



# SMART WATER AGRO-VOLTAIC

## *A Fully Automated Hydroponic System*

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**Abstract:** within the word Agro-voltaic, Agro means Agriculture and voltaic means Photovoltaic. Thus the term Agro-voltaic means Agriculture using Photovoltaic (i.e. solar). Here in Agriculture we use Hydroponic method of farming (NFT type). The meaning of Hydroponics is growing of plants in highly rich nutrient solution. The objective of the project is to create a hydroponic controller that monitors and automatically controls the environmental factors required for hydroponic farming. The main function in this type of method is controlling the TDS and pH level at required level for crops for each and every time. The implementation is done by using the Arduino Mega 2560 unit, as it has a higher processing power and more memory, and provides several ports to communicate with screens, sensors, relays and shields. The system acquires data regarding to light intensity, humidity, temperature, conductivity and acidity of the crop mixture and sends them to the Arduino. The Arduino then takes the decision to control all the parameters to be maintained in a specified range. The user via a display unit is able to monitor the above data in real time and manually or automatically can control the operation of the fan, lamp, pump and humidifier. Arduino regulates the composition of solutions containing nutrients to be circulated with a pump by the NFT system in Hydroponics. The circulation of nutrients for the NFT system is automatically and the data of different parameters can be sent to the owner's device using IoT. The main aim of Smart Water Agro-voltaic cultivation is to reduce water usage, growing more crops in less space and improving quality of crops without using chemicals and pesticides, and to save land. This type of cultivation can be in small scale or large scale and indoor or outdoor farming. This paper provides an overview about the cost-effective implementation of automated system for all farmers in India and other countries.

**Index Terms** – Agro-voltaic, Hydroponics, Agriculture, Farming, Automated, Nutrition, TDS, pH, crops plants, Soil less, NFT- Nutrition Film Technique, Hydroponic Farm.

## I. INTRODUCTION

Agro-voltaic is basically growing plants only in water without the use of soil. It is the most efficient way to provide the required food and water to the plants. Plants does not use soil but they use the food and water that are in the soil. The function of soil is only to supply plants nutrients and provide stability to the plant roots. In an hydroponic garden, we provide our plants with complete nutrition and inert growing medium to provide stability to plant roots so they can have easy access to the food and water. The food is mixed or dissolved in water, as it receives directly from the roots. Hence plants grow faster and will be ready for harvesting. By this method, we can grow more plants in same space as we can with soil, and since no soil is used, no worry about soil borne diseases or pests and no weeding is required.

Soil is an essential source of nutrients and minerals for growing plants. Also, it is responsible for facilitating the gaseous exchange between the atmosphere and roots and helps to protect the plants against erosion and facilitates water retention.

Hydroponics is method of growing plants only in nutrient solution without soil and with or without the use of inert medium. Professor William Gericke invented the term hydroponics in the early 1930s to describe the growing of plants without soil.

Agro-voltaic has been shown to be a viable method of growing vegetables (like tomato, cabbage, cucumber, pepper, capsicum, spinach, coriander etc.) as well as ornamental plants like herbs, roses, freesia, and foliage plants. The market for hydroponic grown produce has increased rapidly in recent years as a result of the methyl bromide ban in soil culture. Agri-business Education and Research International also provide necessary information regarding Hydroponics. Plants obtain nutrients from a solution of water & minerals.

Common methods include: wick, deep water culture, ebb & flow, aero-phonics & Nutrient Film Technique (NFT). Hydroponic systems are used from home-based to medium and to large commercial operations.

## II. EASE OF USE

### 2.1 Hydroponics

Hydroponics is the science of growing plants in soil less medium. Many researchers discovered that plants are able to absorb and consume essential minerals and nutrition in normal water, but researchers also found that plants absorb these nutrition directly from nutrition rich water. And they also found that soil is not a necessary component of plant cultivation. Automation of hydroponics, reduces the actual time it takes to maintain plant growth. Plant grows in an automated system without soil, where mixture of water and nutrition solution which is supplied from storage tank to grow tray and water is regularly circulated.

Soil is default source for nutrients supplements. Scientists found that plants were able to absorb the nutrient supplement directly from water nutrient solution. Normally soil work as the supplement store for the plant. The nutrition in the soil dissolve into the water contained in the soil where the plants roots absorb them. When the same nutrition are provided artificially into a plants water source, then soil is no longer required for plants growth.

