

Hydroponics Farming and Smart Agriculture for Doubling Farmer's Income

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Agricultural problems are abundant in this day and age including insufficient land, lack of water, climate change and expensive production. Hydroponics and smart farming can be regarded as a breakthrough in high-value crop production since they enable to cultivate such crops requiring little land and water. Hydroponics means growing crops without soil, by means of various nutrient solutions. Smart farming implies the use of technology including sensors, IoT, robotics and weather forecasting etc. All the mentioned techniques allow to utilize the resources efficiently. The Strategy of the Government of India aimed at improving the farmers' incomes includes raising productivity, cutting production costs, and increasing the volume of crop production. The use of hydroponics can contribute to achieving some of the goals mentioned earlier regarding the cultivation of high-value types of crops and vegetables. Hydroponics is said to be effective economically if right choice of crops, conducive market conditions, low consumption of electricity, availability of skills and good hydroponics system is in place.

Introduction

A farmers' income will depend on the ability to produce crops and many more factors such as the production cost, market price, cropping intensity, and diversification factor. The Indian government strategy has come out with seven ways of increasing farmers' income namely increasing productivity, decreasing production cost, improving cropping intensity, diversification of agriculture that yields higher value, and increasing prices realized by farmers. Hydroponics is a new technique of soilless farming where the plant roots get the necessary supplies of water and nutrients through some solutions prepared ahead. Systems used for farming are NFT, DWC, the bucket of Dutch system, and dripping system.



Hydroponics in combination with smart farming

Hydroponics in Combination of Smart Farming Technology has more advantages. By means of sensors, it is possible to monitor variables like pH, electrical conductivity, temperature, humidity, water level, and nutrient concentration. The information received may be transferred to a mobile phone or computer by means of the Internet of Things (IoT). The automated system may control the process of irrigation, nutrients' supply, ventilation, lighting, and other grow processes and operations, and hence it decreases the importance of a manual control over the farming process. The simplified concept of smart hydroponics may show the following process:

Sensors → Data Collection → IoT/Cloud → Analysis → Automated Decision → Irrigation/ Nutrient Management → Crop Monitoring.

The integration of hydroponics with IoT and automation is being discussed as a way towards more accurate and effective farming.

Primary Benefits of Hydroponics

Water Conservation

This technology makes it possible to recycle water and nutrients instead of their draining. Studies show that hydroponics and vertical farming methods make it possible to consume less water depending on the plant type and cultivation method.

Better Yield

Hydroponic crops can be grown in places where agricultural land is scarce. Besides, the vertical nature of the farms allows for higher productivity per square meter. Hence, hydroponic crop growing is very important for urban and suburban agriculture.

Continuous Farming

Hydroponics can be used all year round in controlled conditions. This allows farmers to produce off-season crops and gain higher profits during favorable price conditions.

Decreased Soil Problems

To provide essential minerals to the roots of the plants, the hydroponic systems utilize nutrient solution. The grower can change the concentration of the nutrient solution based on the crop growth stage and applies nutrients in a much more effective manner than traditional methods.

Table 1. Contribution of Hydroponics and Smart Agriculture to Farmers' Income

Component	Contribution	Possible Income Effect
Soilless cultivation	Production where soil is unsuitable	Additional production opportunity
Efficient water management	Reduced water wastage	Lower resource cost
Precision nutrition	Nutrient precision delivery	Better input efficiency
Vertical production	More plants per unit area	Higher land productivity
Protected cultivation	Reduced weather exposure	More stable production
IoT sensors	Continuous crop monitoring	Better management decisions
Automation	Reduced repetitive labour	Lower operating cost
High-value vegetables	Premium market opportunities	Higher gross returns
Direct marketing	Better market linkage	Potentially improved price realization
Multiple crop cycles	Increased cropping intensity	Higher annual revenue potential

Role in Increasing Farmers' Income

Hydroponics can boost farmers' income in multiple ways. First, it gives farmers an opportunity to switch from growing conventional cereals to profitable crops including lettuce, basil, coriander, spinach, cucumber, tomato, capsicum and some herbs which depend on the local market demand. Second, with controlled environment agriculture farmers can have more than one crop cycle. Third, selling directly to restaurants, hotels, supermarkets and other customers would increase profit margins compared to just selling through the traditional wholesale marketplaces. But just because there is more production, does not necessarily mean there would be more profits. For example, growing in the hydroponics greenhouse, farmers face many expenses including expenses for electricity, greenhouse construction, growing media and hiring skilled labor.

Smart Agriculture Ensures Efficient Farm Management

Smart agriculture enables precision hydroponics farming. Good use of sensors can help farmers monitor the pH and the EC and gives an alarm when any parameter is outside of the optimal range. Automatic irrigation allows farmers to supply water based on data provided by the plants' needs. Weather information assists with managing greenhouses' ventilation. Data and AI can help with determining the crops' growth rate, understanding when to fertilize or harvest the crops, and predicting disease risk. Such an approach takes farming to the next level thanks to data monitoring and utilization for decision-making.

Challenges

List of Barriers:

- High initial investment
- Requirement for technical knowledge
- Dependence on electricity in many systems
- Cost of greenhouse and equipment
- Requirement for good-quality water
- Nutrient-management complexity
- Risk of rapid crop loss if the system fails
- Limited availability of trained technicians
- Need for reliable premium markets

Therefore, hydroponics should not be adopted simply because it is a modern technology. Crop–market–technology matching is essential.

Conclusion

Hydroponics and smart agriculture are two industries that give hope for resource-efficient, high-value, and market-oriented farming. Hydroponics can make it possible to produce crops efficiently and give farmers more control over growing plants. Smart technology, on the other hand, has the potential to make farm monitoring more sophisticated. Nevertheless, it cannot ensure the rise in farmers' income, but it will enable farmers to choose the suitable crop. The profitability of hydroponics depends on different factors, such as investments made, crop types used for hydroponics, production efficiency, utility prices, and market prices of those crops.

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