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Smart Solar-Irrigo System

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Abstract: *This project suggests an Advanced Solar Tracking and Automatic Sprinkler Irrigation System that is improved by next-generation sensor technologies and mobile message integration. In comparison to static panels, the system greatly increases power generation by optimising solar panel orientation throughout the day using a single-axis solar tracker. High-precision temperature and soil moisture sensors are combined with an automated irrigation system to track field conditions in real time. The technology autonomously regulates sprinkler water distribution based on sensor feedback, minimising water waste and preserving ideal soil moisture levels.*

Farmers can receive real-time SMS warnings about soil conditions, irrigation events, and solar power efficiency thanks to a GSM-based communication module. Without requiring physical presence, this mobile integration enables remote monitoring and decision-making. Using LDR+servo modules for precise solar tracking, DHT22 sensors for high-accuracy temperature and humidity data, and capacitive soil sensors for durability. This Internet of Things-enabled solution supports smart farming, lowers energy and water usage, and boosts agricultural productivity. The design is an important step towards sustainable agro-tech solutions because it is affordable, scalable, and flexible for both small and big farms

Keywords: Solar tracker, LDR (Light Dependent Resistor) sensor, Arduino based control, Soil moisture sensor, Automatic sprinkler system, Smart irrigation system, Real-time monitoring

I. INTRODUCTION

Growing energy demands, water scarcity, and the effects of climate change have made the need for sustainable energy and effective agricultural techniques more urgent in recent years. In many developing countries, agriculture continues to be the main source of food security. However, traditional irrigation methods, which are frequently manual and time-based, result in excessive water use, wasteful energy consumption, and labor-intensive field surveillance. The use of renewable energy sources, such as solar electricity, for sustainable farming operations has also expanded due to the quick depletion of fossil fuels and growing environmental concerns.

An Advanced Solar Tracking and Automatic Sprinkler Irrigation System with single axis solar tracking, real-time soil and environmental sensing, and mobile message (SMS/GSM) integration is proposed in this project to address these issues maintaining desired crop conditions.

The solar tracker maximizes energy production and lessens dependency on erratic grid electricity by continuously adjusting photovoltaic panels to maintain ideal sun alignment under the guidance of light dependent resistor (LDR) arrays. A microcontroller-based control system that uses generated solar energy to power sprinkler valves automatically depending on temperature, humidity, and soil moisture sensor readings saves water wastage and human work. From tiny farms and gardens to commercial holdings, the modular architecture allows for scalability and cost-effective component grouping (e.g. Arduino or PIC microcontroller, LDRs, moisture sensors, GSM module).

Reliable off-grid operation is made possible even in distant agricultural areas by single-axis solar tracking, which continuously aligns the PV panel with the sun and increases captured energy by up to 60%. Precision irrigation and

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water conservation: In order to reduce waste and promote sustainable water use, sensor-based control makes sure that water is only applied when soil moisture drops below ideal thresholds and foregoes irrigation during rains. In line with the latest technology developments, this integrated system offers energy efficiency, water conservation, and user-friendly mobile operation, addressing major issues in off-grid agricultural irrigation.

II. LITERATURE SURVEY

Abdullah Ahmad (2018) et al. [1] proposed the development of an automatic tomato sorting machine based on a color sensor. This work was published in the *International Journal of Recent Engineering Research and Development (IJRERD)*, Volume 03, Issue 11, November 2018, pp. 01–07.

The integration of renewable energy with modern agricultural practices has gained considerable attention in recent years. Solar-powered irrigation systems, enhanced by tracking mechanisms and Internet of Things (IoT) technologies, are emerging as a sustainable solution for precision farming. A review of relevant studies highlights advancements in solar tracking, automation, and intelligent water management techniques.

Pai, S., Acharya et al. [1] Developed one of the early prototypes of a solar tracking and automated water pumping system, in which dual-axis solar tracking was employed to increase solar panel efficiency while simultaneously driving an automated water pump. Their work demonstrated the dual benefit of reducing manual effort and improving water utilization in agricultural fields.

Bhosale [2] presented a smart irrigation system with dual-axis solar tracking, highlighting its application in agricultural environments. The study emphasized real-time solar tracking to maximize power output and showed that combining solar tracking with irrigation control can significantly reduce reliance on conventional energy sources.

Kanwal et al. [3], who proposed an intelligent dual-axis solar tracking system with remote weather monitoring capabilities. Their design integrated renewable energy harvesting with environmental sensing, illustrating the role of such systems in improving farm productivity and resilience to climatic conditions.

