International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** V **Month of publication:** May 2025

DOI: https://doi.org/10.22214/ijraset.2025.71880

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

Solar Based Hydroponics Farm Management System

Pavan Kumar R L[1], B M Darshan[2], Soniya M Chavan[3], Rishitha H S.[4], Avinash C M.[5]
Visvesvaraya Technological University, RajaRajeswari College of Engineering, Mysore road, Bangalore(560074)

Abstract: This study develops a solar-based hydroponic farm management system that combines renewable energy with automated control of nutrient delivery and environmental factors. The system uses solar panels to power sensors and actuators that monitor water quality, moisture, and nutrient levels, enabling efficient and sustainable crop cultivation without reliance on grid electricity. Real-time data monitoring through IoT ensures optimal growing conditions, improving crop yield and resource efficiency. This solution promotes eco-friendly, energy-independent farming suitable for areas with limited power access.

I. ABSTRACT

The increasing demand for sustainable agriculture has prompted the development of innovative solutions that optimize resource utilization while minimizing environmental impact. This paper presents a solar-based hydroponics farm management system designed to enhance efficiency in modern farming practices. The system integrates renewable energy sources, primarily solar power, with automated hydroponic techniques to cultivate crops without soil, thereby reducing water consumption and dependency on arable land. An Arduino microcontroller controls the system and collects real-time data from various sensors, including a soil moisture sensor and a pH sensor. These sensors ensure the soil remains within optimal moisture and acidity levels for healthy crop growth.

Based on the readings, a water pump is automatically activated to irrigate the plants when needed. An LCD display provides live updates of the sensor data, helping farmers make informed
decisions without the need for manual soil checks

II. INTRODUCTION

The main objective of this project is to develop a Solar-Based Organic Farm Management System that supports sustainable agriculture through the integration of renewable energy, organic soil practices, and automation. The system is designed to assist farmers, especially in remote and rural areas, by reducing manual labor, conserving water, and promoting eco-friendly farming methods. It uses a mixture of soil and cow dung as an organic growing medium, which provides natural nutrients to plants and reduces dependency on chemical fertilizers.

The entire system is powered by a solar panel, making it ideal for locations with limited or no access to grid electricity. At the heart of the system is an Arduino microcontroller, which collects and processes data from connected sensors. A soil moisture sensor continuously monitors the water content in the soil.

When moisture drops below a defined threshold, the system automatically activates a water pump through a relay module to irrigate the crops, ensuring efficient use of water. In addition, a pH sensor measures the acidity or alkalinity of the soil, helping maintain suitable conditions for plant growth. The readings from the sensors are displayed on an LCD screen, giving real-time feedback to the farmer. All components are powered by energy stored in a battery that is charged via the solar panel, ensuring uninterrupted operation even in off-grid conditions.

This system has a wide range of applications including small-scale farms, backyard gardens, educational farms, and off-grid agricultural setups. It offers multiple advantages such as water conservation, reduction of labor, cost-effective operation, and promotion of organic farming. The use of cow dung enriches the soil naturally, while solar power ensures energy independence and environmental sustainability. Although it is mainly designed for small farms, the concept can be scaled further with additional features like wireless monitoring and mobile alerts. Overall, the project presents a practical and affordable solution for modernizing traditional agriculture in an ecoconscious way.

III. LITERATURE REVIEW

Design and Implementation of an Automated Indoor Hydroponic Farming System based on the Internet of Things.

This paper describes the design and implementation of an IoT-enabled hydroponic farming system. The system monitors environmental conditions such as temperature, humidity, pH, and nutrient levels using sensors and controls water pumps to circulate nutrients. The system uses solar power as the primary energy source and a Raspberry Pi for data processing and control.