Hydroponics is one of the best choices of conventional cultivation. This technique does not require advanced equipment in cultivating. One advantage of Agro-voltaic system is that whole system can be automated with electronic circuits. Automation reduces the cost of labor, save time and farmer need not worry about watering the plant. Because of automation, the water nutrient solution supply can be control by programming. Hydroponics system can grow unseasonable fruit, vegetables, and flowers.

Water Culture is a hydroponic method which supplies water that has supplements directly to base of the plant regularly. Smart Water Agro-voltaic system type of crop cultivation is increased recently, as it allows the use of water and nutrition more efficiently, and a better climate control and pest factors. This type of production increases the quality of crops and its productivity, hence economy increases.

Smart Water Agro-voltaic system can be used by anyone in any country, but it is more helpful to those having less land availability, which is unable for agriculture purpose. Due to urbanization and industrialization global warming, land which is under cultivation will decrease. The fertility of soil has reached saturation level, and production is not increasing but chemical fertilizer usage is increasing. Poor soil fertility in cultivable land and less natural soil fertility build-up by microbes due to continuous cultivation, drought conditions and effect of sudden change in climate and weather, increase in temperature, water pollution, poor water and waste management, reduction in ground water etc. are main problems for food production under conventional type i.e. soil agriculture. In future it is not possible to provide food to the entire living beings. In soil less cultivation, plants are grown without using soil. Hence more space and water conserving methods for food production in soil less cultivation have shown best outcomes all over the World.

## III. RESEARCH METHODOLOGY

Our project is a hydroponic cultivation, an indoor cultivation based on hydroponics, a method used to grow plants using mineral solutions instead of soil. The general structure is made of aluminum. The structure through which the water circulates consists of PVC pipes cut and glued by hand, and consists of 6 levels through which the water passes. Each level has been drilled to place pots. 3D pieces have also been designed so that the pots do not move and to support the lighting. In the lower part there is a tank in which the water of the system falls and through which different components can be added to the water. In case of having to drain the tank, we have a manual drain.

The project consists of three different parts:

1. Modular structure: PVC and aluminum frame in order to support all the hydroponic system.
2. Electronic circuit: main control of the digital "brain" of our system
3. Sensors/actuators: measure and control all the data and parameters of our system.

The device allows to control the state of the plants by sensing several parameters:

1. Temperature and humidity
2. pH
3. Conductivity (TDS)
4. Time

Then it uses different types of actuators to modify the state of the plants by irrigating them, activating lights or releasing nutrients:

1. Water pump
2. Growing light
3. Nutrients

Arduino mega is used to store and run the code, TDS and pH of circulating water is maintained. Light, Temperature and humidity of the plantation area is maintained. Water is circulated continuously. The required power supply for all the components is provided from the solar panel. The code is done in such a way that if TDS is low then nutrition is added and if TDS is high RO water is added. If pH is low then pH up solution is added and if pH is high then pH down solution is added. If temperature and humidity is low, then fan turned off and humidifier tuned on. If temperature and humidity is high, then fan turned on and humidifier tuned off. If natural sunlight required for plants is not sufficient, then artificial light i.e. grow light is turned on. All monitoring and controlling is done by arduino through relays and sensors. Water level of all the tanks is monitored.

### 3.1 Scope of Project

Scope of this type of technology is the growing fast in agriculture field, and increases food production in the future. As population increases and agriculture land is reducing because of poor land management, people will have to use technologies like hydro-phonic and aero-phonic for crop production. Smart Water Agro-voltaic system has the capacity to produce large proportion of the world's population and hence allows countries to feed their own people, even in places where shortage of water and soil is of poor quality and land availability is less. This type of farming can be used as source of food production in places where space available is less. This method is straight forward, and we can try this without worrying about anything.

Generally, plants need selected nutrition, water, and sunlight to grow. With Hydro-phonic method, this can be done very efficiently, effectively, and with less water and sunlight. Instead of using soil, nutrition-rich water is used so that plants can absorb minerals required for their survival without the soil. They grow better in this environment. We can see it for ourselves when we try on our hands.

