift all of their focus to growing and producing fruits.
- **Fewer pests and diseases:** Like weeds, getting rid of soils helps make your plants less vulnerable to soil-borne problems like birds, gophers, and groundhogs; and illnesses like *Fusarium*, *Pythium*, and *Rhizoctonia* species. Also, gardeners can easily control most surrounding variables when growing indoors in a closed system.
- **Labour and time savers:** Besides spending less on tilling, watering, cultivating, and fumigating weeds and pests, when agriculture is planned to be more technology-based, human intervention can be minimized to a considerable extent.

Way forward

Hydroponics emerges as a promising solution within the scope of Indian agriculture, providing a viable pathway to address a range of complex agricultural challenges, including water scarcity, limited arable land availability, and unpredictable climatic conditions. This comprehensive explanation outlines a systematic approach towards adopting and advancing

hydroponic techniques in the Indian context, emphasizing the integration of data-driven approaches. This can be accomplished through extensive education and training in hydroponics, involving a deep understanding of various hydroponic systems along with an assessment of their respective advantages and disadvantages. Thorough exploration of suitable crops for hydroponic cultivation in the Indian climate is essential. By analyzing relevant local climatic data, such as temperature, humidity, and water availability, it is possible to customize hydroponic setups and nutrient formulations to align with indigenous conditions. Viable options like the Nutrient Film Technique (NFT), Deep Water Culture (DWC), and Vertical Farming warrant careful evaluation. When finalizing the chosen hydroponic configuration, it's crucial to ensure compatibility with available resources, including budgetary considerations, spatial limitations, and labour capacities. Employ state-of-the-art sensor technologies and Internet of Things (IoT) devices for real-time data collection, and implement a well-planned crop rotation strategy to prevent soil-related issues and maintain a balanced nutrient environment in the hydroponic setup. In addition, integrating market and business strategies is vital to capitalize on the demand for locally produced hydroponic crops. Developing a detailed business plan that encompasses production goals, pricing strategies and efficient distribution channels is a key aspect of strategic planning.

SUMMARY

Among the diverse array of farming techniques, hydroponic farming stands out as a prominent choice in today's world. This unique approach to agriculture offers distinct advantages when compared to the conventional methods. This paper delves into the theoretical and technological dimensions of hydroponic-driven food cultivation, tailored for its application across small and medium scales. It furnishes comprehensive guidance to those aspiring to contribute to the global challenge of sustainable and efficient food provision by 2050. Anticipated market prospects indicate a sustained growth trajectory in hydroponic-based food production over the ensuing two decades. Nonetheless, a shift toward decentralized production becomes imperative, particularly within densely populated regions. This transition aims to curtail the ecological footprint associated with this practice while fostering enhanced sustainability. While the initial investment often presents a substantial barrier, the integration of technology into small and medium-sized decentralized food production systems can yield substantial benefits. These encompass the potential to invigorate local economies through the promotion of self-employment and lucrative entrepreneurial endeavours, thus fostering a climate of collaboration within communities.

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Water

- Even though households are relatively low consumers of water, population growth and expanded water use have outweighed the effect of water saving technology and behavior.
- Less than 3% of the world's water is fresh (drinkable), of which 2.5% is frozen in the Antarctica, Arctic and glaciers. Humanity must therefore rely on 0.5% for all of man's ecosystem's and fresh water needs.
- Man is polluting water faster than nature can recycle and purify water in rivers and lakes. More than one billion people still do not have access to fresh water.
- Excessive use of water contributes to the global water stress. Water is free from nature but the infrastructure needed to deliver it is expensive.

- See more at: <http://www.unep.org/wed/theme/water.asp#sthash.ki5vg3IB.dpuf>
Courtesy: United Nations Environment Programme website - <http://www.unep.org/wed>