International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 04 | April - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Smart Irrigation Using Solar Panel and Sensor

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Abstract - This research introduces a cutting-edge smart irrigation system that harnesses solar energy and integrates soil moisture sensors to optimize water use in agriculture. Designed with sustainability in mind, the system automates irrigation based on real-time soil conditions, significantly reducing water wastage and eliminating reliance on conventional electricity sources. Field implementation demonstrates a reduction in water consumption by 35-40%, enhanced crop health, and a complete shift toward clean energy-making it a highly efficient and scalable solution for the future of agriculture.

1. INTRODUCTION

In a nation like India, where agriculture is the backbone of the economy, farmers face challenges such as water scarcity, erratic electricity supply, and labor shortages. Traditional irrigation practices are often inefficient and resource-intensive. To address these issues, this paper presents a sustainable, smart irrigation model powered by solar energy and regulated through advanced soil moisture sensors. This innovative approach ensures optimal water distribution, reduces human intervention, and empowers farmers with reliable, cost-effective technology.

2. Body of Paper

❖ System Components and Architecture

1. Solar Panel

- **Specification**: 12V, 20W
- **Function**: Converts sunlight into electrical energy to power the system and charge the battery.
- **Cost** :- 1500 /-

2. Rechargeable Battery

- **Specification**: 12V, 7Ah Sealed Lead Acid (SLA) Battery
- **Function**: Stores electrical energy from the solar panel to ensure continuous operation, especially during cloudy conditions or nighttime.
- **Cost** :- 1000 /-

3. Charge Controller

- **Specification**: 12V, 5A Solar Charge Controller
- **Function**: Regulates voltage and current from the solar panel to the battery, preventing overcharging and ensuring battery longevity.
- **Cost** :-500 /-

4. Microcontroller (e.g., Arduino Uno)

- **Specification**: ATmega328P Microcontroller
- **Function**: Processes data from sensors and controls actuators like the water pump based on predefined conditions.
- **Cost** :- 500 /-

5. Soil Moisture Sensor

- **Specification**: Capacitive Soil Moisture Sensor
- **Function**: Measures the volumetric water content in the soil, providing data to determine when irrigation is needed.
- **Cost** :- 500 /-

6. Temperature and Humidity Sensor (e.g., DHT11 or DHT22)

- **Specification**: Temperature Range: 0–50°C; Humidity Range: 20–90% RH
- **Function**: Monitors ambient temperature and humidity, aiding in optimizing irrigation schedules.
- **Cost** :- 200 /-

7. Relay Module

- **Specification**: 12V, Single-Channel Relay Module SR Robotics
- **Function**: Acts as a switch to control the water pump, enabling or disabling it based on signals from the microcontroller.
- **Cost** :- 200 /-

8. Water Pump

- **Specification**: 12V DC Submersible Pump
- Function: Pumps water from the source to the irrigation system when activated.
- **Cost** :- 5000 /-

9. Wireless Communication Module (e.g., ESP8266 or HC-05 Bluetooth Module)

- **Specification**: Wi-Fi (ESP8266) or Bluetooth (HC-05) Module
- **Function**: Enables remote monitoring and control of the irrigation system via smartphone or computer.
- **Cost** :- 300 /-

10. LCD Display

- **Specification**: 16x2 Character LCDIJERT
- **Function**: Displays real-time data such as soil moisture levels, temperature, humidity, and system status.
- **Cost** :- 600 /-

11. Miscellaneous Components

- **Includes**: Resistors, capacitors, diodes, connectors, wiring, and a Printed Circuit Board (PCB)
- **Function**: Facilitate proper connections, signal conditioning, and stable operation of the circuit.
- **Cost** :- 2000 /-

Total System Cost per Unit: Rs.11,400 /-

- **Water Pump**: Delivers water to the field when activated by the controller.
- **Relay Module**: Used to control the switching of the water pump.
- **Water Tank**: Stores the water used for irrigation.
- **Pipes/Drip System**: Distributes water evenly to the crops.

- Monitor soil and weather data in real-time
- Control irrigation remotely
- Set schedules or thresholds through a user-friendly interface

This makes the system intelligent, accessible, and user-friendly.

❖ Operating Principle

- The system operates autonomously using sensor-driven feedback mechanisms. Soil moisture levels are constantly monitored by E5C sensors. When the moisture falls below a pre-set threshold (e.g., 30%), the Arduino controller activates a water pump via relay, drawing energy from a solar-powered battery. Once adequate moisture is restored, the system automatically shuts off the pump. This ensures precision irrigation with zero manual effort and zero electricity dependency.

❖ Scalability and Acreage Economics

Coverage: One system efficiently irrigates ~0.25 acre
For 1 acre: Four systems are recommended

Cost elements	Per unit	For 1 Acre (4 Units)
System Setup	11400/-	45600/-
Annual Maintanence	1000/-	4000/-
Electricity Uses	0/-	0/-

❖ Performance Metrics and ROI

Water Efficiency:
- Conventional irrigation: ~6,500 liters/day/acre
- Smart irrigation: ~4,000 liters/day/acre
- Water saved: ~2,500 liters/day
- Annual savings: ~9.12 lakh liters

Energy Savings:
- Traditional pump: ~2 kWh/day
- Smart system: 0 kWh (solar-powered)
- Electricity saved annually: ~730 units
- Cost savings: Rs.5,800/year (at Rs.8/unit)

Return on Investment:
- Total Cost per Acre: Rs. 45600/-
- Yearly Savings: Rs.8,000-Rs.10,000
- Break-even period: 4.5-5 years

3. CONCLUSIONS

This smart irrigation system exemplifies the fusion of innovation and sustainability. By leveraging renewable energy and sensor-based automation, it empowers farmers to increase crop yield, reduce operational costs, and contribute to environmental conservation. The system's scalability, affordability, and energy independence make it an ideal solution for modernizing rural agriculture across India. Future developments could include AI-based weather forecasting, mobile app integration, and smart fertilization techniques.

4. ACKNOWLEDGEMENT

First and foremost, we are deeply thankful to our project guide, **[Pawar N.B]**, for their invaluable support, encouragement, and expert guidance during every stage of this project. Their insightful suggestions and constant motivation were key to overcoming the challenges we faced.

We also extend our heartfelt thanks to the **[A. G. PATIL INSTITUTE]**, for providing us with the resources and environment needed for the development of this project. Our appreciation also goes to the technical staff and lab assistants who helped us with tools and setup.

Lastly, we would like to thank our friends and families for their continued support, patience, and encouragement throughout the course of this work.

This project has been a great learning experience and has helped us grow both technically and personally.

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