Ubarhande et al. [4] also investigated a similar approach by creating an IoT-based smart irrigation system using dual-axis solar trackers. The system monitored soil moisture and utilized solar energy for efficient irrigation, reflecting the growing emphasis on IoT in sustainable agriculture.

In addition to irrigation-focused systems, solar power has been utilized in robotics for agriculture. Tarun et al. [5] designed and fabricated a solar-powered remote-controlled all-terrain sprayer and mower robot, demonstrating the potential for multifunctional agricultural machinery powered by solar energy. This innovation showed how solar technology can be extended beyond irrigation to broader farm mechanization.

Gupta et al. [6] reinforced the application of dual-axis solar tracking in agriculture, concluding that accurate solar tracking leads to optimized energy capture, which is particularly beneficial for irrigation and other energy-demanding farm operationsRecent studies have shifted toward more intelligent, data-driven approaches.

Mamun et al. [7] introduced an IoT-enabled solar-powered smart irrigation system for precision agriculture, which optimized both water and energy use by leveraging real-time data. Similarly,Balamurali et al. [8] reviewed a solar-powered IoT-controlled irrigation system that incorporated rainfall forecasts and aerosol monitoring. This approach underlined the importance of integrating climate prediction and environmental variables into irrigation scheduling, thereby improving agricultural resilience.

To enhance the decision-making capability of such systems, Ahmadi Pargo et al. [9] proposed a hybrid agent-based and system dynamics model for IoT-enabled irrigation systems. Their study demonstrated that combining simulation with IoT control can lead to more efficient and adaptive irrigation strategies.

Abdelhamid et al.,[10]2025—Solar-powered smart rooftop irrigation for urban agriculture. designed and field-tested a PV-powered, sensor-driven drip system on an urban rooftop (peppermint), comparing a conventional drip line vs. a "smart" line with real-time monitoring and control. Demonstrates technical feasibility for small urban plots and indicates water/energy savings relative to conventional drip; positions rooftop agriculture as a viable, low-carbon option. Real-world validation in a constrained, urban micro-farm setting—useful external validity beyond lab pilots.

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Gaps. Limited crop diversity and timescale; the control strategy appears rule/threshold-based rather than predictive (no weather-aware scheduling).

Attia et al. [11], 2024—Intelligent MPPT for off-grid PV-DC irrigation pumps Proposed a deep neural network–based MPPT (with sliding-mode enhancements) for PV-powered DC water-pumping in remote irrigation, targeting fast/accurate tracking under irradiance transients (cloud edges, load changes). Results (as reported). The proposed system achievs faster convergence and higher energy capture compared to the classic P&O/INC system, thereby improving pump Duty cycles and delivering water volume under variable conditions. Brings state-of-the-art AI MPPT to the specific duty cycle of irrigation pumps (where flow continuity matters).

Ariyanto et al.,[12] 2021—PV-based automatic irrigation monitoring with fuzzy logic (IOP Conf. Series) Implemented a PV-powered irrigation monitor/controller using fuzzy logic to translate multi-sensor inputs (e.g., moisture/temp) into pump/valve actuation—aimed at water savings with simple rule bases. Early, practical demonstration of computationally light control (fuzzy) suitable for low-cost microcontrollers off-grid. Complements AI-heavy MPPT work by addressing the water-side decision layer

It is clear from the survey that solar-powered irrigation systems have developed into intelligent, self-sufficient, and multipurpose agricultural solutions. It has been repeatedly demonstrated that dual-axis solar tracking maximises the use of solar energy. These systems have been converted into data-driven precision agriculture frameworks through the integration of IoT and environmental monitoring, guaranteeing better crop output, sustainable energy management, and optimised water use. Future studies will probably concentrate on cloud integration, AI-based prediction, and completely autonomous agricultural equipment, which will make solar-powered irrigation systems essential for environmentally friendly farming.

The general trend points to a shift towards data-driven, autonomous, and ecologically friendly solar irrigation systems that not only maximise the use of renewable energy sources but also solve the problems associated with water scarcity in agriculture. These developments open the door for the creation of next-generation smart farms, which combine solar energy, IoT, and artificial intelligence to guarantee effective and sustainable farming methods.