- Muhammad Niswar (2024) stated that concentrated solar powered hydroponics in India: current status, challenges, and outlook. In this article, some of the challenges that have inhibited the growth of concentrated solar power are identified and possible solutions suggested.
- The convergence of hydroponics, renewable energy, and IoT-based automation has been widely explored in recent years as a sustainable solution for modern agriculture. Various studies have demonstrated the viability of soilless cultivation systems in improving crop yield and resource efficiency.
- Patel et al. (2021) designed an IoT-based hydroponics system that automates pH and nutrient monitoring, enabling remote access and control via a mobile application. While the system provided a significant reduction in manual labor, it relied entirely on grid power, limiting its deployment in remote areas.
- Mishra and Sinha (2020) studied the impact of solar canals on water quality and found that algae growth was suppressed.

Effect of Solar Powered Hydroponics , Water Quality, and Power Production.

- Gupta et al. (2021): Developed a solar powered hydroponic model for leafy vegetable cultivation in semi-arid regions.
- Their results showed that using photovoltaic panels to power pumps and control systems reduced dependency on grid electricity by over 90%, enabling continuous operation in off-grid conditions.
- Rao and Thomas (2020) compared solar powered and conventionally powered hydroponic systems, reporting that the solar system showed more stable operation and a lower carbon footprint, albeit with slightly higher initial setup cost

IV. OBJECTIVES

1) Design a solar-based system to enable offgrid, energy-efficient operation of a hydroponic farm
2) Develop an automated hydroponics setup with sensors to monitor pH, EC, temperature, humidity, and water level. Solar energy is produced without pollution using solar modules.
3) Optimize water and nutrient usage through a closed-loop system, minimizing waste and improving sustainability.

V. RESEARCH METHODOLOGY

1) Solar PV modules: Solar panels are installed on a support structure above the canal. These panels are connected in series and parallel, which provides effective voltage and current.
2) Buck-boost: This power electronic device can step up the input voltage, producing the desired output.
3) Solar charge controller: A solar charge controller regulates current flow from solar panels to a battery, preventing overcharging and ensuring efficient charging.
4) Battery: Three lithium-ion batteries are connected in series, providing a total voltage of 14.8 volts.

VI. DATA ANALYSIS

A. Project Data of the Hydrponics.

Details of the Hydroponics

pH Level	5.5-6.5
Moisture sensor	3.3-5V
Solar Powerd output	13.2V
Battery backup time	6-8 hr

B. Solar Panel Data

Solar panel details.

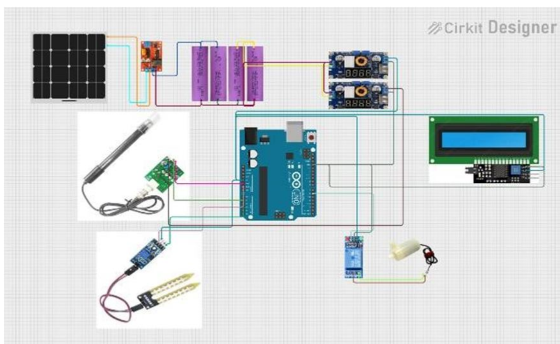
Panel size.	70X70 mm
Number of panels used.	04

C. Overall Output.

Performance of the Solar Panel

Voltage	13.2V
Current	0.1A
Power	1.32W

VII. CIRCUIT DIAGRAM



VIII. FUTURE SCOPE

The solar-based hydroponics farm management system holds significant potential for further advancements by integrating artificial intelligence and machine learning. These technologies can enable predictive analysis for nutrient dosing and environmental control, optimizing crop yields and resource usage. Additionally, scaling the system for large commercial farms with modular designs can enhance productivity and automation, making sustainable farming accessible on a broader scale.

IX. CONCLUSION

The solar-based hydroponics farm management system demonstrates a sustainable and efficient approach to modern agriculture by combining renewable energy with automated nutrient and environmental control. This integration not only reduces dependence on grid electricity but also optimizes water and nutrient usage, leading to improved crop yield and quality.

X. PROBLEM STATEMENT

Traditional farming faces water scarcity, energy dependence, and poor resource management. This project develops a solarpowered hydroponics system to enable efficient water use, renewable energy, and automated crop monitoring for sustainability.