There are many benefits of this type of farming. Few of them are:

- 50% faster growth compared to soil.
- Can be harvested throughout the year.
- Constant availability of nutrition for the plants.
- Water used in this system can be reused.
- Less landmass is required as it doesn't need soil.
- Can grow indoors and outdoors throughout the year.
- No weeding required.
- More plants in less area.
- Used in places where gardening and soil agriculture is not practical like deserts.
- Greater control over nutrition, pH, and growing conditions.
- Water and nutrient recycling reduces the expense of water and nutrients.
- Insects, fungi, bacteria found in soil are eliminated hence doesn't need any herbicides or pesticides.

### 3.2 Scope for Future Work

As demand for agriculture land is increasing and also population increasing, fulfilment of food by soil cultivation becomes challenging task; change in weather like flood, drought etc. causes difficulty for farmers for soil-agriculture. Agro-voltaic system implementation requires only one time initial investment. Once the frame, tanks, sensors, controllers are set up then for future, there is no need of further investments. Only seed sowing in the caps provided in the frame and filling the water and essential nutrition in the tank provided is done initially. Then there is no work for human. All process is done automatically. The yield time is also more, hence productivity increases in less time as compared with the conventional soil farming. The harvesting is also easier. Agro-voltaic system can be installed both indoor and outdoor as required. Design of frame can be modified depending on area available. All types of crops can be grown in Agro-voltaic system. Green house type structure can be used to provide temperature control, reduce evaporative water loss, and reduce plant disease and reduce use of pesticide.

### 3.3 OVERVIEW

The aim of Agro-voltaic system is to enhance control and efficiency in crop production. The productivity depends on the main factor which is environment in which plants are grown. In a conventional outdoor production system, crops depends on weather and soil conditions. Shifting the crop production from soil to Smart Water Agro-voltaic system is the first step of automated controlled environment production which can be used for both indoor and outdoor cultivation. In Smart Water Agro-voltaic system, the nutrition, pH level, temperature, humidity and lighting condition required for plants is adjusted automatically. No need of human interference, hence labors are reduced. The real time data and previous data can be monitored remotely.

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### 3.4 Main Components

**3.4.1 Arduino mega 2560:** The Arduino MEGA 2560 has 54 digital I/O pins, 16 analog inputs, more sketch memory and RAM. It contains everything required to support microcontroller. Easy to connect to a computer using USB cable. The Arduino Mega can be turned on by using USB or external power supply. The programming is easy by using arduino software and arduino c language or c++ or java.



Fig. 3.4.1 Arduino mega 2560

**3.4.2. pH sensor:** A pH sensor is used to measure the acidity or alkalinity of the water which is in range of 0 to 14. When the pH value is below seven, the water is acidic and above seven, water is alkaline. pH electrodes are made from special glass which sense hydrogen ion concentration. The alkali metal ions of glass and hydrogen ions in solution undergoes ion exchange, generating a voltage. This voltage is converted into pH.



Fig. 3.4.2. pH sensor

**3.4.3 TDS sensor:** The TDS Sensor detects the Total Dissolved Solids (TDS) in the water which gives the data of water quality. The TDS Sensor can be used in TDS meter, well water, aquarium, hydroponics etc. Measurement Range is 0 to 1000ppm.



Fig. 3.4.3 TDS sensor

**3.4.4 Temperature and Humidity sensor:** The DHT-22 or DHT-11 is a digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and sends digital signal. There are two thermal sensors conduct electricity based on humidity of surrounding air. The difference between the two measures the humidity. Hence the Temperature and Humidity of air is received digitally.

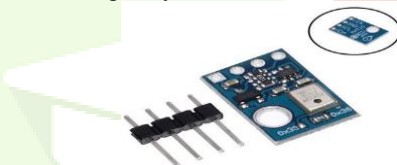


Fig. 3.4.4 Temperature and Humidity sensor

**3.4.5. Relay:** A relay is an electrically operated switch that can be turned on and off. It is controlled with low voltage like the 5v, 9v, 12v etc.



Fig. 3.4.5. Relay

**3.4.6. Pump:** A submersible pump is used to circulate the water in Agro-voltaic system and to add nutrition, pH up - pH down solution, RO water etc.



Fig. 3.4.6. Pump

**3.4.7. Solar Panel:** A solar panel is a collection of solar or photovoltaic cells which is used to generate electricity by photovoltaic effect. The cells are arranged in grid pattern on the surface of solar panels and mounted on a supporting structure. The solar panel converts the solar energy to electrical energy.