III. PROPOSED METHODOLOGY

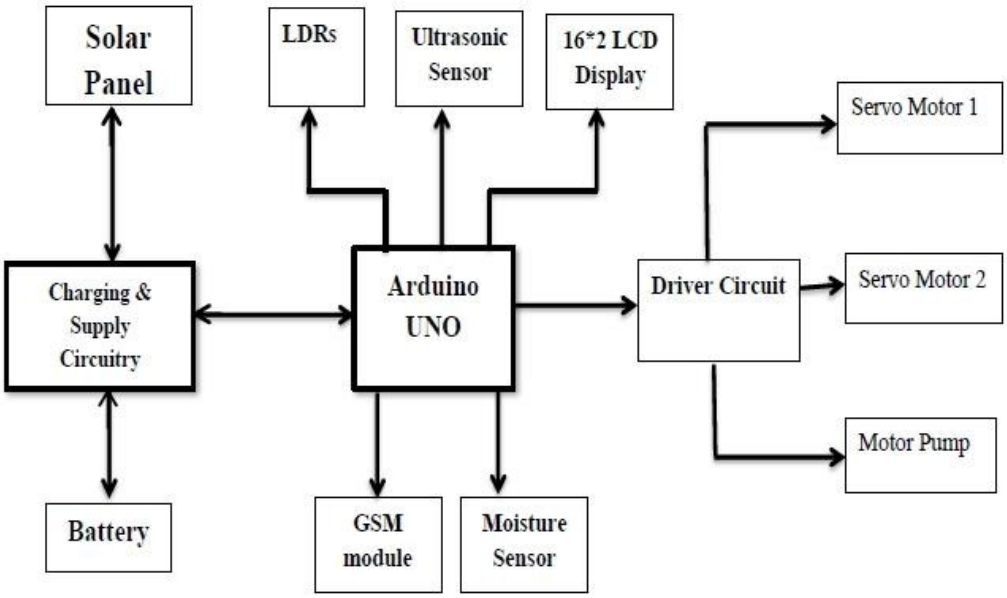

Fig 1:- Block diagram of advance solar tracking and automatic sprinkler irrigation system.

1. Solar Panel: Sunlight is converted into electrical energy (DC power) using a solar panel. Serves as the system's main source of power. Provides power to the circuitry for charging and supply.

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2. Charging & Supply Circuitry: Controls the solar panel's voltage and current. Enables the battery to be charged for backup power. Gives the Arduino UNO and other devices a steady power source.

3. **Battery**: Holds solar panel energy for ongoing use, particularly in the event of inclement weather or at night. Ensures the system's dependability.

4. Arduino UNO: The project's brain is the Arduino UNO (Main Controller). receives data from sensors (moisture sensor, LDRs, and ultrasonic). manages outputs (motors, pumps, GSM, and displays) and processes data. makes decisions for autonomous irrigation and solar tracking. **5. Light Dependent Resistors:**LDRs, measure the intensity of sunlight in various directions. Arduino modifies the servo using this data.

6. Ultrasonic Sensor: Determines the storage tank's water level. Prevents the motor pump from operating dry. Transmits information to the Arduino for water control.

7. Moisture Sensor: Tracks the amount of moisture in the soil. A motor pump is used to start irrigation when the land becomes dry. Stops the pump when the soil is sufficiently moist to prevent overwatering.

8. GSM: Wireless communication is made possible via the GSM Module. Notifies or warns the user (e.g., tank empty, soil dry, irrigation started). Enables system monitoring from a distance.

9. LCD Display: Shows data in real time, including solar tracking status, water level, and soil moisture. Offers an intuitive user interface.

10. Driver Circuit: Serves as a conduit between high-power devices and Arduino. Supplies enough voltage and current to safely run motor pumps and servo motors.

11. Servo Motors 1 and 2: Manage the solar panel's horizontal and vertical axis positions. To capture as much sunlight as possible, adjust the panel's angle.

12. Motor Pump: Water is pumped from the tank to the field by a motor pump. automatically adjusted according to the level of soil moisture.

IV. CONCLUSION

Utilizing contemporary technologies like single-axis solar tracking, soil moisture and temperature sensors, and mobile communication modules, the Advanced Solar Tracking and automatic Sprinkler Irrigation System effectively illustrates how smart agriculture can be greatly improved. Automated irrigation controls combined with real-time data collection guarantee effective water use while optimizing solar energy use for sustainable operation. When solar tracking systems are used instead of static panels, energy generation can be improved by up to 25–35%. By preserving ideal soil moisture levels, the adaptive irrigation system, which is powered by accurate sensor inputs, not only minimizes water waste but also encourages robust crop growth.

Furthermore, mobile integration through GSM or IoT-based systems improves responsiveness and convenience by giving farmers direct access to system status and notifications. This project tackles important agricultural issues such limited manual labour, water conservation, and energy scarcity. It supports the larger goals of sustainable rural development and smart farming, which makes it a workable option for both small- and large-scale farming enterprises.

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