

# A Survey on Smart Hydroponics for Sustainable Agriculture

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**Abstract:** Since India is an agro-based nation, different agricultural methods should be developed other than the conventional methods. From earlier period to 21st century the various changes have been took place in climate. So, to meet these environmental changes, need to develop a sustainable agricultural method. Hydroponics is a sustainable agricultural method since it is soilless, independent of environment, and produces quality crop. Combining the new trends of technology like IoT could bring a revolutionary change in the agricultural field. Smart hydroponics using emerging technology could be a milestone in cultivation field has it automates, controls, monitors, and manages the all system effectively and remotely without any manual assessment. It provides healthy and good agricultural product and also helps to increase the yield.

**Keywords:** Hydroponics, IoT (Internet of Things), Agriculture, soilless, technology.

## I. INTRODUCTION

“No Agriculture, no culture”; means that cultures and civilizations are dependent on crops for their survival. It is the main reason for plants to grow under favourable conditions. As India is agriculture-based nation, different techniques of cultivation methods have to be preferred. From evaluations, agricultural techniques have been evolved from traditional method to smart farm technique. And also change in the using of soil-based cultivation to soilless cultivation. That is great change in agricultural methods from earlier period to 21<sup>st</sup> century. The soil-based cultivation is the traditional method; here a particular crop is cultivated based on the suitable soil for it. And also, the environmental condition is main factor to be considered. The soilless farming methods are hydroponics, aquaponics, and aeroponics. And the emergence of different techniques also provided a great influence in all the agricultural methods, mainly the internet of things which led to the automation of the system. And the word smart farm came along with this type of technology. Method of growing plants using mineral nutrient solutions instead of soil is called Hydroponics (Fig. 1) and it is a form of hydro culture. That is, the science of soilless cultivation. Hydroponics is a milestone to the future agriculture, because it is of low income, and consumes less area for cultivation. The word hydroponics was taken from two Greek words hydro (water) and ponos (labor). Hydroponics can be integrated with the vertical farming, which would help to increase quantity of production within a limited area (Fig. 2). Since India is second largest populated nation, increased demand for food production has to be focused. Mainly on efficient methods of water usage, less dependent on toxic pesticides, higher yields and good quality in flavour and nutrition. Hydroponics can meet up this type of requirement, so it can be called as the green method. So, in general hydroponics is a sustainable agricultural method with a minimum environmental footprint.



Fig. 1. Hydroponics method [16]



Fig. 2. Vertical Hydroponic method [17]



Hydroponics method is of different types like Nutrient Film Technology (NFT), ebb and flow, deep water culture, wick system, drip system. Among these different methods, the nutrient film technology (Fig. 3) is preferred because here the nutrient solution is continuously circulated through the narrow channel. An aeration gap between the plant and the solution is very essential for the plants to grow, which is provided in NFT. This will increase the oxygen content and helps the roots to grow and absorbs the nutrients effectively.



Fig. 3. Nutrient Film Technology [18]

When the technology is integrated with the hydroponics method, the benefit increased is all sense. The smart hydroponics system is the combination of hydroponics along with the internet of things and other communication protocols. The smart system utilizes the advantages of technology in various areas of farming method like monitoring, controlling, accessing, data storage and effective management. All the smart farm methods are very useful to the farmers such as automating all the cultivation methods. Since modern society are in a busy scheduled life the smart system could help in automatically doing all the processes remotely from anywhere through the mobile app or website with the use of cloud service. And it also helps in the water management, waste management, and can be cultivated in limited space in any of the needed condition.

## II. STATE OF ART IN SMART HYDROPONICS

When gone through different works related to hydroponics, a variety of methods have been addressed from conventional method to the method influenced by technology. Conventional farming methods have changed to smart farm method due to many unfavourable conditions. DIY Sensor – Based Automatic Control Mobile Application for Hydroponics, enables automatic environmental control for hydroponics using different sensors such as temperature, humidity, and light. To fulfil planting demands, it consists of planning, managing and harvest data recordings. For the cultivation, this harvest records can be referred. The farmer can monitor the progress of crop remotely [1].

[2] In this style of farming, the sensor technology will control devices accurately and correctly via the mobile. The remainder, plant growth of various stages, irrigation plans and amount of water required per day are done by monitoring system. It provides guidance and help to the farmer at the appropriate time. For the data collections, the ThingSpeak™ cloud service is used. The system provides location information, marketing, prediction of weather.

Hydroponics Farming [3], provides detailed idea on hydroponics. Designed and constructed the system that fully automatic and can be integrated with agricultural field in a business motive. Using the proper management of temperature the Arduino based automation for water and nutrient are done. At the time of unfavourable situation it provides alert by indicators and alarms. Inform all details about the farm continuously to the farmer.