Fig. 3.4.7. Solar Panel

**3.4.8. Grow light:** A grow light is artificial light which help plants to grow. Grow light provides light similar to that of the sun. For indoor or during night time or during cloudy atmosphere, grow lights are used to provide artificial light which is same as sunlight, for better plant growth.



Fig. 3.4.8. Grow light

Hence by using these components, a fully automated smart water agro-voltaic can be implemented. Power from Solar Panel is fed to Solar Charge Controller, and then stored in Battery. Then the power is consumed using DC to AC Converter. Arduino mega is used to store and run the code, TDS and pH of circulating water is maintained. Light, Temperature and humidity of the plantation area is maintained. Water is circulated continuously. The required power supply for all the components is provided from the solar panel. The code is done in such a way that if TDS is low then nutrition is added and if TDS is high RO water is added. If pH is low then pH up solution is added and if pH is high then pH down solution is added. If temperature and humidity is low, then fan turned off and humidifier tuned on. If temperature and humidity is high, then fan turned on and humidifier tuned off. If natural sunlight required for plants is not sufficient, then artificial light i.e. grow light is turned on. All monitoring and controlling is done by arduino through relays and sensors. Water level of all the tanks is monitored. All the data processed i.e. tank level, temperature, humidity, pH, TDS etc. is sent to website or app where we can remotely access the data and we get the graphical representation of the data.

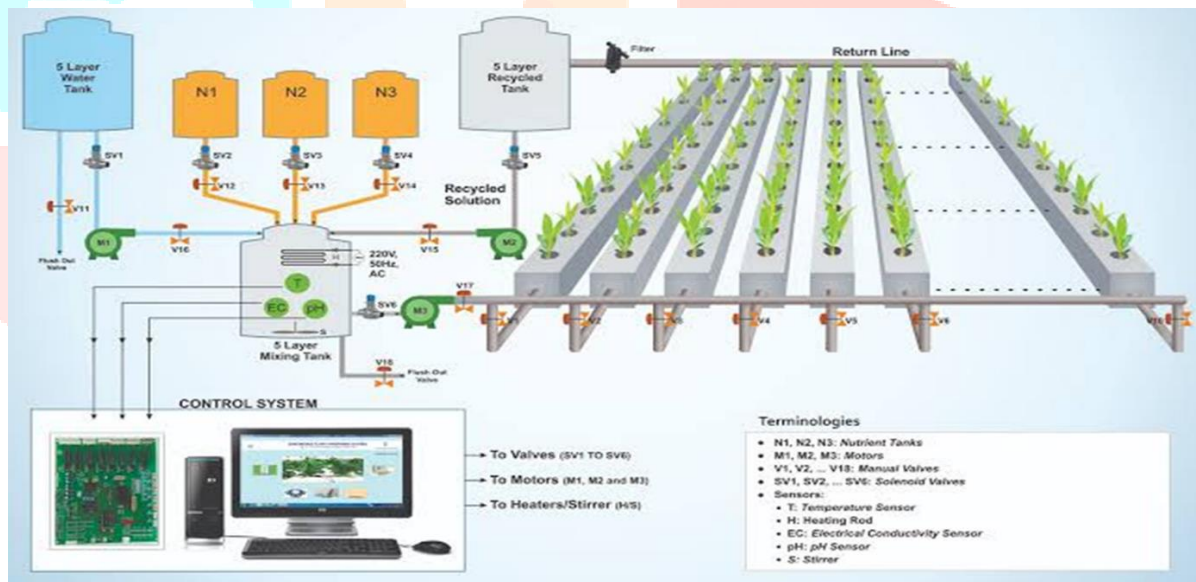


Fig. 3.4 (a) Smart Water Agro-voltaic



Fig. 3.4 (b) Execution of Smart Water Agro-voltaic

#### IV. RESULTS AND DISCUSSION

The Agro-voltaic system is to enhance control and efficiency in crop production. The productivity depends on the main factor which is environment in which plants are grown. In a conventional outdoor production system, crops depends on weather and soil conditions. Shifting the crop production from soil to Agro-voltaic system is the first step of automated controlled environment production which can be used for both indoor and outdoor cultivation. In Agro-voltaic system, the nutrition, pH level, temperature, humidity and lighting condition required for plants is adjusted automatically. No need of human interference, hence labors are reduced.

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