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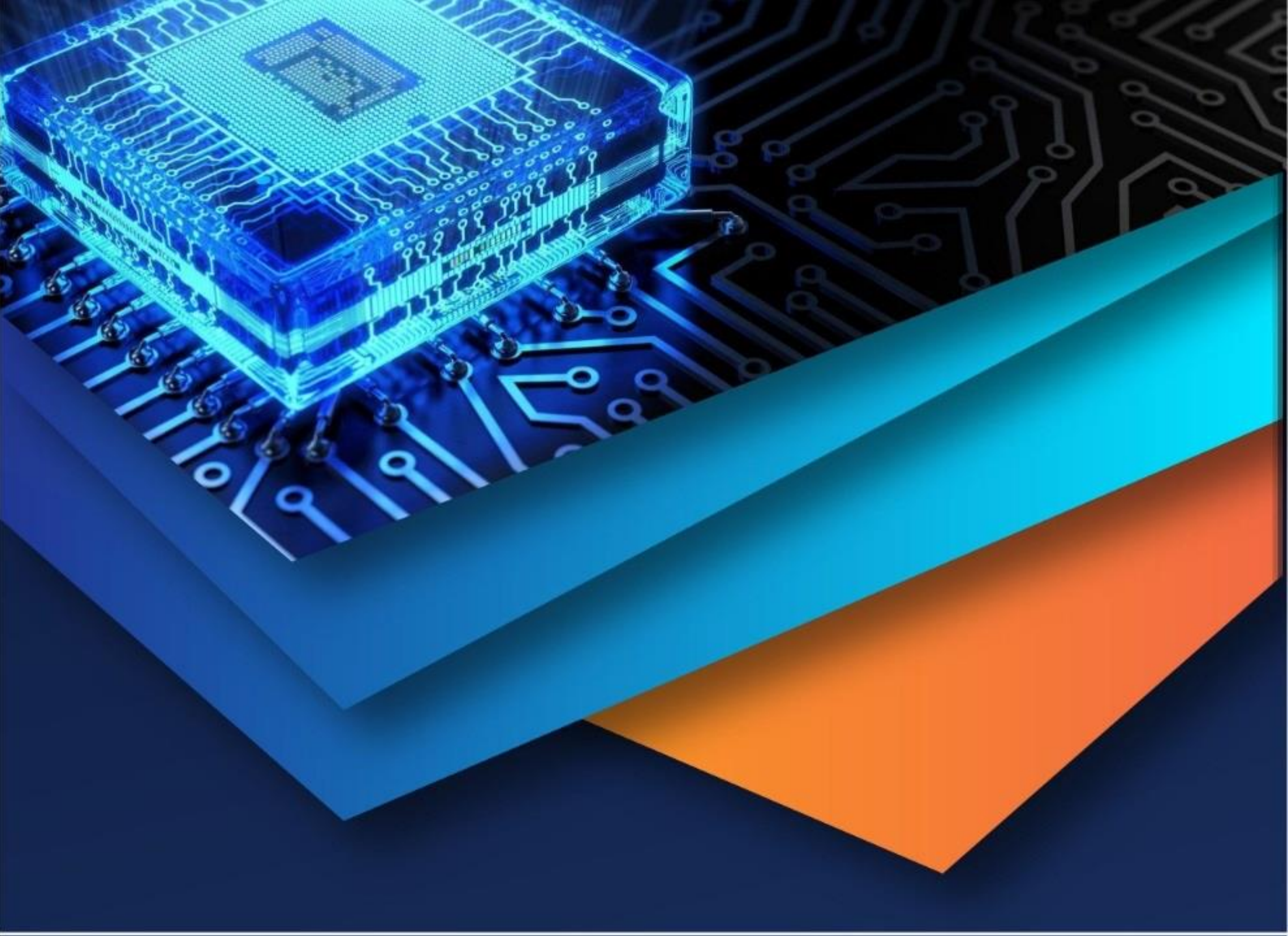

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