The system support non – professional farmers, living in cities in doing agriculture. Hydroponic farming ecosystem uses IoT devices to monitor humidity, temperature, pH, and electrical conductivity. There are three sections: sensors, control system manipulated for the regulation of sensors and the application. MQTT Broker, connectivity protocol for IoT, it plays has an intermediate to send and receive the data. Android application is used to make the system reliable and easy to handle [4].

[5] A compact sensor module developed for hydroponics that uses simple oscillator circuits to measure water level and nutrient concentration. The oscillation frequencies change along with resistance and capacitance of metal wires immersed in liquid fertilizer. Sensor module is designed as a daughter card of Arduino. Integrated sensor circuits, an ATmega328 processor, serial



and I<sup>2</sup>C communication forms the single CB stick module. The system can be usable both for indoor and outdoor places. It is developed as motive for service industry in urban areas.

Aliac [6], presents an integrated system for monitoring and management of hydroponics based on internet of things. Like the system above mentioned it also provide ideal environment for plants to survive. By simple mechanism the system maintains a controlled irrigation and nutrient supplying. The backend for the system are data provided by sensors and cloud based technology. With the internet the information is stored, managed, applied and shared by the users. The system uses web application for the control of drainage, fan, sprinkler, and water pump. The effective management of resources results in an efficient hydroponic system.

Detailed study on hydroponics and the method works with the use of microcontroller kit connected to WSN with internet which senses various values. The real-time status of plant growth can be monitored by the farmer from remote area with the help of IoT technology [7]. With the same concept of IoT is used in smart hydroponics system for lettuce and shows the variation with traditional farming in the case of weight, nutrient requirement, number of leaves and growth conditions. [8]

The system atomizes the monitoring during the plant growth using the sensor networks and actuators. The sensor networks helps in monitoring and controlling the different physical events at the farm. By providing decisions through the message system the physical events are controlled. A minimum fluctuation in sensor values is showing by the system will results in an automatic control. The system helps to provide accurate decisions to the user and will leads to grow crop in any reason [9].

Munandar et.al, [10] by the concept of IoT a hydroponics system is designed, developed and implemented and as data acquisition module the Open Garden is used. Data reaches the cloud server after realization and then transferred by Wi-Fi module. The data is displayed by using the web app or android app in web or Smartphone.

Automation of Hydroponics Green House Farming using IoT [11], it does two tasks; one the automation of monitoring of greenhouse environment and the other one is the pH, electric conductivity maintenance. By using internet facility mobile app helps to communicate with farmers regarding the current status of crop, and also monitoring and management is done easier. This method is currently applicable for commercial production sites to evaluate farmers' responses and details of various crops. It also concludes more production is obtained from hydroponics system with less use of water [12].

Namgyel et.al, [13] smart hydroponics system enabled by IoT along with the LED lighting technology. Under various condition plants are grown and parameters are characterized. The use of blue supplementary light led to greater accumulation of leaf density, biomass, and other features. LED light arrays are controlled and regulated by microcontroller. By the use of camera capable of real-time pictorial transmission, the real-time monitoring of sensor values, actuators and solar energy. Wi-Fi module used to transmit data to the cloud server. For easy access to farmers for executing the intelligent decisions and monitoring the system is automated completely.

On the design of Nutrient Film Hydroponics farm for Smart Agriculture [14], smart hydroponics system that automates the crop growing using the Bayesian Network model. To monitor and control the pH, light intensity, temperature, electrical conductivity the sensors and actuators are installed. In the automatic control, by the Bayesian network the fluctuations in sensor values were minimized. It has obtained more than 65% of yield compared to traditional method and above 85% of prediction accuracy. The system is integrated with internet of things technology for the data transferring and accessing. It also using two websites through My NO-IP and Firebase for viewing, monitoring and controlling the actuators used in the farm. Due to the development of modern agricultural information-based intelligence the end users can achieve good economic and ecological benefit compared to manual method.

Implemented smart hydroponics system using the wireless 6LoWAN and wired CAN Bus for studying and optimizing various factors affecting the crop. The system designed using the off-the-shelf devices like CC2650 MCU, MS432 launchpad, Digilent PMOD CAN and RaspberryPi. With the use of 6LoWPAN, the number of nodes commonly used in fully automated system can be reduced to 87%. Here three communication protocols are used such as 6LoWPAN, CAN, and HTTP. The system designed for indoor hydroponic room with multiple number of soilless culture setup [15].

### III. CONCLUSION

As agriculture is the basis for meeting the food requirement, a wide variety of methods should be practiced. Since the FAO of United Nations predicted that in 2050 the world population will meet 9.1 billion people. The food production also has to be increased to more than 70% of current production within this time period. But the conventional method along would be able to meet this requirement. So, the soilless agricultural method hydroponics along with the technology has to be encouraged in the society. Since the hydroponics integrated with the internet of things can plays a vital role for the large-scale production of crop of

any type without going behind the environmental factors. And this method will be a sustainable way of agricultural production because it can automate the whole system, effective water management, less area for production, cultivate in indoor and outdoor areas, provides a good quality product and also no need of detailed knowledge about the farming.

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